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TECHNOLOGY AND SOCIETY: INTERFACES WITH INDUSTRIAL ARTS

1980

American Council on Industrial Arts Teacher Education

29th yearbook

Technology and Society: Interfaces with Industrial Arts

TECHNOLOGY AND SOCIETY: INTERFACES WITH INDUSTRIAL ARTS

Co-Editors
Herbert A. Anderson
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University of Wisconsin-Stout
Menomonie, Wisconsin

29th yearbook 1980

American Council on Industrial Arts Teacher Education

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Foreword

Just over thirty years have elapsed since a handful of dedicated industrial arts teacher educators helped to found the American Council on Industrial Arts Teacher Education (ACIATE). During the time of organization and structure, these people of considerable vision saw the need for a Yearbook series which would be dedicated to the improvement of industrial arts and teacher education. The first yearbook, *Inventory-Analysis of Industrial Arts Teacher Education Programs* was issued in 1952, only two short years after ACIATE was formed.

This year the profession is fortunate to receive the 29th edition of the ACIATE Yearbook series. It too is an inventory-analysis, but more from a philosophical basis than Yearbook One. The editors and authors of this publication have taken a serious and in-depth look into the ways technology and our modern society have interfaced with the discipline of industrial arts. They have given a broad overview of our technological society in the three chapters of Part I.

In Part II, a selected set of societal problems have been addressed. These problems as identified by the editors and elaborated on by individual authors will help all of us better understand these problem areas in greater detail. Part III is an important part of this Yearbook. Here some strategies are presented for our review. Here is where we can learn of some ways to implement problem-solving techniques in our industrial arts curriculums. Also, additional technological and societal problem areas are identified which should encourage further work and study into solving present and future problems created by technology and society. Can industrial arts play a part in contributing to the solving of these problems? The answer must be – YES!

Co-editors Dr. M. James Bensen and Dr. Herbert A. Anderson are to be commended for bringing this excellent topic to the industrial arts profession. The contributing authors must also feel a sense of pride in their contribution to this 29th Yearbook of ACIATE. I encourage every industrial arts professional to read and learn from the content which follows.

Ervin A. Dennis
President 1978-1980

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Yearbook Proposals

Each year, at the AIAA national convention, the ACIATE Yearbook Committee reviews the progress of yearbooks in preparation and evaluates proposals for additional yearbooks. Any member is welcome to submit a yearbook proposal. It should be written in sufficient detail for the committee to be able to understand the proposed substance and format, and sent to the committee chairman by February 1 of the year in which the convention is held. Below are the criteria employed by the committee in making yearbook selections.

ACIATE Yearbook Committee

Guidelines for ACIATE Yearbook Topic Selection

With reference to a specific topic:

1. It should make a direct contribution to the understanding and the improvement of industrial arts teacher education.
2. It should avoid duplication of the publications activities of other professional groups.
3. It should confine its content to professional education subject matter of a kind that does not infringe upon the area of textbook publication which treats a specific body of subject matter in a structured, formal way.
4. It should not be exploited as an opportunity to promote and publicize one man's or one institution's philosophy unless the volume includes other similar efforts that have enjoyed some degree of popularity and acceptance in the profession.
5. While it may encourage and extend what is generally accepted as good in existing theory and practice, it should also actively and constantly seek to upgrade and modernize professional action in the area of industrial arts teacher education.
6. It can raise controversial questions in an effort to get a national hearing and as a prelude to achieving something approaching a national consensus.
7. It may consider as available for discussion and criticism any ideas of individuals or organizations that have gained some degree of acceptance as a result of dissemination either through formal publication, through oral presentation, or both.
8. It can consider a variety of seemingly conflicting trends and statements emanating from a variety of sources and motives, analyze them, consolidate and thus seek out and delineate key problems to enable the profession to make a more concerted effort at finding a solution.

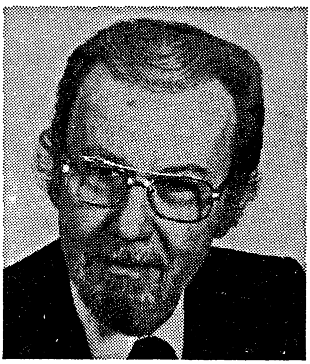
Approved, Yearbook Planning Committee
March 15, 1967, Philadelphia, PA.

Previously Published Yearbooks

1. *Inventory-Analysis of Industrial Arts Teacher Education Facilities, Personnel and Programs,* 1952. Walter R. Williams, Jr. and Harvey Kessler Meyers, eds.
* 2. *Who's Who in Industrial Arts Teacher Education,* 1953. Walter R. Williams, Jr. and Roy F. Bergengren, Jr., eds.
* 3. *Some Components of Current Leadership,* Roy F. Bergengren, Jr. *Techniques of Selection and Guidance of Graduate Students.* George F. Henry. *An Analysis of Textbook Emphases,* Talmage B. Young. 1954, three studies.
* 4. *Superior Practices in Industrial Arts Teacher Education,* 1955. R. Lee Hornbake and Donald Maley, eds.
* 5. *Problems and Issues in Industrial Arts Teacher Education.* 1956. C. Robert Hutchcroft, ed.
* 6. *A Sourcebook of Reading in Education for Use in Industrial Arts and Industrial Arts Teacher Education, 1957.* C. Gerbracht and G. O. Wilbur, eds.
* 7. *The Accreditation of Industrial Arts Teacher Education,* 1958. Verne C. Fryklund, ed., and H. L. Helton.
* 8. *Planning Industrial Arts Facilities,* 1959. Ralph K. Nair, ed.
* 9. *Research in Industrial Arts Education,* 1960. Raymond Van Tassel, ed.
*10. *Graduate Study in Industrial Arts,* 1961. R. P. Norman and R. C. Bohn, eds.
*11. *Essentials of Preservice Preparation,* 1962. Donald G. Lux, ed.
*12. *Action and Thought in Industrial Arts Education,* 1963. E.A.T. Svendsen, ed.
*13. *Classroom Research in Industrial Arts,* 1964. Charles B. Porter, ed.
*14. *Approaches and Procedures in Industrial Arts,* 1965. G. S. Wall, ed.
15. *Status of Research in Industrial Arts,* 1966. John D. Rowlett, ed.
16. *Evaluation Guidelines for Contemporary Industrial Arts Programs,* 1967. Lloyd P. Nelson and William T. Sargent, eds.
17. *A Historical Perspective of Industry,* 1968. Joseph F. Leutkemeyer, Jr., ed.
18. *Industrial Technology Education,* 1969. C. Thomas Dean and N. A. Hauer, eds. *Who's Who in Industrial Arts Teacher Education,* 1969. John M. Pollock and Charles A. Bunten, eds.
19. *Industrial Arts for Disadvantaged Youth,* 1970. Ralph O. Gallington, ed.
20. *Components of Teacher Education,* 1971. W. E. Ray and J. Streichler, eds.
21. *Industrial Arts for the Early Adolescent,* 1972. Daniel L. Householder, ed.
*22. *Industrial Arts in Senior High Schools,* 1973. Rutherford E. Lockette, ed.
23. *Industrial Arts for the Elementary School,* 1974. Robert G. Thrower and Robert D. Weber, eds.
24. *A Guide to the Planning of Industrial Arts Facilities,* 1975. D. E. Moon, ed.
25. *Future Alternatives for Industrial Arts,* 1976. Lee H. Smalley, ed.
26. *Competency-Based Industrial Arts Teacher Education,* 1977. Jack C. Brueckman and Stanley E. Brooks, eds.
27. *Industrial Arts in the Open Access Curriculum,* 1978. L. D. Anderson, ed.
28. *Industrial Arts Education: Retrospect, Prospect,* 1979. G. Eugene Martin, ed.

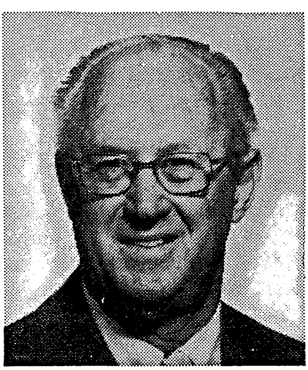
*Out-of-print yearbooks can be obtained in microform and in Xerox copies. For information on price and delivery, write to Xerox University Microfilms, 300 North Zeeb Road, Ann Arbor, Michigan, 48106.

Contents



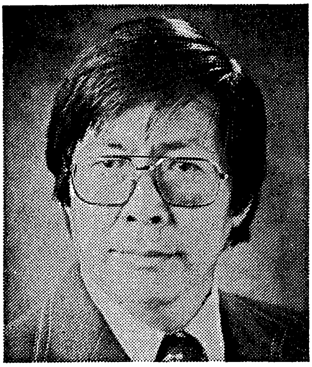
S. F. Kasprzyk
State University College at Buffalo
Buffalo, New York

An examination of the term "technology" and how it has evolved to its present use in describing one of the most powerful influences in our society.



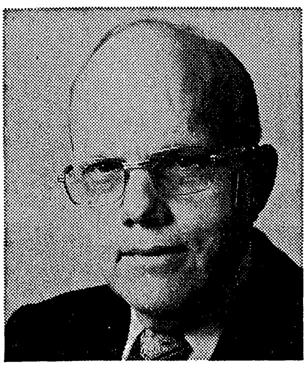
J. W. Chaplin
San Jose State University
San Jose, California

All elements and forces of change in society function in various roles. Technology has had a significant role to play in meeting the needs of society as it has been put to use in solving societal problems.



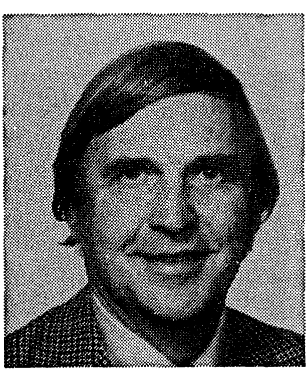
Thomas Tsuji
Glassboro State College
Glassboro, New Jersey

People have sought and developed shelter in order to improve their quality of life. Early housing utilized what was convenient and at hand. The shelter of tomorrow may differ as much as our current housing solutions do from the primitive.



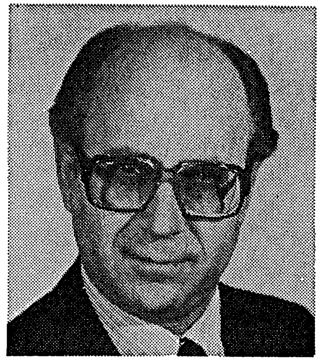
William D. Umstattd
The Ohio State University
Columbus, Ohio

The environment in industry has caused major health, safety, and psychological problems. Improvements have been made through new technology, improved management, and legislation.



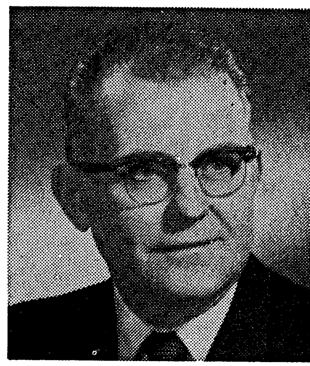
Ralph C. Bohn
San Jose State University
San Jose, California

Industrial production, transportation, and public consumption have been the major contributing factors to a polluted environment. The cause and effect of pollution continue to perplex society, and it is imperative that we provide opportunities for increased study of the problem.



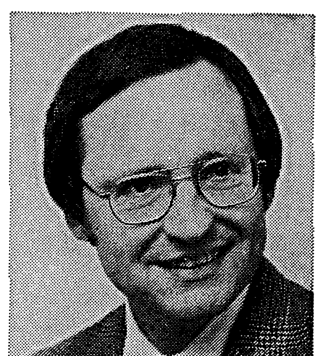
Myron Bender
University of North Dakota
Grand Forks, North Dakota

Transportation capabilities have advanced dramatically, yet concurrent problems brought about due to these advances have become evermore perplexing. A more synergistic approach to solutions is needed.



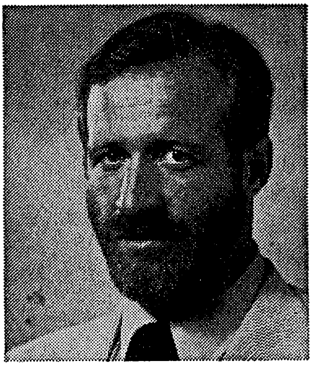
Delmar W. Olson
Professor Emeritus
North Carolina State University
Raleigh, North Carolina

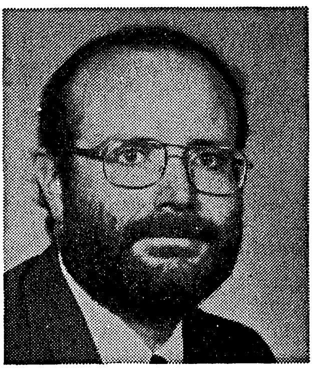
A viewpoint of the infusion of leisure and recreational activities into our lives and the role that these concepts play in designing industrial education programs.



Leonard F. Sterry
University of Wisconsin — Stout
Menomonie, Wisconsin

Societal problems are everywhere! In addition to the problem areas which were addressed in the chapters in Part II, several problems are identified and presented as areas where technology can be used to provide solutions.





David L. Passmore
The Pennsylvania State University
University Park, Pennsylvania

To improve anyone or anything, change must take place. How this change occurs depends upon those who plan, implement, and assess the process. Several strategies are presented for consideration and use.

William A. Welsh
National Institute for the Deaf
Rochester Institute of Technology
Rochester, New York

M. James Bensen
University of Wisconsin — Stout
Menomonie, Wisconsin

The ideas presented as a Technology/Society interface by earlier authors are summed up. A parting perspective and challenge to the profession are presented for consideration. Our course of action may well determine whether industrial arts will flourish or wither as a viable subject in our schools.

Preface

Between the covers of this yearbook, industrial arts educators will find a challenge! This challenge will test their philosophy concerning current and future programs with that of the fourteen authors on topics that will impact upon our profession.

If the challenge is not met and if industrial arts teachers continue to focus programs of study on several selected materials and how to process these, they may find their work taken over by science, economics, and business teachers.

As yet, industrial arts teachers have the edge over academic-content teachers to incorporate technological instructional content by virtue of their facilities in the laboratories where they can combine problem-solving techniques with hands-on activity. The opportunity to update industrial arts and to view the solving of societal problems through technology and industrial production is rapidly slipping away as more science teachers shift from teaching theory to the applications of science. If industrial arts as a school subject is to survive, industrial educators will need to formulate within their own minds how industrial arts can contribute to the solution of societal problems by applying advances in technology.

To this point in time, industrial arts has generally attracted the student who wishes to make something for his or her daily use. Except for isolated instances, it has not attracted the potentially capable boy or girl who would like to prepare for or explore fields which would lead to research and development, communications, mass transportation, alternate sources of energy, automated production, innovations in housing, etc. Every youngster in the elementary and secondary school should have this opportunity in industrial arts classes. Teachers can make this possible by bringing about some changes in classes which reflect present and future societal concerns.

Therefore, the purpose of this yearbook, TECHNOLOGY AND SOCIETY: INTERFACES WITH INDUSTRIAL ARTS, is to assist industrial arts teachers to consider some new directions without engaging in long hours of research. The authors of the yearbook have done this for you.

The yearbook has been divided into three parts to aid the reader in focusing in on the issues, problems, and proposals. Part I provides a concise background to the problem from a societal, technological, and educational perspective. Part II presents a series of selected problem areas which include some ideas for industrial arts teachers to initiate in their programs. The third, and final part of the yearbook, provides additional societal problem areas that our programs could address themselves to, presents a strategy for fostering improvement through change, and closes with a parting perspective and challenge.

The editors wish to thank and commend the authors for work well done. They have made a significant contribution to our profession. As industrial educators, we can show our appreciation by carefully considering the content of each chapter and bringing about a new direction for industrial arts.

It might be wise to read the summary chapter first, which will whet your appetite to carry the book around with you so that you can read it as you have time.

Herbert A. Anderson

M. James Bensen

part i

An Introduction to the Technology and Society Interface with Industrial Arts

Technology is the "know-how" and creative process that utilizes tools, resources, techniques, and systems in extending the human potential for the purpose of solving problems to enhance control over the natural and man-made environment to alter the human condition. (Adapted from *Technology: A Study,* The School of Industry and Technology, University of Wisconsin-Stout, Menomonie, Wisconsin, 1979).

Chapter 1

Technology: A Socio-Historical Perspective

S. F. Kasprzyk
State University College at Buffalo
Buffalo, New York

A consideration of technology in historical perspective is inevitably a study of the etymological origin of the word "technology" and its meaning in the context of subsequent usage. Etymologically, "technology" derives from the ancient Greek *technologia,* the roots of which are *tēchne* and *logos.* These commonly accepted facts, readily substantiated by lexicographers, are frequently introduced into discussions assumedly addressed to the meaning and scope of technology, suggesting that the ancient Greek terms have something in common with their derivatives, and parenthetically, that ancient Greek thought is relevant to twentieth century issues. That being the case the mere reference to a few accepted etymological facts sheds little if any light on the meaning of technology, much less its socio-historical significance. To be of epistemic value, other pertinent etymological and historical observations need to be taken into consideration particularly the various connotations of *tēchne, logos,* and *technologia,* along with other relevant ancient Greek terms, such as, *epistēmē, thēoria, praxis* and their derivatives.

Assuming that an etymological and historical inquiry may well help to clarify the meaning of technology in contemporary thought, let us set aside dictionaries and lexicons, and inquire instead into some pertinent primary sources to find out what specifically the early writers meant when they used the terms in question; when and in what context the terms originated; how and in what context the word "technology" evolved; how it subsequently 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.

I

Although the words, *technē* and *logos* must have been embodied in the Greek language long before they found expression in literary form, they are first met with in the epics of Homer and Hesiod.[1] These works are supposed by scholars of classical literature to have been committed to writing about the sixth century B.C. Uncertainties 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 technology.

We find in the epics sufficient evidence to indicate that numerous manual technics must have flourished in Greece prior to the time of Homer. His vivid descriptions of them, in terms of processes, tools, and crafted products, indicate that Homer's acquaintance with them was more than passing. In the *Iliad* and in the *Odyssey* he talks about the potter *Kerameus,* the worker in leather *Skutotomos,* the smith or worker in metal *Halkeus,* the carpenter and joiner *Tekton.*[2] He alludes to the processes of working bronze, iron, gold, and silver; of fashioning armor 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, where 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).[3]

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 that 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 and below human dignity). There was even a place in their mythology for Daedalus *Daidalos,* the "ideal craftsman" (Il. 18.592); and among their gods, the high-ranking god of fire and metal-working, "the famed craftsman," Hephaestus *Hphaston*

Klutotechnon (Il. 18.491). It is in this context that the modern mechanical-industrial concept of *technē* has its origin.

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*;[4] and *logos* conveyed the unequivocal meaning of a word or *words*, in the sense of the *spoken word*.[5] With the subsequent growing interest in literary technics 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 wherein 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 philosopher, all wrote in the poetic style of Homer and Hesiod. 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 people. From Hesiod, the common man – the shepherd, the husbandman, the merchant – drew his simple ethics for daily conduct and practical rules for industry.[6] 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.[7]

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 "fine arts," commerce, science, and philosophy, and a movement toward popular forms of government. In Athens, Solon had already laid the foundation for a democracy.[8] 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 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."[9]

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 systemized. Here again, the epics furnished the model. In the Iliad for example there is evidence of Achilles' practical skill of exhorting warriors into battle, and of Nestor's oratorical eloquence in matters of litigation.

The beauty of style exemplified by 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.[10]

The urgent demand for some method of teaching the *craft* of speech writing and *skill* in public speaking was soon met in the publication of numerous treatises on the *"art"* of rhetoric. "As often happens," 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.[11]

Now, *technē* was used synonymously with *the "art"* of rhetoric; and *logos* came to be associated with *technē* in the same context. What we know about Corax (fl. 5th century B.C.) and other rhetoricians comes from Aristotle's accounts (c. 330 B.C.) of its history in his own *Technē Retorikes* ("Art" of Rhetoric).[12]

II

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 Greek scholars and artist-craftsmen of that age – 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 *technē* of Ictinus erected the 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, "almost entirely scientific and materialistic."[13] 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)[14] of the processes of nature. "But with the growth of rhetoric, men began to think in more abstract terms."[15] 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 systemize the existing philosophic and scientific knowledge.[16] Moreover, he was particularly concerned with "working toward a more precise terminology."[17] 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, as Chaucer is to an ordinary Englishman of the present century."[18] 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:

> (A) the word or outward form by which the inward thought is expressed; and (B) the inward thought itself; so that the *logos* comprehends the ratio (reason) and *oratio* (discourse).[19]

At the same time several terms other than *technē* came to signify "skill", among them, *sophia*[20] and *epistēmē,*[21] two important concepts in post-Socratic philosophy. Aristotle reserved the term *sophia* to signify the highest intellectual excellence of which the human mind is capable, namely, "theoretical wisdom" and *epistēmē* to signify "scientific knowledge."

All of Greek terms relevant to the present discussion are embodied in Aristotle's *per genus et differentiam* definition of *epistēmē*. See Fig. 1-1, page 24. A synopsis of the definition should help to show their interrelationships, and will provide a useful frame of reference for the remainder 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

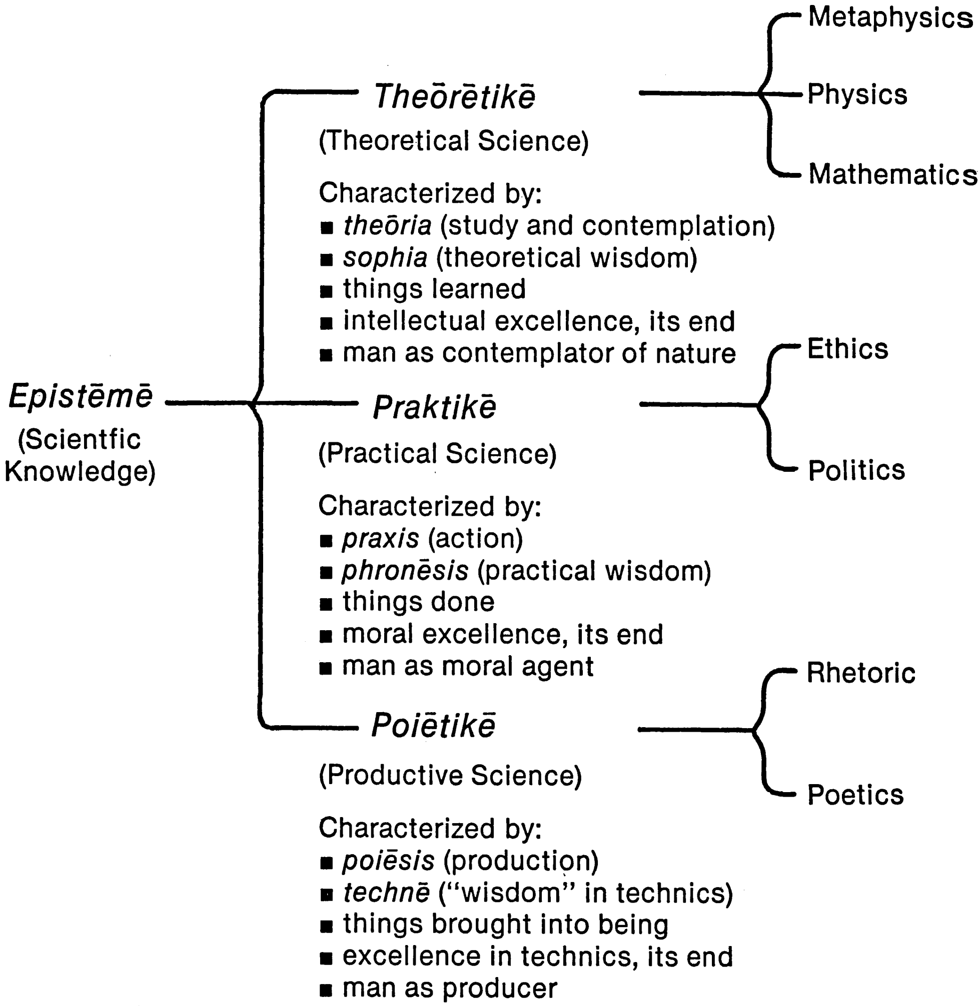


Fig. 1-1.
Aristotle's *per genus et differentiam* Definition of *Epistēmē*.
(This writer's schematic interpretation.)

science, according to Aristotle, encompass all human knowledge which, governed by *logos* (reason, the rational principle), constitutes the basis 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* ("wisdom" in technics); its end is excellence in technical accomplishment.

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.[22] 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."[23]

It may be argued that Aristotle had no intention of assigning to "productive science" a special place in his classification of sciences; 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 *poiētikē* on the other, i.e., between "knowing," "doing," and "making." Moreover, *praxis* (action) and *poiēsis* (production), though categorically 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."[24] 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 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."[25] It is here that the modern dualisms of theory and practice, abstract knowledge and sensual experience, "pure" science and "applied" science, so called, have their origin.

Aside from clarifying the relationship of *technē* and *logos* to *epistēmē,* Aristotle's classificatory scheme shows *technē* and *praxis* to be categorically different concepts: *praxis,* a 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 sculpture in marble and to Polyclitus as a sculptor in bronze. In this sense we signify by 'wisdom' nothing but excellence of art or craftsmanship.[26]

The distinction between *technē* 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 *technē* 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.[27]

Moreover, since *technē* is a kind of wisdom, things produced and their production are but outward manifestations of *technē*. It does not necessarily follow that every instance of excellent production reflects wisdom in "the arts," for it is possible to attain excellence either by chance or by knack acquired through experience. A particular instance of producing something is a matter of experience; *technē* implies that many notions of experience bring about a single universal judgment with regard to like objects.[28] In short, experience is knowledge of particulars, whereas *technē* is knowledge of universals, i.e., knowledge of the underlying causes of excellence in 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."[29]

The foregoing conception of *technē* is exemplified in Aristotle's *Rhetoric,* which enters upon the subject with his observation that,

> 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)* . . .[30]

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 *technē*. It is in this context that *technologia,* the parasynthetic derivative of *technē* and *logos,* has its origin.

When Aristotle coined the term *technologia* (c. 330 B.C.) its meaning was unequivocal, viz., "the systematic treatment of rhetoric."[31] Despite his assertion that the rational principle of reducing rhetoric to a system "holds good in respect to all other arts"[32] *technologia* is met with in no work other than his *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.[33]

About the same time, attention was gradually shifting from rhetoric to the technic 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 technic of grammar been subjected to *systematic treatment*. Perhaps the earliest evidence of it is the *Technē Grammatike* compiled around 60 B.C. by the Alexandrian grammarian, Dionysius Thrax.[34] 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 this *Moralia;*[35] and the Alexandrian grammarian, Appolonius Discolus, uses it in the same sense in *De Conjunctione.*[36]

In addition to its etymological association with the technics 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;"[37] the philosophical skeptic, Sextus Empiricus (fl. 200-250), uses it with reference to the "systematic treatment of definitions;"[38] the Athenian philosopher and rhetorician, Longinus (c, 213-273), uses it in reference to his "systematic treatise" on sublimity.[39]

In every instance the term appears to have retained the essence of its original etymological meaning, to wit, "systematic treatment of . . ." But nowhere in the ancient literature does the term *technologia* appear to have been associated with the manual or mechanical technics. Nor does there appear to be any evidence that the ancient writers addressed themselves to the task of systemizing such technics. "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.[40]

Even though Aristotle holds that all technics are in principle amenable to systematic treatment, he asserts that all of those pertaining to the necessities of life had already been invented and "fully developed."[41] Moreover, *technē* like "other kindred mental activities," are to be pursued "*for the sake of knowledge,* and not *for any practical utility.*"[42] Is it any wonder then that the manual and mechanical technics 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 technics. The working class, on the other hand, those who provided the necessities of life – the smith, the potter, the jointer, 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 a "liberal" education. The privileged class, on the other hand, pursued a "universal curriculum" in which there was no place for manual or mechanical subjects. As Taylor sums up the Aristotelian bias in education,

> 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 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.[43]

III

Conditions in the expanding Roman Empire appear to have been more conducive to the proliferation of mechanical technics but were no more respected than they were in Greece. There too an unbridgeable gap existed between the theoretical and productive realms of human activity. The relationship between these divergent realms, however, was curiously paradoxical: although the Romans surpassed the Greeks in technics such as 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.[44]

The tenuous relationship between *sophia* and *technē* inherited from the Greeks prevailed in Roman thought; the theorist and the man of technics remained worlds apart. This dichotomous tendency was bequeathed in turn to the medieval European civilizations which embraced and fostered Aristotelian precepts and predispositions toward ends alien to ancient Greek thought.

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 pursuits 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.[45]

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.[46] 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.[47] Throughout the period, popularly referred to as the Dark Ages, such Latin works as may have made reference to *technologia* are either very rare or nonexistent.

The situation in the literary field changed considerably around the twelfth century. Exposure of Middle Eastern culture to Europeans during the first Crusades sparked a revival of interest in 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 verbal technics, particularly the technic of grammar; and coincidentally the term *technologia* again came into prominent use in that context. 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."[48] DuCange notes that the term *technologia* appears "repeatedly" in treatises on grammar and elsewhere, and cites as examples 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.

It is not surprising that *technologia* should reappear restrictively in the context of verbal technics. At the same time it seems inconceivable that the status of the natural sciences and the kindred technics 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 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 the kindred technical 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 tended to check individual enterprise and to retard invention or progress of any kind."[49] Christianity, on the other hand, supported by the traditional philosophic systems of Plato and Aristotle, fixed medieval thought on a supernatural course.

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

> Medieval philosophy continued and reinforced 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 of the 'intellectual' over the 'practical' not simply in educational philosophy but in the higher schools.[50]

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 upon them as unfitted to cultivate intelligence."[51]

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 science and technics, 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; technics other than rhetoric and grammar begged systematic treatment, and "technology" gradually acquired connotations associated with objects of a manual or mechanical nature – medical, military, agricultural, industrial and the like.

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,*[52] 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 technics. But what is curious about his restricted usage is the fact that he seems to have been well aware of the trend in the mundane technics 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.[53]

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

IV

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' and it gave to the world a new Messiah: the machine."[54] The hundred year period from 1550 to 1650 which produced the telescope and the compound microscrope, 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, all of whom 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."[55]

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

In the new science (natural philosophy), 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 utilitarian ends; 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."[56] 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),[57] catalyzed the new science and manual technics, and laid the foundation for "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 "preperative Towards a Natural and Experimental History" should suffice here 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 . . . 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 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.[58]

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 concept, and subsequently through the publication of collected scholarly papers, scientific gazettes and journals which reached a wider audience.[59] 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 consistently associated with things mechanical.

V

The earliest reference to the term *technologie* in the context of things mechanical 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).[60] Although neither of these treatises had ever been translated into English, the latter is generally referred to as an "Introduction to Technology."[61] But 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*.[62] This classic work, which ran into several editions (the fourth in 1846), traces the history and describes the status of science and technics related to 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.

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"[63] in connection with his lectures on agriculture, economics, mineralogy, manufacture, and related subjects. Other sources concur in the assertion.[64] More importantly, Johnston notes that Beckmann "united an extensive knowledge of nature, with a decided turn for applying it to practical purposes;" and it was his especial endeavor to bring all industrial technics under "systematic rules, based upon fundamental principles."[65] These observations bespeak Beckmann's concurrence with Bacon's attitude toward the 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.*

In 1816, two decades after Beckmann's *History of Inventions* first appeared in the English translation, Jacob Bigelow, professor of *materia medica* at Harvard accepted the Count Rumford professorship to deliver a course of lectures on the "Application of the Sciences to the Useful Arts." They were edited and published (in 1829) under the title *Elements of Technology.*[66]

Here we find the earliest evidence of the word "technology" in American literature used with reference to mechanical-industrial technics.[67] 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 express, 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.[68]

Like Beckmann, Bigelow was concerned with the utilitarian ends of human knowledge; but unlike Beckmann, Bigelow limited his literary efforts to the mechanical technics and selected "fine arts" appropriate to the technics of industrial production.

It is important to note that "the principles, processes, and nomenclatures" constitute the elements of technology. Having stressed the underlying principles, Bigelow's definition is in harmony with the Greek concept of *technologia,* and 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" appears to satisfy the criterion of appropriateness. Moreover, its use with reference to "the more conspicuous arts" does not imply a definite restriction, but rather a tentative one dictated by the "limits of the volume."[69]

In a literary review of Bigelow's work (in 1830), Treadwell comments on the definition and makes an interesting prediction:

> 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.[70]

Despite its earlier use in English literature, the word 'technology' appears to have been totally ignored by American lexicographers prior to Bigelow's published work. But with the publication of the first edition of the *Encyclopedia Americana* in 1832 its compilers saw fit to include "technology," and defined it as "the science which treats of the Arts, particularly the mechanical."[71] Note the change in definition from Bigelow's "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 changed considerably. And it did not take long for emphasis in meaning to center on "the mechanical arts."

In 1855, when George Wilson accepted the newly established chair of Technology at the University of Edinburgh, he raised the question "What is Technology?" in his inaugural lecture. In answer to his question he noted that

> It is by a quite conventional limitation, that the word Art *(technēs)* denoted by the first dissyllable 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.[72]

These remarks, as far as they go, appear to be compatible with Bigelow's views, and in harmony with the Aristotelian concept of *technē.* But when he goes on to define "technology" as "the Science of the Useful Arts"[73] and arbitrarily excludes certain arts which in his estimation are not useful, he compounds the terminology problem. He asserts that:

> It is not 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.[74]

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?" 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 *essential* Arts." The substitution of terms would, according to his interpretation, have been more appropriate but would hardly have rendered a definition any more genuine.

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" technics. 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 our 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 loosely referred to as either "technical" *or* "technological."

A similar situation surfaced at the secondary-school level during the latter part of the nineteenth and the beginning of the present centuries, at which time various forms of "technical training" programs were being introduced into existing liberal-arts-oriented programs. The new educational concepts brought about radical changes in secondary school curricula 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 used these terms indiscriminately.

VI

For more than a century after it emerged as a naturalistic concept, technology rarely found literary expression in other than industrial-technical papers. Despite its prominent place in the "institutes of technology" where it first found its clerisy,[75] or perhaps because of its subsequent connection with "vocational training," the "technology" received scant recognition in scholarly literature. Ironically, even the institutes soon lost sight of its significance, whereupon "technology" assumed little more than a nominal existence, at best a fortuitous appendage to "science" which itself had been slighted by scholars and critics.

The situation changed somewhat during the early 1900's. A few influential writers began to call attention to the significance of technology in the expanding industrial economy and its effects on established cultural institutions. Among the most influential and perhaps most critical were Thorstein Veblen and John Dewey.

Veblen, best known 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."[76] 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.[77]

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

In 1915 Dewey presented a comparable characterization of industry and the "changed social conditions" in his critique of formal education.[78] But it was not until he addressed himself to a wider audience in the 1930's that he explicitly referred to technology. In his words,

> 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.[79]

Let us make special note here that other influential social critics of the period, at home and abroad, made similar observations with reference to science and technology – Lewis Mumford, Stuart Chase, Oswald Spengler, Jose Ortega of Gasset, to name a few. Like Veblen and Dewey they characterized technology (explicitly or by implication) as a misdirected social force, as the intelligence upon which industrial production is based, as a force that must be understood and brought under the control of reason if industrial production is to serve the common good.

They who misunderstood the nature of technology, who saw *it* rather than its misguided use in industrial production as the source of social problems, contributed little toward the resolution of the problems. The few who understood were the harbingers of what was yet to come; and their pronouncements on the so called "impact of technology" have for the contemporary reader a familiar ring.

NOTES AND REFERENCES

[1]"The time of Hesiod and Homer," say Herodotus (c. 485-425 B.C.), "was not more than four hundred years before my own" (Il. 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]The term *tekton* is used to refer to a builder (Od. 17.384), a shipwright (Od. 9.126), a craftsman (Od. 19.56), in addition to the carpenter (Il. 15.411); refer to 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).

[3]Note: All of the references to the *Iliad* and *Odyssey* are taken from the Murray translations.

[4]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.

[5]According to Liddell, "*logos* 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.

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

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

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

[9]R. C. Jebb, "Rhetoric" *Encylopedia Britannica,* Tenth Edition, Vol. XX, p. 509.

[10]*Manual of Classical Literature, op. cit.*

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

[12]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.

[13]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.

[14]For Heraclitus (fl, 500 B.C.), one of the most important presocratic philosophers (he wrote *On Nature*) the term *logos* 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.

[15]*Op. cit.*

[16]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.

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

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

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

[20]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.

[21]Homer used the term in several forms, e.g., *epistato* "manifold *skill* in handiwork" (Il. 23.705), and *Epistamenoi "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., *epistato* "man who hath understanding" (Il. 14.92), and *epistamenoi* "knowledge of handiwork" (Od. 2.117).

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

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

[24]*Nicomachean Ethics, op. cit.,* p. 153.

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

[26]*Nicomachean Ethics, op. cit.,* p. 155.

[27]*Ibid.,* p. 152.

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

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

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

[31]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.*

[32]Aristotle's *Rhetoric, op. cit.*

[33]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.

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[36]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.*

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

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

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

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

[43]Taylor, *Aristotle, op. cit.,* p. 107.

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

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

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

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[48]Carolo DuCange, "TEXNIKOI," *Glossarium Ad Scriptures Mediae & Infimae Graecitates* (Graz: Akademische Druck, V. Verlagsanstalt, 1958; printed in facsimile from the 1688 edition).

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[51]*Ibid.,* p. 321.

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[53]*Ibid.,* pp. 20-21.

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

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

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[66]Jacob Bigelow, *Elements of Technology* (Boston: Hilliard, Gray, and Wilkins, 1829).

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[68]*Op. cit.,* pp. iv-v.

[69]*Ibid.,* p. iv.

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

[71]*Ibid.,* In Vol. XII under the article "Technology," p. 163.

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Chapter 2

The Role of Technology in Solving Societal Problems

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INTRODUCTION

Man has been living with dynamic acceleration of technology through most of his history. He has used his evolving technology to solve his problems of survival and must continue to apply his technical achievements to the solution of a whole series of societal problems. Technology is indispensable to the resolution of these crises.

Western technology has given us the ability to cope with the living environment whether it be natural, political, or economic.

The role that technology plays in solving societal problems will depend upon what people will do with technology. Technology is the handmaiden and will serve to produce the effects of new creative technological opportunities. Society is the controller.

Value choices control technology choices, but technology offers the use of a new option. (Mesthene, 1969) Technology has a powerful impact on societal values by the fact that it has the capacity of creating new options that can constructively be used to create a new and positive climate of opinion for the solution of difficult problems. To state briefly, considerations of the role of technology in solving societal problems are chiefly two:

1. Challenges for technology and alternative solutions (defining the problems and providing alternative new technical solutions).
2. Redesigning technology into a new discipline (gradually evolving a climate of opinion through the development of technically provided options that brings about a positive and constant value change and that supports solutions that are socially responsible).

Technology has provided or can provide the knowledge, energy, and the physical material necessary to solve society's serious problems of ecological damage, occupational and social dislocations, hunger, threats to privacy, the feeling of political insignificance of the individual, population growth, poverty, and the depletion of resources.

New technology must identify and assume new roles in order to be more effective in problem solving and to become more sensitive toward the greater promotion of, and the effective fulfillment of, the roles that provide for general human welfare as contrasted to individual and corporate extravagance.

AN EPISODE OF THE ROLE OF TECHNOLOGY IN EARLY MAN'S PROBLEMS AND SOLUTIONS

Problem: Changing Geographical Endowment (Paleolithic)

Man's ability to solve problems has resulted in cultural evolution. As man devised and invented solutions to problems of food, shelter, clothing, tools, weapons, and vessels, technologies evolved which allowed alternate solutions. This often made it possible for man to choose between life styles and technologies to overcome environmental and social problems.

Paleobotanists and archeologists suggest that about 10,000 B.C. early man had an ecological problem presented to him of dramatic proportions. A change in the geographical endowment resulted as the climate entered a warming cycle at the close of the Ice Age. As this occurred, an early green revolution took place; water was available, plants and grasses exploded in new lands, large herds of grassland animals expanded thus providing a new food source for the inhabitants. Paleolithic man had had a technology centering around living in caves and hunting slow-moving musk ox, mammoths, and bison with trapping corraling, or stampeding animals over cliffs, followed by the spearing and disassembling of the animals for food and clothing. (Klemm, 1959). In cave drawings in Southern France and Spain, J. E. Lips described what he called man's first machine. A portrayal of a mammoth in a gravity trap at Font-de-Gaume (Late Paleolothic) illustrated that the animal had tripped a lever mechanism which caused a number of transversely-piled heavy tree trunks to fall and to contain the animal. (Lips, 1951).

With the retreating of the ice, the large and slow-moving animals moved northward. This gave man an alternative in choices:

1. Follow the animals and keep his technology.
2. Stay in a more pleasant climate and develop a new group of technologies.

The choice to stay was made by a portion of the people. Because fleet-footed animals of the evolving grasslands were replacing the

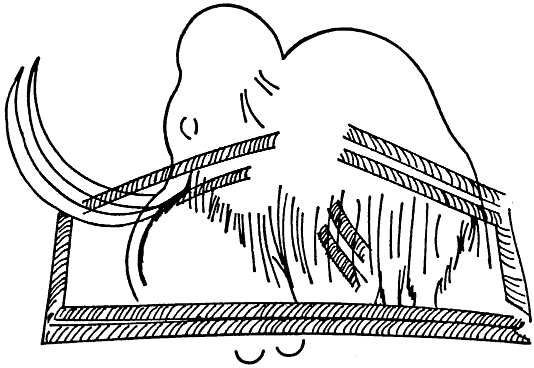

Fig. 2-1.
Mammoth in Gravity Trap.
Cave drawing at Font-de-Gaume (Lips, 1951)

slow-moving ice age animals, new hunting techniques were required. It took a cunning mind to outthink the animal and develop new lighter and faster weapons with longer range and greater accuracy. Thus to the technology of the club, ax, and spear were added the throwing stick and the bow and arrow.

Man's mind and creative invention had provided him with technological options or alternatives for solving societal problems, a very early step in the role of technology.

A SECOND EPISODE, ABOUT 6000 B.C., IN THE EVOLVING OF THE ROLE OF TECHNOLOGY IN SOLVING SOCIETAL PROBLEMS.

Problem: Obtaining Food for Larger Groups of People

Agricultural discoveries occurred in the rich plateaus of the Near East where family groups found and made use of natural cereals. These Neolithic people applied a flint-bladed sickle to gather wild wheat (Triticum boeoticium) which later evolved into Einkorn, a grain of Southeastern Anatolia. In addition, another grain, a more restricted plant (Triticum dicoccoides) the wild ancestor of Emmer was utilized. These early families, working for three weeks when the wild wheat was ripe, could gather more grain than they could consume in a year. (Cole, 1970) This activity together with hunting and fishing provided a new economy. The grains were highly nutritious and easily stored. This high return on their labor provided time for other occupations and inventions. Later accidental sowing provided plots of grain near the family home that could be more efficiently and reliably grown than that produced by the gathering of the grain from wild and scattered fields. The growth of a new agricultural technology changed the lives of people and gave them new options for choice. Attitudes were changing; the importance of land and water took on new values and meanings.

With the domestication of plants and animals, a whole host of technologies evolved to aid in the solving of problems. To prepare and transform these resources into food and enable them to be stored produced a series of technologies of growing, harvesting, grinding, and storing. The new grains were baked into breads and breadlike products. Also new technologies grew up around the breeding and growing of animals, and the preparing, cooking, and preserving of the meat products from these animals.

The technologies of cheese making, wine making, and the weaving of fabrics from animal wool and hair with the equipment designed and built to carry out these processes evolved and made life more tolerable.

At this time technology had provided the digging stick, hoe, pottery, sickle, spindle, loom, fortified tower, and other advances, all aimed at solving societal problems.

EPISODE 3 CIRCA 3000 B.C.

Problem: Organization and Government (Sumerians)

As systems of agriculture became more efficient, men found that greater and more reliable crops could be grown in a mediterranean climate if irrigation systems were developed and the water controlled. A water technology was developed whereby levees, ditches, and weirs were used to water the fields. Complex societal problems soon became confusing and required planning and organization needed to carry out group efforts for large projects such as dams and canals. These irrigation projects needed planning, control and maintenance.

A unifying authority was needed to solve these problems thus technology helped to form the need for a government that was led by a strong ruler and his army.

As agriculture became more efficient and technologies of agriculture evolved, surpluses of food and wealth began to accumulate. Urbanization, architecture, bronze weapons, tools, chariots, harnesses, sails, balances, potter's wheels – all contributed to the technological richness of man and represented the role of technology in the society.

The organized government required the use of records and thus cuneiform script was developed as well as the use of silver in ingots to transact exchanges in making payment, an embryonic form of money. Metals from the Caucasus Mountains plus these new inventions brought about profound changes in the social structure. One man cannot till a field, travel as a merchant, (Clough, 1964) serve as a soldier, mine, smelt, and refine metals and develop crafts to use these products. So technology provided alternatives to a host of economic life styles and new societal solutions evolved.

These brief episodes from the past will be referred to throughout the chapter to help illustrate the concepts of the roles of technology as applied to the solving of societal problems.

CHALLENGES FOR TECHNOLOGY

Technology can be used to solve societal problems for the benefit of all society and not only for a narrow section of a society.

Equality of Opportunity

A fuse is burning in many nations in all parts of the world because of wants and desires of people who have not had an equal opportunity to satisfy physical needs, to learn, to establish a home of their expectations, and to earn a living equal to their capability. The distribution of the world's resources has not been equal and as a result the riches and power have accumulated unequally.

One of the roles of technology is to aid in solving these problems by releasing the political systems of the world from shortages by applying new technological innovations. In many cases the elementary money generators (workers) of the various economies feel that they have been disenfranchised. They feel that the various legislative bodies and governments are not completely dedicated to the betterment of the general welfare of society as their first priority. Through the application of technology, better systems of accounting and communication could bring about legislative progress for the benefit of the general public rather than tradeoffs between politically powerful groups. The use of computer application voting within and between the nations is a role that technology can provide for instantaneous and universal suffrage by voting from a home communication and recreation center. Technology can supply a role that can provide and foster understanding and the resolving of difficult political problems. The technologies related to television, communication, and computer data processing can make possible almost universal suffrage in nearly real time interaction. The people could resolve difficult problems immediately rather than with political bodies and leaders that frequently are not in touch with their true constituency.

This will also involve new technologies of communication that could provide truthful, accurate, and relevant information to the electorate so that social psychological principles of a tyrant cannot be turned into propaganda against the electorate.

Technology can supply computer/electric voting so that the various national political systems may be guided and the political system released so that legislation can progress for the benefit of the general public rather than having compromises between the economically wealthy and politically powerful groups.

International Understanding

Another role of technology is to aid in the development of institutions that will develop and foster international understanding through the better equalization of technical knowledge levels, production, and economic operation throughout the world.

The distribution of raw materials from one nation to another should not continue under a psychology similar to colonialism but in a way so that each nation has the opportunity to develop and expand its own economy. Computer technology will have an ever-expanding role in communication as to where materials are located in the world, the price, and the most economical means of transporting them, and in what time frame they will be available for use in a production schedule.

The computer technology can aid in the equalization of economics by perfecting methods used for appraisal, arbitration, planning, and forecasting. These understandings within trade should work toward a greater equalization of markets and wealth. Thus, there should be a lessening of tension between the "haves" and the "have nots."

Technology Has an Expanding Role in Agriculture

The role of technology in agriculture is to redesign or apply new practical solutions to the production of new and traditional foods and materials for clothing.

Science has provided the knowledge of animal genetics, and technology has been applying this knowledge in the development of faster growing and more productive animals. By breeding stock from proven quality and selecting the best of a generation for future breeding stock, farmers have been able to obtain a one hundred percent increase in the wool yield from sheep in approximately 140 years. Likewise, dairy cattle have been improved, from producing 500 gallons of milk per 300 odd days to 4000 gallons of milk for that time period. Hogs in the 19th Century required two and one-half years to mature as contrasted with six and one-half months now. Livestock management and animal diet research in application of technology have increased productivity by providing the animals with the best housing and feeding conditions. Lighting, temperature, and ventilation control are maintained to increase the productivity. (Bronowski, Berry, Fisher, Huxley, 1964)

Recently, new beef animals have been genetically produced by introducing a cross between the buffalo and beef cattle. This new animal has increased production of meat as well as efficiently using the natural range grasses of the Western States. Animals of Africa, Australia, South America, and Asia may also provide valuable genetic pools for mankind's food supplies by applying science and technology to this concern.

New plant materials, like animals, will also continue to be improved and genetically evolved through technology. The discovery of the potato in the fourteenth century had a dramatic impact upon the whole of Europe and later of the world. Continued improvement in the production of such crops as potatoes, corn, rice, and vegetables must be shared by science and technology. Recently, science has given the knowledge to technology of not only improving plant materials by discovery and breeding, but the added power to produce plant materials by cloning. This process of reproducing plant material has been applied to asparagus recently with enough success to encourage cloning as an additional method of developing new sources of plant food.

The role of science and technology in the future will be that of continuing to explore and develop synthetically new meats, fish, fruits, vegetables, and cereal products. A number of these products have already been developed in scientific laboratories and the role of technology now is to expand and produce them for broad utilization of the world's people.

Mechanization of Agriculture

One of the contributions of technology is in the advanced farming machinery and methods, chemicals, and biological sciences, available to the production of food. American farmers export half of their wheat, soybean, and rice crops; about one fourth of their corn crop; and one third of the sorghum crop. The ability to produce food so abundantly that a substantial contribution is made to the world's food supply is in large part due to the technology employed. The mechanization of agriculture will continue, and technology will improve the yield and efficiency to create even greater productivity.

Aquaculture

New technologies are being developed that have great potential in the increase of a protein food source. Public aquaculture of salmon began a century ago and today one fourth of our salmon (60 million pounds) originates from hatcheries. Today private salmon aquaculture, a new industry based on technology developed from public hatcheries, is taking two forms: (1) production in floating net pens or in sea water ponds, (2) ocean ranching where salmon are released into the ocean to be recaptured when they are mature and return to spawn.

Worldwide output from aquaculture has approximately doubled in the last five years and amounts to 13.2 billion pounds.

The technology for the large commercial culture of oysters, mussels, shrimp, catfish, trout, and other common marine life is developing. This new food technology is resulting in an increasing emphasis on aquaculture throughout the world because of the high potential for augmenting the protein supply for mankind. (Joint Hearings, 1977)

As was illustrated in the first Episode, man still continues to use technology to solve societal problems, in this instance by harvesting products from the ocean.

INDUSTRY

Western Technology

Technology's role in industry also continues to provide that which the world wants and needs. Technology has given our nation an unprecendented ability to adapt and change to the needs required at a particular time in history. Industrial technology has allowed us to develop "intellectual" industries to replace the long-established and labor-intensive activities that gradually are being transferred to the emerging nations. The role of technology is to provide more options for the world to creatively solve its problems. Technology is a key driving force behind modern society which will shape the world we live in tomorrow.

Industry has provided high technology productive leadership in the following applications:

Aircraft
Spacecraft
Road motor vehicles
Power generating machinery
Construction
Mining machinery
Electrical machinery
Switch gear
Communication equipment
Measuring and controlling instruments
Heating and cooling machinery
Metalworking machine tools
Mechanical handling equipment
Tractors
Farm equipment
Office machines
Computers

All of these high technology products of industry provide options and opportunities to cope with societal problems. The computer, however, is generally recognized as having the greatest potential for continued improvement to industry's contribution.

New electronic development in devices and circuit designs has resulted in "Bubble memories," devices that contain memory densities of up to 92,000 bits of information per chip, and they still retain their memory after a power failure; "Integrated injected logic devices" with chips that are 0.1 inch square and which will perform the function of 360 logic circuits; "Charge-coupled devices" that are up to 50% smaller and use 95% less power than semiconductor devices, these devices are even ten times faster than bubble memories; and software which is constantly being developed which greatly reduces the programming skill required to operate the computer. (Dann, 1977)

Microelectronic circuits are being applied to industry in many ways. Major growth areas are in industrial controls of all types. Microprocessors replace electromechanical controls in manufacturing processes as well as in the products themselves. A $20 microprocessor today has about the same computing power as the first large scale computer of the early 1950s. The cost of such a computer then would have been approximately one million dollars. These microprocessors control equipment from machine tools to sewing machines to microwave ovens.

With industry producing new products with greater use and flexibility and at a price that masses of people can afford, the number of options for people rapidly increase; intelligent decisions concerning technology's role for the betterment of the general public must be considered.

By providing these new options, technology can lead the way to gradually change nations' values by offering better solutions to needs and problems. The responsibility of industry that becomes paramount is that technical solutions offered must not violate the trust or destroy the natural, social, or economic environment.

Banking

Technology has presented many options to the institution of banking through the application of the computer and other such advances to aid in international understanding. The possibility of this new role of aid in the problems of international equalization of economic opportunities is tremendous.

The role of technology in international economic development can be fostered by banking institutions or services. As in 1694 when Parliament chartered the Bank of England, the greatest extension of the use of credit resulted in the formation of a vast number of new enterprises. (Cheyney, 1937) New financial institutions are needed that will develop alternative extraction and utilization to bring about a more equitable distribution of the world's raw materials, agricultural commodities, industrial materials, and products. In addition, the improving economic climate will promote educational and cultural opportunities.

A powerful tool that technology can supply banking is an economic computer exchange that forecasts problems and crises before they occur, thus making remedial actions or solutions possible before a disaster strikes. New roles for banking and technology will lead to new industries if governments are cooperative and are concerned with equalizing standards of living and living conditions of a large number of the world's people. These new environmentally-controlled industries can generate the resources necessary to solve or reduce many societal problems such as poverty, pollution, energy, and natural resources utilization.

Education

Education and technology can be used to solve problems for all of society chiefly by supplying new information and designing programs based on new data and knowledge. Knowledge in many phases of technology is constantly renewing itself with entirely new and different technologies to meet human needs and desires. One of the roles of education in technology is to foster the concepts of technological change. Education is more than the mere teaching of facts. Education in the future will be more concerned with teaching how to live with change. This will be largely value and attitudinal in orientation. The teaching of flexibility and attitude change as new processes, procedures, and institutions are discovered or designed will be a vital relationship between technology and education. An additional key concept that education and technology will deal with is to teach a new concept of citizenship. The gradual changing of deeply ingrained human attitudes of striving for individual advantage to the meeting of the needs of humankind as a whole will need to be considered. These new attitudes and values will be multidimensional and will foster understanding. The new ethos will stress cooperation rather than competition and conflict as has been the past behaviors and attitudes. The new ethos gains in the achievement of wisdom over power.

Living Conditions

Living conditions for a vast proportion of the world's population have been a source for social and political dislocation. With increases of communication and education throughout the world, the levels of expectation for achievements in life styles have been raised. People are not as isolated as they have been in the past, and ideas, produced from technology and education, are breaking some old cultural restrictions of behaviors of class and caste. Large numbers of people are seeking opportunities in order to achieve the expectancies that are held out to them through all forms of technology. The desire for a healthy, disease- and vermin-free home, with wholesome food, water, and neighborhoods and schools free from physical violence, is the basic expectancy.

In the past the evolving of technology through historical periods has provided an illustration of the role and contribution of technology towards solving societal problems. Similar to the change in living conditions as described in the first Episode when the changing climate after the Ice Age created a choice between the old hunting technologies and the evolving technologies for smaller, faster wild game, we today are offered a choice of living conditions. One role of technology in our living conditions has been the ever increasing density of the people living per square mile of land. This trend seriously began at the close of the Middle Ages after the resolving of the Black Death and the reorganization and new technologies in farming so that farms became more productive. The living space density was created by the application of multistory buildings with stone, brick, and timber. With these materials, there was a practical limitation of structures with six and possibly eight stories being the maximum. With the advent of cast iron, the height of buildings continued to increase, and after the designing and application of steel as a structural framework, the height of buildings increased dramatically.

During the 1800s and early 1900s the majority of our large urban cities were built. Both traditional and modern building materials were used. In the last half of the 20th Century, serious societal problems are occurring because of the deterioration and decay of these buildings in core cities. State and Federal policies have made an effort to reverse this decay which had resulted in the flight of businesses and middle class citizens from the blighted central cities. The effort has concentrated on a concept to increase the density of population by redeveloping areas with high-rise building complexes using modern building materials designed for the comfort and security of the people working and living in a new urban environment. New state and federal buildings are planned to be the basis of these complexes and around and within these complexes new businesses which supply recreational facilities, dining, and living accommodations are located. Modern transportation systems that allow people access to the city from both long and short distances are required. With a change in the living conditions and the resultant change in attitudes concerning living in the central city, urban sprawl can be reduced or stopped, and valuable agricultural and recreational land saved.

Many technologies have made it possible to develop the trend toward high-rise architecture. The invention of the elevator was a key component that made the high-rise building practical and workable. Structural steel and concrete have provided the physical strength. Electricity has provided lighting, ventilation, temperature control, and communication as well as the many appliances within the buildings. Plastic technology has provided much of the decoration, furniture, and fabrics. The necessities of life have been enriched by luxuries through the application of technology. Technology has continually accepted the challenges society presents and has provided alternative solutions to the problems.

Protection

Throughout history, one of the functions of technology has been the providing of adequate methods of protection to the society. In Episode 2, when grain farming transformed the type of living style, protection was obtained by armed men and the fortified tower. In the deep excavations of Jericho of Biblical fame, one of the first permanent structures was a fortified tower, constructed to store and protect the village's grain from marauding bands. (Kenyon, 1956) (Braidwood, 1957)

Military technology has advanced to stages whereby it consumes a large proportion of the national budget. The building of the ballistic missile, laser guided rockets and bombs, satellites, the heat-seeking anti-missile with its capacity of destroying an offensive missile while it is still in space has had far-reaching effects upon society. National protection uses technological means to achieve near stability in the world.

Personal protection, too, has been provided for by technological means: burglar alarms, time locks, and proximity devices are common in our culture. Whether protection is provided by police responding to an alarm, a Nomad responding to a foreign object, or a N.A.T.O. maneuver in Germany, protection for individuals and societies has become an important role of technology.

NEW SOLUTIONS WITH A HIGH TECHNOLOGY

The existing technology within our nation has given this generation unprecedented ability to adapt, adjust, and change the economic, social, and environmental needs of our time. The underlying problem is to determine which values should judge the various alternatives chosen to solve the major problems of society. Our destiny will be determined in a large extent by which national technological alternatives are chosen.

Some of our problems are so large and powerful that they will require vast amounts of money, planning, and elan to cope with the needs. New institutions may be needed to be invented to produce results on difficult problems, in addition to government and private enterprises.

The depletion of natural resources is of vital concern. The necessity for fresh water for urban living and agriculture is a known problem. Thus the further development and application of water technology is essential. The amount of water available for consumption has long been an index of a nation's technical progress. The Romans established a reputation with their water works around the end of the first century A.D. They impounded water of the Anio River and lakes around Rome and built nine aqueducts to supply the water needs of the city. They constructed the aqueducts from stone, brick, and hydraulic concrete, strong and waterproof materials. They conveyed the water in ditches that followed a gradient, tunnels through high ground and long arcades over lowlands to maintain the gradient, with high bridges for crossing valleys and siphons to cross very deep valleys. (Smith, 1978)

Water technology in modern times has continued by building larger dams and has added a new technology of drilling very deep wells and constructing long pipelines. The cities of Los Angeles and San Francisco use very long pipelines to convey water from the Sierra Nevada Mountains to their respective cities. The pipeline supplying Los Angeles extends some 350 miles from one of the reservoirs. In the center of the Sahara Desert a deep well was drilled and tapped water trapped between two layers of impervious rock under pressure. When this strata was drilled, an artesian well was produced providing irrigation in that arid region. (Bronowski et al., 1964)

The technology already exists that could bring water from our northern Midwest areas such as Montana, Minnesota, Wisconsin, and Washington to the desert regions of our southwest. Institutions to supply the vast amounts of planning and money needed to develop those water projects would be outgrowths of that technology. With the completion of these projects a new frontier could be built. The desert could be transformed into irrigated farms where many of the nation's impoverished people would have the opportunity of participating in the economic systems. New cities would be needed to supply the services needed by the new agricultural area. A large number of business opportunities would be created resulting in a large number of new jobs.

A pilot project has been functioning for some 70 years in the Imperial Valley in California. The 1902 Reclamation Act provided irrigation water from the Colorado River for 160 acre farms. Time has come to redesign and learn from this experience and give an opportunity of a new frontier to unemployed and underemployed people.

A unique process obtains fresh water from sea water. The technology was developed in 1970 based on the principle of natural osmosis – the diffusion of a fluid through a semipermeable membrane until there is an equal concentration of fluid on either side of the membrane. The E. I. duPont deNemours Company's desalination devices are called permeators. They utilize reverse osmosis to remove 98.5 percent of the dissolved salts from sea water. DuPont's permeators can desalinate 5000 gallons of sea water daily, and they require only half the energy normally used by traditional methods of desalination. At the present time people in Rotonda, Florida are using permeators to purify well water for cooking, drinking, and washing. Next year a large scale fresh water plant will be built in the Soviet Union to supply three million gallons of fresh water per day for an oil recovery project. (San Jose Mercury, 1978)

A desalting plant at Elath, Israel, utilizes the "flash" distillation process. The sea water is heated to 70 degrees F. and then passed into a lowered pressure flash chamber. The salt water boils suddenly or "flashes" into a pure water vapor. The vapor condenses in a pure water collector. The water is passed through many flash chambers and finally the vapor is frozen and then melted to produce fresh water. The final output consists of two streams of water, one pure and the other very concentrated salt water. The system produces large volumes of water per day, but it does use energy to pump the vacuum flash chambers and to heat the water to the flashing temperature.

In Johannesburg, South Africa, a plant is functioning on a different principle. In this process brackish water is passed through an electrolysis cell where an electric current running through the water causes the positive ions to migrate to the negative electrode and vice versa. Water, being neutral, is purified when the salts are deposited at the electrodes. (Bronowski et al., 1964)

Technology's role in this challenge of bringing fresh water to the world's population is obvious.

NEW SOURCES OF ENERGY

Early demands of man for weapons and tools made of bronze and iron instigated the demand for energy. Energy produced by chemical means, the burning of charcoal in a furnace, produced that first small amount of precious iron.

Since that early beginning, technological growth has been paralleled by the amount of energy utilized to produce goods and services for our society. Today cheap energy is in short supply; the reasons suggested for this deficiency are varied: in the past developers have not made much effort to expand production because the economic incentive was not present. They often did not expand or modernize facilities because of the high cost involved. There has been a phenomenal increased demand for energy, and alternate energy producing technologies are often still in pilot stage of development. Markets have moved to nations who could supply "low cost" energy.

In Episode 3, the early Mesopotamian, the development of metals was one of the agents for change in that culture. They found that their tools no longer had to be made of stone, they could heat the new bronze metal tools and quickly bring them to a more efficient shape. During these new metallurgical processes energy was being applied to industrial processes. The fuel used was undoubtedly charcoal derived from the forests of the mountains. As long as the forests lasted with abundant cheap wood, man based most of his heating technology on wood and charcoal.

The technological change in a source of energy from charcoal to coal was a difficult and a long change. Although the Chinese had used coal to smelt copper as early as 2000 to 3000 years ago, it was not commonly used in Europe as a source of energy until the 13th century. It was thought that coal from the Fu-shun mine in Manchuria was used as a fuel for a porcelain factory 600 to 700 years ago and that coal had been used to smelt copper long before then. "Coal cinders are found among the ruins of Roman villas and towns in England especially in Northumberland along the Roman wall near which well-known seams outcropped. The Romans in Britain at least, were familiar with its use before 400 A.D." (Eavenson, 1939).

In Western Europe coal was used to provide energy for domestic applications in the 13th century. Easily mined commercial coal was mined by the monks of Lynemouth and shipped from that port in 1269. Earlier, sea coal had been used in London in 1228. "Secole Lane" is the street where artisans such as smiths, limeburners, and brewers would purchase their coal.

Just as the 13th century inventions and the resulting technology struggled to replace the chief source of energy, wood, whose source had been sadly depleted by the deforestation and neglect to replant, with coal – so today our technology strives to solve the problem of energy. Adequate supplies of energy are available, but our problems are concerned with converting it to usable forms economically and transporting it to the area of utilization.

It is estimated that 30 billion barrels of oil are trapped in tar sands. Also 1.8 trillion barrels of oil are locked into oil shale. The role of technology is clear; it will develop processes that will make this oil economically available.

Natural gas as an energy source can be expanded by a new gas line through Canada to the North Slope fields. In addition it is estimated that 300 trillion cubic feet of natural gas are trapped in oil shales and from 300-500 trillion cubic feet held in the high-pressure brines of our Gulf Coast. These sources also require new technologies for energy to be released economically. (Aronson, 1977)

About 50% of the world's coal is in the United States but technology has the problem, not only of economically extracting it from the earth and transporting the coal, but also of meeting the challenge of burning it without pollution of the surrounding air. Technology is working on the problem of coal gasification so that transportation may be carried out by pipeline to the point of need.

Technology has been developed for atomic energy power plants that are capable of developing vast amounts of electrical power but the incompatible question has been that of safety. The huge amount of heat energy produced by the fission of heavy atoms like uranium is tapped and utilized to drive steam generators. The difficulty arises in locating the site for the power plant. Great concern is expressed of the danger of risk of atomic accidents through explosion or spills. The damage to the citizens' food chain and the total environmental impact are very serious concerns. At the present time studies are being conducted on a series of site locations.

In meeting the demand for energy, new facilities will be required, particularly in the coastal areas of America where population density is high, and industrial, residential, transportation, and recreational users compete for the land. Besides that competition, energy facilities are also viewed by a concerned public as threats to the ecological and environmental balance of the coastal areas.

One considertion for the siting of nuclear power plants is that of constructing floating plants. It has been suggested that 59 floating nuclear power plants could be built by a single manufacturer by the year 2000. Other alternatives could be nearshore sitings open-cycle cooling, inshore siting cooling towers, and riverine siting open-cycle cooling. Decisions will need to be made within the next decade so that electrical energy will be available and the surrounding environment be safeguarded. (Daddario, 1977)

The nations of Europe have been experimenting with an alternative type of energy source. This electric power generation system utilizes physical principles of magnetohyrodynamics (MHD). Very hot gas, over 2000 degrees C., becomes ionized and contains free electrons. By passing ionized gas at a high rate through a magnetic field, a current is generated in the gas, and electrical power can be drawn off by "electrodes" placed in the gas stream. A serious problem with this as a commercial electric source is that of designing materials which will withstand such intense heat. However, as plasma physics develops, the problem may be resolved and about 30 percent of the fuel saved by combining a magnetohydrodynamic generator with a conventional power station; thus another challenge for technology emerges.

The use of fusionable materials has rated a high priority in considerations for energy sources. The Lawrence Radiation Laboratory at Livermore, California, has stated that with the application of laser technology to provide the initial concentrated heat to start nuclear fusion, the problem of supplying and controlling that tremendous temperature may be alieviated. Almost any form of material can be used to form a continuing source of nuclear energy. Additional technology will have to be developed to safely control this source, but the basic scientific work proves it a reality. (P.B.C., 1978)

The role of technology continues in the development of such energy sources as tidal, wave, and current mechanisms as well as ocean and geothermal technologies. Solar and chemical energy technology are receiving intense study with the hope of developing "free" sources of energy for the individual consumer.

Ocean thermal power plants have recently become included in technology's role of producing energy. The termperature differences between warm surface water and cold deep water provide a source of power. A floating power plant that will probably resemble a ship will pump the surface water up to 80 degrees F. through heat exchangers that transfer the heat to liquid ammonia. The ammonia evaporates and the vapor turns a turbine generator to generate electricity. Water at 40 degrees F. pumped from beneath the boat at about 3000 feet is used to condense the ammonia vapor to create a partial vacuum. The cooled liquid ammonia is returned to the heat exchanger for recycling within the system. (Machine Design, 1977)

Power cables will run to shore to supply electricity for cities or factories. In some applications the factory would be located on the power ship. In this fashion metals and chemicals could be recovered from the sea water utilizing the thermal energy to provide the electrical power.

For many people solar energy is the energy hope for the future. The present applications are directed toward flat-plate collectors which transfer the heat to rooms in homes by means of warm water panels. At present these industries have a great deal of competition; small businesses have had financial difficulties during this developmental period, but soon components will be standardized and mass produced making home conversion to solar heat a more practical solution.

The McDonnell Douglas Corporation is planning to build a heliostat assembly in the Mohave Desert. The assembly will be composed of 1800 heliostats (sun-tracking mirrors) that will concentrate the solar rays on 24 heat absorbing panels. The panels will be mounted on a tower in the center of the heliostat. The sun's rays will be focused on the high tower, and water in the panels will be converted to superheated steam at about 900 degrees F. The steam will then be applied to a turbine generator to produce electrical power. To even out the power production cycle, surplus heat will be pumped into a rock/oil filled thermal storage tank so that the power generation unit may function in periods of reduced sunlight. (Machine Design, 1978)

Power grids exist over large areas with the objective of meeting the demand for electricity at different time periods. In urban centers such as Chicago, Philadelphia, London, and Paris the load required in any given system shifts from various consumer peaks, that is, from early commuter train service, to supplying manufacturing industry needs, or even for supplying power for office elevators at certain hours. The load may shift many times during the day; during the evening the peak demand is in the suburbs for home consumption. These shifting power loads may be made a number of times in the geographical regions as the demand increases or decreases. The interconnection is accomplished by a network of power lines between substations and is called a grid. The grids cover most of America and Europe and carry power in either direction depending upon the location of the peak load. Today the Metro in Paris may be using power that is generated at Calder Hall Atomic Power Station in Northern England. At a later time, a London commuter train may be powered by electrical energy generated at a hydroelectric station in the French Alps. That power grid is completed by a submarine power cable under the English Channel. (Bronowski, et. al., 1964)

With stable political conditions, an electrical power grid could be built that would interconnect the dark side of the earth with the daylight side of the earth. The excess of power generating capacity could be sent over the polar cap on a grid to the factories working on the light side. As the power demands changed with the approach of the night, the power in the network would reverse.

Eventually, technology and science may be able to harness the earth's magnetic field to generate electrical power as it rotates. There may be an establishment of orbiting solar power plants in technology's future. Also geothermal power generation may provide a new economic base for land areas where volcanic activity is prevalent. Such areas as Alaska, Iceland, California, Oregon, Washington, Hawaii, Montana, Wyoming, and Japan have potential for developing electrical power from heat of the earth. This resource of energy may be supplied to local industries or sold to a power grid.

Another area of concern is that of the use of the automobile. A small urban electric car is very desperately needed to lessen pollution, noise, and the parking space dilemma. General Motors and other car manufacturers have designed a car to meet requirements, however, they have been unable to obtain an adequate power source. The Bell Telephone laboratories have announced that they have invented an experimental high-energy battery. This battery uses a lithium vanadium disulfide reaction to produce an output of about double the voltage of nickel-cadmium batteries. The battery is designed to utilize layered compounds that function without permanently changing, physically or chemically, during the charge and discharge cycle. (Machine Design, 1978)

Technology is responding to the needs of people in attempting to supply a non-polluting quiet form of point-to-point transportation.

REDESIGNING TECHNOLOGY/EDUCATION INTO A NEW DISCIPLINE: SOCIAL TECHNOLOGY

Again, as in Episode 3, our society has become more complex, and we have discovered that more planning and organization with its specialization of training and occupation has been required. We have become so specialized that frequently technologists have a different vocabulary from others within the same industry. Because of these new concepts and language, the general public has found it increasingly difficult to understand the interaction between technology and society. For this reason, we must consider new solutions which will supply youth with a new body of general technical education, an education which supplies technical fundamentals for understanding broad areas of technology and its impact on society.

Today, one of our high technology industries advertises that "Technology is a response to the needs of life." (United Technologies) What, then, is the educator's responsibility? Might it not be to make certain that the new generations of youth comprehend not only the fact that technological progress can provide vast new opportunities, but also be the means for improving their life style and environments? Citizens have the opportunity, for the first time in human history, to discipline technology. They can help minimize the damage to the human environment, that damage which has caused massive social problems: economic dislocation, social unrest, political upheaval, and war.

The challenge, then, is in the decision-making between alternative technological and social changes that will provide for the greatest human and environmental enhancement to the general welfare of the people. An objective of education for young people is to help them gain the kinds of information needed to formulate and assess the interactions of technological innovation and the general society. The primary concern is to develop humanitarian priorities for the evolution of social control of technology. These priorities should consider the most critical deficiencies or consequences that may result in domestic and finally global environmental disasters.

The exploiting of resources by intensified utilization, whether it be land, water, labor, or minerals by anyone – individuals, corporations, public institutions, or nations, should be evaluated from a broad perspective and redirected so as to lessen undesirable consequences for others. The group of planners and decision makers who determine technology's national priorities should be responsible to the general public rather than to a political group. The dominance of the profit concept over social awareness can no longer be tolerated. Thus, technology will unite with education in changing attitudes and values. The new values will foster a very real sense of individual responsibility that respects natural materials and develops a reverence for nature. Natural resources are gifts for people of all generations and must be cared for. The mission of Industrial Arts is to foster and teach technology that will maximize the best utilization of materials for their efficiency and beauty.

Science has been moving in this direction for more than ten years. The objective of science, however, is to obtain new knowledge. This search operates largely at the intellectual level. Technology applies knowledge and functions at the operational level; that is, it produces things and performs services. Thus the new social and human role of technology should be carried out by technical educators, teachers of Industrial Arts general education.

The new role of technology has the facts and knowledge, but it lacks the program and method of bringing the new social responsibility role to the new generation. A new discipline of social technology should evolve that welds the human and social requirements to technology. The central theme of social technology would involve gathering information and analysis of courses of actions or alternatives and developing informed decisions concerning the interactions between science and technology.

Technology is capable of moving at an unfathomed rate of speed but social and political institutions change at a much slower rate. These two aspects of our society do not interlock because of the different movement and change. A great deal of misunderstanding and confusion exists in the areas of conflict. The conflict frequently occurs between the profit-making economy and the environmental-preserving heritage.

CONTENT FOR A NEW DISCIPLINE

A discipline is a branch of instruction or learning, or a field of study. A discipline over a period of time develops a literature, however, it may use literature compiled for other disciplines or general academic fields. The discipline will have a history and frequently the history begins with a public need or service. It may also come about by the division of a larger discipline or the recombining of two disciplines on a new emphasis. A discipline has a theory or theories around which research hypotheses may be based, and it will provide the ability to foster research to discover or create new knowledge in a field of study.

A discipline may have a mission for society; it may give the society help in solving problems or by contributing knowledge that aids in solving society's problems. A discipline is required to present subject matter to young people who can use the material to aid in their decision making throughout their lives.

Technology/education is at a point where the understanding of our American technology needs to be presented in an organized form to our future national decision makers. The teaching about industries, materials, processes, methods of organization, and manufacture is good but it is not a broad enough general education that is needed to teach about technology and society.

Social technology decisions that voters need concerning general technological information in their society may be related to these facets: energy, environment, food production, industrial processes and products, health, natural resources, transportation, space, communication, education, national security, institutions, crime, planning and design, waste disposal, pollution control, shelter and construction, and others. Under these general headings such specifics as the following may be studied:

- Energy
    - Electric power generation using fusion nuclear reactors
    - Discovery of a new energy source (not chemical, fission, or fusion)
    - Electric power transmission by super-conducting power lines
    - Gas fuel cell
- Environment
    - Land usage, areas of high and low population density
    - Urban development of deteriorating environment
    - Stewardship toward natural areas
- Food Production
    - Chemical synthesis of highly nutritious food
    - Aquaculture
    - New animal and plant species developed for food
    - Artificial protein grown by cellular processes
    - Natural environment as food storage (underwater and underground grain storage)
- Industrial Processes and Products
    - Fully-automated manufacturing plants
    - Fully-automated chemical plants
    - Automated engineering design systems
    - Desalination plants for irrigation and water supply
- Health
    - Safe antivirus drugs
    - Control of aging process
    - Successful animal/human organ/tissue transplants
    - Medical diagnosis data bank
    - Automated laboratory analysis
    - Chemical control over birth defects through gene modification

- Natural Resources
  - Extraction of chemicals and metals from the ocean
  - Diversion of water through large pipelines to desert areas
  - The enrichment of low grade ores
  - Weather control
- Transportation
  - High speed trains (500 KpH)
  - Deep level straight subways
  - Atomic powered aircraft
  - All composite material aircraft
  - Submarine transport ships
  - Off-shore deepwater ports
  - Pneumatic freight systems
- Communication and Education
  - Speech pattern recognition input for computer information
  - Magnetic bubble memory cores
  - Three-dimensional presentation systems
  - Home computer terminals with video output
  - Automated tax collection system
  - Vote at home
  - Automated abstracting systems for books, periodicals
- National Security
  - Nonlethal anti-personnel weapons
  - Tactical combat surveillance and control from ground, airborne platform and satellite
  - Laser target illumination and designation
- Space
  - Global meteorological observation system
  - Global monitoring of atmospheric and ocean surface pollution
  - Direct broadcast satellites
  - Space metallurgical factory
- Institutions
  - Electronic funds transfer
- Crime
  - Automated judicial system
  - Computer based legal brief analysis of a crime
  - Computer decided trials
  - Crime information system
  - Legal precedent information system
  - Personality drugs to control anxiety and aggression
  - Early recognition and then correction of social deviant behavior
- Planning and Design
  - Multicolor display devices in three dimensions
  - Conversational programming
  - Space metallurgical factory
  - Remote real estate visual sale system

Waste Disposal
- Advanced sewage treatment and recycling
- Advanced treatment of water waste with industrial reuse

Pollution Control
- Chemical to dissolve oil slicks
- Automated pollution control of air and water

Shelter and Construction
- Precasting of modular housing components
- Precasting of kitchen, bathroom and service areas in modules with units in space
- Preconstructed homes with alternate cooling and heating systems contained, solar, geothermal, electrical or conventional (Ayres, Shapauka, Humes, 1973)

THE NEW DISCIPLINE'S PRIMARY RESPONSIBILITY: TO DEVELOP A VALUE SYSTEM BASED ON CREATIVITY AND HUMAN DIGNITY

The new spirit in technology/education is one of caring and involvement, caring about how technology has impinged upon the lives of people, caring about the interactions of materials, environment, and human feelings.

Technology's role in the new discipline is to evolve in youth a series of new ethos which may become a self governing value, waste will not be littered about the landscape because waste itself is considered a resource and can be recycled. Attitudes would be fostered that materials no longer used should continue to receive good care in that the waste material can be reutilized. Vandalism and damage of property, cutting or slashing of trees, or general defacing of the environment should be perceived by peers as inappropriate behavior. The concept that such damage of property is tantamount to the destruction of resources should become a value.

The technology/social discipline will stress that each individual has numerous creative talents and that these gifts need to be explored and developed. The possiblity that technical and social creative talents are more broadly defined and obtainable in a large number of our youth must be recognized and rewarded when work is well done.

Technology/education on the conceptual level may well be the study of high level technology such as electrical power grid technology, designing new cities, producing disposable draperies and furniture, waste and salt water distillation, etc., but the laboratory phase of this work may be working in the realm of designing and producing low cost and low-power-consuming machines or processes such as a hand-operated adobe brick-making machine, a bicycle-powered metalworking lathe, a hand-powered forge, a small mobile saw mill, a cupola furnace, a simple man-powered rotary pump, four-wheeled low bed cart or wagon, hand-powered wench, and many small machines that could be used in the preparing and processing of home foods and manufacturing.

These laboratory experiences could be carried out as task forces applying the knowledge of high technology to problem solving and development of a low technology that would be at a level of abstraction that the youth could see the social technological problems of international societies and our own.

The important objectives of the laboratory activities are to give the youth the opportunities to understand his society clearly and to explore alternate solutions to the problems of a technological society. Technology/education cannot duplicate all of the technological and production environment, but it can study this environment to observe its trends and to understand it by redesigning machines and processes to their simplest form, always stressing the value system based on creativity and human dignity.

ANOTHER RESPONSIBILITY OF SOCIAL TECHNOLOGY: TO UNDERSTAND THAT TECHNOLOGY WILL AID IN THE EQUALIZATION OF THE ECONOMIC LEVELS OF NATIONS

Struggles between nations and political bodies because of scarcities and shortages of food and services, greed, and competition, have been common throughout man's history. Technology now has the capacity to bring people together with its ability to provide food, shelter, transportation, clothing for all the world. (Fuller, 1978) It has the power to do more with less if proper applications are made. What is needed is a new psychopolitical solution, an intellectual solution; for instance, one of the political problems that will need to be accomplished is the overcoming of the fossil fuel interests that largely control these sources of energy.

A very serious problem of our time is relating to "bigness;" large industrial combines, large governments, large financial institutions. People are confused and feel that they have no input or control over such organizations. A great amount of frustration results. Frequently, this results in a revolution such as the California tax revolt. This feeling of lost control by individuals can be helped by applying the concept of E. F. Schumacher, 1973, *Small is Beautiful.*

Because of our high technology and high energy utilization being self reinforcing, we have invented a more and more complex technology of labor saving machines. The societal problem in various parts of the world including America is that we have manpower but it requires a large amount of capital investment per industry work station which means that each job or position requires a large amount of financing in equipment. An emerging thought is suggested that high technology should be used to develop efficient new low-technology machines, tools, and processes that would be man-oriented. These small low-energy industries would require less amounts of capital investment to produce a work station. The concept is to have many small plants, farms, or mines rather than a few very large organizations. This type of technology has been referred to as Intermediate Technology and in the United States it is called Appropriate Technology. (Pete, 1978) This means that the technology applied to a problem is appropriate to the culture, economic, and social needs of the community. An example of this would be an efficiently designed plow to be pulled by a water buffalo in a culture where water buffalo is used rather than a hydraulically lifted plow pulled by a modern wheel tractor.

In this fashion technology can help with society's problems by providing work and economics that are compatible with the geographical area in which the people are located. By having many small modern man-oriented production units dispersed throughout an area, relatively small work groups could maintain a rural life style and at the same time relieve the pollution problem by placing less ecological stress upon the environment.

With the computer to inventory parts and products and modern scheduling of transportation, it would be possible to develop a life style of the cottage industry that existed before the Industrial Revolution and still be productively efficient.

Such innovations will be helpful in developing a technology that is people-oriented and will aid in the equalization of the technological levels of the various parts of the world.

HUMANITY APPLIED TO TECHNOLOGY IN MAKING DECISIONS THAT CONSIDER EACH GROUP OF THE WORLD'S CITIZENS IS A SUPREME CONCEPT THAT NEEDS TO BE FOSTERED IN TECHNOLOGY/EDUCATION

Human values should be the controllers of behavior in decision making. In the past those educated in technology frequently became imbued with facts and operations of machines, formulae, and mathematics. The humanity of people was not emphasized; the responsibility for teaching about basic human values was relegated to other institutions and programs of education. To counterbalance undesirable behavior; violence, terrorism, vandalism, and egocentrism, the exposure to basic human values must be a planned part of all educational programs.

In technology/education decisions concerning the value of the very existence of life forms will be made. In the early 1800's technology provided transportation in the form of the railroad. At that advent the prairie states with the vast herds of buffalo were available. At the same time technology had produced a powerful long range rifle that would easily kill the buffalo. The result, because of uncontrolled greed or an irresponsible value system, was the near-extinction of the buffalo herds. Today the motorcycle and dune buggy race and tour the western deserts. The deserts probably have the most sensitive ecological balance of all environments. Thus we encounter a challenge. Technology/education needs to instill sensitivity into the youth so that habitats can continue. The biologists and zoologists of the future need to be able to obtain genetic pools from which to develop future food and material products, a very practical reason as well as the intrinsic one of not allowing any species to become extinct.

The new discipline's objective will seek to humanize technology so that youth will have information necessary for making desirable political decisions as they relate to technology. A social value system that is based on humanity must take precedent over mere technological prowess.

EPILOGUE

Industrial arts education has been active for over half a century in meeting needs of youth. However as the needs of youth and society change, so must the objectives and activites of institutions.

Industrial Arts has been very heavily industry-oriented. The problems of industrial training have gradually been federally supported through vocational education, expanded even to include parts of general education which traditionally have been considered Industrial Arts.

It is now time to revitalize Industrial Arts by gradually changing the emphasis from industry to technology, a much broader field of education, and to stress the area of technology between Science and Industry rather than working with only the industry and production aspects of it.

As institutions mature, there must be some reevaluation, reorganization, and revitalization in order for them to remain a dynamic force in society. Thus a new discipline should focus upon the evolving technology and the social interactions it creates. The problem and experimental methods of teaching in the laboratory should be maintained and increased. However the important new role will be the support of human values for all mankind. For this new discipline I would suggest that we work diligently to retool, reorganize, and expand our knowledge base and call our new discipline, Social Technology, the new role of technology in solving societal problems.

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Chapter 3

Ideals and Practice — The Profession's Response to Technology/Society

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This chapter was originally intended to be a review of the industrial arts profession's efforts in solving problems in society through the use of technology. Except for modest efforts of some individuals, there is virtually no evidence of such efforts and there is no major commitment of the profession to this end. On the other hand, the profession does endeavor to prepare technologically literate individuals to cope with problems in society which result from technology or which may be solved by technology.[1] Unfortunately, the success of this endeavor is scant. The measure of the profession's success in preparing technologically literate citizens became the focus of the chapter. It also became apparent that the profession's success in this regard may be related to the degree to which its members engage in the solution of technology/society problems.

The profession is taken to include public school industrial arts teachers, local and state supervisors of industrial arts, faculty in the more than 250 colleges and universities who serve as industrial arts teacher educators or teachers of teachers and faculty in the several doctoral degree-granting institutions who may be regarded as teachers of teachers of teachers.[2] The few additional personnel who serve full time in the professional organizations are also included. However, emphasis here is on teacher educators.

Observers have remarked upon the strengths, weaknesses, essential goals and objectives, practice, changes, and ideals which guide in-

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[1]The term "technology/society" will be used to communicate this sort of interaction.

[2]This reporter favors the terms teachers of teachers and teachers of teachers of teachers first encountered in Evans, R., and Terry, D.R., *Changing the role of vocational teacher education.* McKnight & McKnight Publishing Company, Bloomington, Illinois, 1971.

dustrial arts. The rationales of the major curriculum efforts of recent years contain critical analyses of existing goals, objectives and practice. Such analyses establish that the curriculum effort being touted is appropriate, will remedy defects noted and bring practice into greater conformity with ideals. Such statements and the curriculum efforts themselves have met with varying degrees of success and acceptance within the profession. Practice seems to change only slightly. There seems to be little dramatic response from practitioners to the admonitions and exhortations of leaders. Calls for revolutionary change have received modest, virtually imperceptible evolutionary responses, the permanence of which remain in doubt.

The first segment of this chapter reviews this ideal/practice discrepancy. Selected statements are presented about ideals, and characteristics of practice including the practice of curriculum revision.

This is followed with a discussion – somewhat speculative – about the underlying causes for discrepancies between ideals and practice and why attempts to change practice may not be received wholeheartedly.

The chapter closes with additional speculations on the changes which should be considered in the teacher education component of the profession. Roles, obligations, competencies, commitments, and perceptions of teachers of teachers and of teachers of teachers of teachers may need to change radically if the profession wishes to achieve its ideals.

IDEALS — THE ISSUE IS SHARPENED

A review of recent industrial arts history reveals the existence of the ideal that an important component of intelligent citizenship can be fostered by industrial arts. Because of his historical importance as a progenitor of industrial arts, Woodward's (1890) recitation of the objectives, or fruits, of Manual Training are cited. One objective, Intelligent Citizenship, if achieved, would produce

> (a) People well versed in the principles which underlie the mechanical operations of a majority of our citizens are much more likely to take an intelligent interest in the people themselves, in their condition, and needs . . . (b) They are more likely to discuss questions of public improvements with judgment . . . (p. 147).

Shortly thereafter, John Dewey (1899) advocated that intellectual development of youth can be most effective if offered within a context that paralleled real life activities within real institutions of society. Woodward and Dewey are not considered specialists in industrial arts.

Their thoughts became models for statements which permeated the eighty or ninety years between their time and the present. A series of ideals for the profession emerged around concepts of social moralism, social reconstruction, technological literacy and social efficiency. Although the terminology used today is different, the message has remained: Industrial arts could and should impart an understanding of society influenced by technology as observed in industrial organization and practice. Industrial arts studies impart understanding of technological society and prepare the individual to participate within that society in order that technology may be controlled or used to promote human and democratic ends. The theme is carried forward by Bonser and Mossman (1923), and later Warner in his report *A prospectus for industrial arts in Ohio* (1934). Even the statements of the past 15 years do not deviate from the earlier ones. Rather, advocates of curriculum change seem to be saying, "We accept the ageless values, but we suggest a better way to achieve them."

Some Additional Views

Others have enumerated ideals that they discerned in industrial arts instruction. Bode (1942), a philosopher like Dewey, echoes the ideals of 50 years when he offers ". . . the general proposition that the teaching of industrial arts should be as much a process of shaping social outlook as it is anything else . . . that a student has not studied industrial arts . . . if he had not acquired some convictions with respect to the social reconstruction which is necessary . . ." (pp. 8, 9).

Kranzberg (1964), an established historian of technology, who studied the structure and aspirations of industrial arts education, charges the profession with the responsibility for (what may appear redundant by now) developing technological literacy of youth. It is incumbent upon the practitioners – teachers and teacher educators, Kranzberg says, to realize ". . . the social significance of the Industrial Arts in society and to transmit a sense of the value and worth of participation in the technological process . . . And, you can prepare your students to meet the problems and challenges posed by our dynamic technology" (pp. 11, 12).

Bernardo (1970), the National Aeronautics and Space Administration's Educational Programs Division Director, reinforces the already established theme of . . . industrial arts as a curricular area which chiefly develops . . . "a technological literacy among our young people." As science education is designed to create scientific literacy, Bernardo sees industrial arts education helping students to understand technology as a new dynamic force which . . . is having profound effects on our society" (p. 14). Similarly, Littleford (1974), a professor of educational theory, finds that the title *Man/Society/Technology* of the journal of the American Industrial Arts Association and the association's definition of industrial arts are anti-dualistic and interdisciplinary and "... compatible with the goal of pursuing a humane technology..." (p. 142). Finally, an inheritor of the Bonser-Mossman tradition continues their 1920's theme in the 1970's. In the elementary school, Scobey (1977) tells us, "... we can... help children trace technological change and analyze its influence on our lives" (p. 17).

That expressions of concern continue is reflected in two articles in a recent issue of *Man/Society/Technology.* Zaner (1979) presents several compelling arguments in support of the necessity for industrial arts to make a most important contribution to the needs of students in today's society. The need to develop within our citizens the ability to evaluate and understand our technological society is so primary, he suggests that is the profession does not respond . . . "another mechanism will be created that will, and we (the profession) will become even less than we are now" (p. 17).

Lux (1979) continues in this way as he responds to an earlier suggestion made by Feirer (1979) in *Industrial Education.* The field is wandering from its objectives, Feirer declares, and this is due to the abundant curriculum innovations which seem to be saying different things to different people. Feirer suggests going back to basics which Lux rejects. Reviewing some primary cultural concepts of technology, Lux claims that the back to basics movement is more threatening to industrial arts than a mere throwback to the materials and process emphasis. The advocates of back to basics are not likely to see any value in industrial arts *old* or *new,* he cautions, because they may not see either as basic and:

> It is especially urgent for industrial arts to be aware of the crisis posed by the back to basics movement. The field generally is in a weak position for defending itself. Our prolonged non-response to clearly needed changes has left us with a program which in most cases we cannot persuasively argue is a part of present-day basics. Only those of our programs which realistically can claim to contribute substantially to providing technological literacy for the 1980's and beyond are in fact basics. Others can expect to be and ought to be terminated.
>
> If industrial arts moves quickly, clearly presents evidence of the need for technological literacy, and provides programs which can be judged to be responsible to the need (the new basics), the current situation can cause industrial arts to prosper. More importantly, we will have helped to meet one of the essential educational needs of youth — the need for technological literacy (p. 26).

The ideal has also been confirmed by professional organizations — the Industrial Arts Division of the American Vocational Association in a revision of its *A Guide to Improving Instruction in Industrial Arts*

(1967), the American Industrial Arts Association, and in the various publications of Epsilon Pi Tau, the International Honorary Professional Fraternity for Education in Technology.

Others within the profession have tried to remedy the situation along with Lux. They have tried to impact upon relatively unchanging practice which Lux calls a non-response in order to achieve the ideals expressed in the foregoing.

PRACTICE

Eighty years ago Dewey (1899) virtually forecast the emergence of industrial arts when he announced that the primary purpose of manual training should not be tool skill mastery or making certain objects. Today, "industrial arts" replaces "manual training" but the practice he wished to de-emphasize remains dominant.

For a variety of reasons, practitioners, teacher educators, and public school teachers continue activities which visionaries like Dewey and other leaders in the field have criticized for almost a century. The nature of practice in the field can best be determined by its results. Undoubtedly, meaningful conclusions about practice should be based upon observations of the behavior of youth and adults who have experienced industrial arts instruction. This is beyond the scope and resources of this reporter for purposes of this chapter. However, it is possible to characterize practice in other ways. Results of activities and the organization of the profession can be observed. It is possible to review reports and comments about public school and teacher education curriculum structure. Some products of student learning can be observed. Publications which serve the field can be reviewed and analyzed. These forms of evidence reveal practice that is largely discrepant with the ideal. On the other hand, several individuals and groups have pursued their professional practice through curriculum innovation to change the activities of the profession. Their efforts are a counterpoint to the largely static portrait which follows.

Publications

The nature of practice may be deduced from the textbooks that are being marketed for use on the elementary through high school (read also industrial arts teacher education) levels. More color inside! Better designed covers on the outside! With very few exceptions, the content is not much different from the texts of 20 or 40 or 70 years ago. It is true that there may be more texts which cover additional areas of industrial arts and there are occasional innovative publications like Wright and Jensen's (1976) work on *Manufacturing*. What distinguishes most new textbooks is not the publisher's and author's attempts to include content and experiences which respond to technology/society problems and issues – but rather an up-dating of content usually dealing with specific processes or industrial categories.

Textbook advertisements (Ohio Industrial Arts Association, 1979) of two prominent publishers typify the situation. Both include books on drafting, woodworking, metalworking, and electricity. One publisher also announces a book on home maintenance, one dealing with electricity and another covering metric practices in drafting. The other publisher offered graphic arts, plastics, power mechanics, and photography texts. These topics seem to perpetuate a trade and job analysis syndrome or a materials and processes emphasis which leaders in industrial arts have criticized over the years. The titles also continue to reflect an absence of a well-reasoned content classification system. But publishers publish what sells and it appears practitioners continue, in large measure, to purchase "traditional" materials and only to a lesser degree "innovative" educational materials.

The "traditional" process or material oriented textbook, of course, has its place . . . at least that sort of *content* may remain relevant. It is not inconsistent to expect students to achieve skill with tools and machines in working with materials in industrial arts in order to accomplish other objectives. Books with such content seem to continue to transmit an essence of industrial arts education which is unacceptable to leaders of the profession. This is also true of the journals which serve the field.

While articles on career education and articles by proponents of advanced curriculum concepts do exist, journals such as *Industrial Education, School Shop* and *Man/Society/Technology* continue to reinforce traditional practice. The industrial arts teacher is more likely to be attracted by the how-to-do-it kind of article, be it on laboratory organization, a new process, or about a project students can make. Some articles in these categories may enable the teacher to reorient content to achieve the technological literacy ideal. Most articles remain related to objectives of technical skill and manipulative skill, with technical information limited to specific materials and processes.

Curriculum — Public Schools

Most members of the profession know that industrial arts has roots in the woodworking, metalworking and drafting of another era. Today, one would expect that a curriculum area based upon the technology of industry would reflect change in industry and in its practice. But through the sixth and seventh decade of this century there has not been significant change in curriculum. Schmitt and Pelley (1966) report that in the 1962-63 school year 82.5 percent of the students who studied industrial arts enrolled in general industrial arts, woods, drafting and metals. In his follow-up study conducted during the 1972-73 school year, Schmitt (1976) reports a significant increase in total enrollment but that 63 percent of the total were enrolled in the same four courses. While this represented fewer students in these courses by 19.5 percent, the courses to which they gravitated were primarily an expansion of materials and processes courses and only modestly represented courses devoted to wider consideration of technology.

Curriculum — Teacher Education

The source of the problem of curriculum response to ideals may very well lie in the teacher education program. All things considered, these programs harbor the essential leadership group. While the nature of responsibilities of this leadership group are addressed in more detail later in this chapter, the following helps to characterize practice in teacher education.

An analysis of the *Industrial Teacher Education Directory* (1978) reveals that over 80 percent of the teaching areas other than those dubbed "professional" or "graduate" continue to be either trade, material or process oriented. These teaching areas certainly depict confusion within the profession. Whatever the cause, the image suggests that teacher education is not organized to achieve the technological literacy ideal.

Industrial arts teacher educators do use the term "technology" in many forms, perhaps to give credence to their function. The *Industrial Teacher Education Directory* (1978) also uses titles to describe academic units which offer industrial arts teacher preparation programs:

Industrial Education and Technology
Industrial Arts and Technology
Industry and Technology
Engineering Technology
Industrial Technology
Technology Education
Applied Science and Technology
Engineering and Technology
Technology (Dept. of, Div. of, School of, College of)
Science and Technology
Scientific and Technological Studies
Vocational Education and Technology

On one hand, the titles communicate practices which may be extremely diverse. On the other hand, they seem not to be consistent with the aforementioned teaching areas which are listed in the directory.

These diversities are not new to teacher education. Ten years ago industrial arts became involved in the scurry to improve curriculum.

NDEA Institutes offered by industrial arts educators reflected the variety of directions in the field. In their titles alone, shown in Fig. 3-1 (Streichler, 1970), they seem to wander over a spectrum of areas and topics and reveal: (1) continued offerings in materials and processes, (2) emphasis on certain industries or elements of industrial technology, construction and manufacturing, and elements of technology in general.

While a direction toward the achievement of the ideal of technological literacy in these institutes may be discerned, the *Industrial Teacher Education Directory* a decade later seems to say that not much movement has occurred.

Student Behavior Products

The conclusion that inertia prevails is reinforced when one examines the student behavior products which result from public school and teacher education practice. As we look toward the 1980's, it is still possible to visit any state, regional or national convention in industrial arts, confident that projects which represent the "traditional" trade, materials, processes areas will be on display. Though beautifully crafted and representing a high degree of skill achievement with tools and materials, the projects do not reflect the essential learnings advocated as the primary mission purpose of industrial arts – technological literacy.

Major changes in manufacturing, construction, and processing systems, as well as in communication and transportation systems, have not been reflected in industrial arts. The orientation toward woodworking and metalworking has been maintained. Journals and textbooks serving the field have focused on the design and construction of custom projects made from wood or metal, generally for personal use, the home, or the shop.

Practice in the profession seems to have resulted in curriculum design based upon "omission by choice," according to DeVore, Maughan and Griscom (1979). This makes industrial arts an interpreter of hand processes in manufacturing industries to the exclusion of the study of all other technological systems. The skill that is taught remains within the curriculum long after the skill or procedure became obsolete in reality. Further, these observers hold that industrial arts curricula have been bypassed by advances in technological systems and the industrial arts profession has been slow to respond to change. It has offered too little, too late, to meet the real needs of students as citizens in a highly complex technological society.

DeVore is one of a small group of educators who has worked diligently to move the profession toward achieving the technological literacy ideal.

Administration
Aviation, General and
Transportation
Automation and Numerical
Control
Computers, Digital
Construction
Creativity in Industrial Arts
Curriculum Development-
Secondary School (2)*
Curriculum Development (4)
Curriculum Development,
Junior High School
Industrial Arts (3)
Curriculum, Junior-Senior High
Industrial Arts
Some approaches have been developed under such topics as:
____ Visiting Industry
____ Anthropological
____ Group
____ Individual
____ Line Production
____ Personnel Development
____ General Shop
Drafting and Design
Drafting and Graphic Arts
Electricity/Electronics (5)
Electronics, Graphic Arts &
Drafting
Elementary Industrial Arts
Fluid Power, Integration of ____
into Energy and Propulsion
Systems
Graphic Programs
Industries, Laboratory of
Industry, American (2)
Industry, Contemporary
Industry, Ferrous – Study of
Industry, Interpreting –
Small School
Industry, Interpreting –
General Shop
Inner City Industrial Arts
Curriculum (2)
Leadership Institute,
Industrial Arts
Manufacturing
Manufacturing Industries and
J.H.S. Curriculum
Materials Development
Manufacturing Industry,
Function of
Materials, Industrial
Mentally Handicapped
Metal working
Metalworking Technology (2)
Occupational Information,
Developing
Plastics
Power
Science and Engineering
(New) Scientific and
Engineering Influences on
Industrial Arts Education
Supervision of Industrial Arts,
State
Systems Analysis
Technology, American
Technology, Space Age
Technology, Wood (2)
Transportation
Visual Communication
Visual Communication,
Automated

*Denotes number of institutes under this topic.

Fig. 3-1.
Titles of NDEA Institutes for Advanced Study in Industrial Arts
Summer 1966, 1967, 1968, and 1969

Curriculum Revision Practice

Those who wish to see change in traditional practice may be dismayed by the preceding evidence on practice. On the other hand, the curriculum revision dynamics in industrial arts may offer hope and optimism. While the rationale of one proposal may contend with another; while content which is recommended in one appears inconsistent with others, all attempt to respond to the technological literacy ideal.

Some historical perspective relating to curriculum proposals seems desirable. One can trace many antecedents but one of Warner's (1965) works serves as a prime example. Warner and his students presented the results of a team effort at the 1947 convention of the American Industrial Arts Association. Several large divisions of subject matter resources, namely power, transporation, manufacture, construction, and communication and management, were proposed for industrial arts content. This certainly was one stimulus for industrial arts to reflect technology on all levels of education. Ten years later, Olson (1957) proposed eight major categories of industry which he identified as manufacturing, construction, power, transportation, electronics, research, services, and management; and, similar to the Warner team's effort, he identified subject matter groupings within the major categories. While this attempt resulted in an amalgam of products and materials, it too must be regarded as a significant effort within the field and a precursor of present-day efforts.

In the 1960's, several proposals attacked the industrial arts curriculum problem. Ziel (1962) proposed the study of the world of work, its dominant technologies, and its complex social interrelationships as a program for secondary school industrial arts. Elements of general shop activity, a study of selected technologies, and subject matter related to finance, psychology, and sociology were highlighted.

The Functions of Industry approach was somewhat more clearly defined than Ziel's proposal. Bateson and Stern (1963) and Stern (1964) sought content from the goods-producing and the goods-servicing branches of industry. Functions and sub-functions within the major branches were identified and organized around a sequential set of concepts.

In another proposal, Yoho (1964) applied the Systems Network Analysis Process and developed SNAP MAPS or models. From a model of the total functioning society he extracted an Industrial Communication Arts SNAP MAP, from which the curriculum content for industrial arts could be derived.

Two curriculum projects attempted to refine some of the earlier work and eventually implement programs in schools. The Industrial Arts Curriculum Project (IACP) (Towers *et al.*, 1966) delimited and defined the subject matter of industrial arts with a view toward organization for instructional purposes. The supporting rationale for the project suggests that there is an area of man's knowledge into which the study of industry appropriately fits and that a body of knowledge which pertains to industry *per se* can be identified and separated. Some of the content which has been judged appropriate in the past is rejected as being more relevant to other disciplines and, when applied to industrial arts, is viewed as creating confusion in philosophy and practice. Essentially, the research workers on this project viewed the subject matter of industry as limited to the theory of man's practices in the transformation of materials by man and machine through the two major divisions of industry, construction and manufacturing. Knowledge of man's practices about these two major processes can be extracted and organized to form the content of industrial arts. Consequently, they differ with those who suggest that the content of industrial arts should include such areas as transportation, marketing, or banking and finance as major concerns of industrial arts.

Face and Flug (1965) directed a major curriculum development effort called American Industry. American Industry is seen in a broad context; all areas of subject matter directly related to industry (*all* knowledge used by industry, not only industrial knowledge as defined by IACP), and which in turn affect humans, seem to be judged pertinent for consideration for inclusion within the curriculum. Their pedagogical approach is based on concept teaching and learning, as is the IACP program. This represents recognition by industrial arts leaders of recent findings of educational psychologists and of awareness of curriculum directions in other disciplines.

Schwalm (1966) worked on a conceptually-oriented and interdisciplinary curriculum at Western Washington State College. He selected one of the traditional areas of industrial arts, the graphic arts, and enlarged this area conceptually. He sees visual communication as the organizing agent for his concepts. Concepts apply to the conception, development, production, use, and evaluation of the effect of any type of visual communication in such a way that once understood for one type they aid in understanding all forms of visual communications. The curriculum development results are underway in many schools all over the United States. Something equivalent to a general education track, a pre-vocational track, and a pre-technical track leading into a junior college are offered and the curriculum has been fully implemented on the college level and serves over 400 majors at Western Washington State College alone.

Maley and Keeny (1962) suggest that industrial arts as general education should be oriented to the talents of different students. To demonstrate this view, a program of research and experimentation for high ability junior high school students was developed. This was based on activities and content derived from research, experimentation, and development functions of industry in the belief that students having a scientific or mathematics orientation could do well in laboratory work which reflected this industrial activity. This program was established and piloted in some schools of Montgomery County, Maryland.

Others have commented on curriculum concepts and have attempted to order categories of industry, industrial technology, or technology: DeVore (1967) with production, communication, and transportation; Duffy (1970) with material processing, information processing, and energy processing; and Stadt and Kenneke (1970) with visual communications, materials and processes, energy conversion and power transmission, and electronics and systems.

Except for Maley's efforts, particularly his Anthropological Approach, the others tend very dramatically to de-emphasize crafts and tool skills development. Although creative needs of humans are recognized, they are conceived only within the creative problem-solving activities in the enterprise system.

Several of the projects mentioned earlier deserve more complete discussion because: (1) they have survived in concept and implementation for at least ten years; (2) they have received relatively wide attention in the profession; and (3) they have enjoyed careful conceptualization and development under stable stewardship. Leaders who began the effort remain with the project and remain accountable. For one or more of these reasons these efforts may be penetrating the wall of reaction and steadfast tradition.

Extraordinary vision, financial support, exemplary curriculum development technology, and superb staffing may account for the success of the Industrial Arts Curriculum Project. In the case of three of these innovative curriculum efforts or conceptualizations, the imagination and dint of effort of one individual and a modest size team has yielded results, usually without funding support. This is applicable to the DeVore/Lauda, and Maley's efforts as well as the successful implementation of Ziel's work in the province of Alberta, Canada. Ziel was in an excellent position at the University of Alberta to conceive a program to which other faculty and public school teachers of the Province of Alberta contributed much instructional development time and effort. In *Man, Science and Technology: An Educational Program,* Ziel (1971) describes the educational program he conceived to enable man to understand science and technology and make more intelligent decisions regarding their use. This contemporary version of industrial arts involves the materials and processes of technology. Ziel's intended outcome for students is knowledge of *options* and *alternatives* as well as of the consequences of their selections. His program, he ventures, will produce major contributions towards the technological literacy of future generations.

Part of Ziel's concepts were seen by participants at the American Industrial Arts Association Convention, San Antonio, Texas, February 25 - March 3, 1979, when elementary school youth, their teachers and university professors joined together in a program titled "Alberta's Kids."

Maley has attempted to bring together some ideals of instructional method and content in his *Maryland Plan.* Through active student involvement and empahsis upon problem solving, Maley reaches students not through particular content conceptualization, but by achieving positive effects upon the learner through a system that is sensitive to the learner's needs, interests, and aspirations at given stages of development. Some of the titles of major components of this evolving Plan for Junior High School are: The Anthropological Unit Approach to Teaching Industrial Arts, Group Project and Line Production, Research and Experimentation – and for the high school, The Application of Technology in the Solution of Major Problems Facing Man in the Future. Motivated by concern for students in society and the desire to equip them psychologically to develop cognitive skills needed to solve societal problems, Maley continues his work. He reaches teachers through his chairmanship at the University of Maryland, through workshops there and other parts of the nation, through periodical articles and other publications, and presentations at conventions (Maley, 1967 a,b, 1979).

However, the greatest impact upon industrial arts curriculum seems to have been made by the Industrial Arts Curriculum Project (IACP). It is believed to have reached more teachers and junior high school students than any other single effort in the history of the field. Lux (1979) reports that since the summer of 1970, about 8,000 industrial arts teachers have enrolled in IACP workshops in about 125 colleges and universities.

He adds that since its implementation, numbers of students have increased with about 350,000 children recorded in IACP courses in 1975-76. Between 2,700-3,000 junior high schools are believed to be using the IACP materials. Individual teachers have also been adapting parts of the IACP program and incorporating them into existing courses and since this is likely to continue for some time Lux believes it will have some impact upon traditional industrial arts content. The IACP effort is characterized as a "more relevant educational experience with the technological practices used by people to satisfy their material needs and desires (p. 149.)"

DeVore and Lauda have concentrated on reconceptualizing the goals of the profession. They have achieved considerable recognition and enjoy the respectful attention of their colleagues. While they have not yet produced much hard curriculum materials over the years, DeVore (1964, 1970, 1979) and Lauda (1978, 1979) have most effectively articulated a basis and rationale for industrial arts to assume its appropriate role which according to them requires technology as the content base.

The commercially produced materials resulting from the IACP effort and similar materials produced by competing publishers contrast with the titles of textbooks noted earlier in this chapter. Likewise Ziel's and Maley's efforts have yielded instructional materials very different from the "traditional" texts. In this sense also, they are exceptions. DeVore at West Virginia State University and Lauda at Eastern Illinois University have not yet produced text materials for use in the public schools. DeVore (1977) is heading a major publication effort involving a number of authors. This project has the support of a major publisher and material should be available in the second half of 1979. Given the nature of industrial arts practitioners, this class of publication should be welcomed. First because it will put in concrete form the abstraction of DeVore's bold conceptualizations. Second, the process of curriculum dissemination, adoption, and diffusion can move forward through these textbooks. The field will have an opportunity, then, to determine whether the technology discipline base will be adopted.

It is difficult to assess the true impact of these curriculum projects. For example the 8,000 teachers who are reported to have enrolled in IACP workshops represent about 10 percent of the total number of industrial arts teachers in the United States. It is uncertain whether all who experienced workshops actually teach what they've learned. On the other hand, it may be assumed that others who have not attended workshops are teaching IACP content. After adding the cumulative impact of these curriculum efforts . . . it may still be possible that as much as 80 percent of industrial arts teachers remain wed to instructional activities which these efforts have tried to change.

Professional Organizations

The effectiveness and roles of the American Industrial Arts Association and the Industrial Arts Division of the American Vocational Association must be raised also. Throughout the decade of the 1960's, these organizations were active in modernizing and organizing programs. Industrial arts' affiliated organizations did not play a leading role in any significant curriculum development project but they did provide forums in which new ideas were shared. They also worked in an evolutionary mode, with committees of professionals devoting time and energy to upgrade standards for programs and rewriting rationales and objectives.

A significant revision of *A Guide to Improving Instruction in Industrial Arts* (American Vocational Association, 1968) is a noteworthy contribution to updating industrial arts program expectations.

Yearbooks of the American Council on Industrial Arts Teacher Education also covered relevant topics during several years.

The continuing preoccupation of industrial arts with technology is reflected in conference themes of the American Industrial Arts Association over the past ten years:

In 1970, Man/Society/Technology;
1971, Industrial Arts and Space Age Technology;
1972, Industrial Arts in a Changing Society;
1973, Industrial Arts and the Challenge of the Urban Society;
1974, Industrial Arts and a Humane Technology for the Future;
1975, Essential Developments of Industrial Arts;
1976, Industrial Arts at the Crossroads;
1977, Industrial Arts: Which Way Now?;
1978, Industrial Arts: Youth's Gateway to the Future; and
1979, Industrial Arts: Preparation for Life in a Technological World.

Obviously, there has been ongoing interest in and concern with Industrial Arts in the context of the technological society that is its environment. Lemons (1973) states that these concerns:

> ... indicate dynamic, positive attitudes for industrial arts educators. They further suggest a sensitivity to the environment in which we live – a searching for the most critical needs to be met through education. This has been the history of Industrial Arts. Just as the world in which we live has become more complex and technically sophisticated, so has Industrial Arts continued to change and to meet the challenge (p. 373).

In the face of these apparent dynamics, the Executive Director of the American Industrial Arts Association provides information that less than 10 percent of the nation's teachers belong to national organizations (Rathbun, 1979). Since membership rolls of both AIAA and the Industrial Arts Division of AVA include a significant number of post-secondary teachers, the number of public school teachers involved may be lower than Rathbun's estimate.

Obviously, there has been change in industrial arts – more ferment and curriculum conceptualization, more actual implementation in schools in the past 15 years than in all the years preceding the 1960's. Yet, one cannot escape the feeling that the general public still perceives industrial arts as a prevocational or even vocational type program or perhaps, as in England, as a general education program in crafts. In spite of highly sophisticated philosophizing, in spite of relative agreement on mission and goals of the profession (at the highest levels of the profession) industrial arts does not yet function as most leaders would like. Large numbers of practitioners, the persons really on the firing line, seem to disregard the entreaties, exhortations, commands, and pleas of the leadership. Practitioners continue to teach as they have been taught and apparently students, parents, and public school administrators seem to, if not love it – accept and support it. If that were not the case, there would have been far less evidence of the kind presented on practice. The more difficult questions remain to be answered . . . Why the discrepancy exists and assuming the technology/society emphasis is proper, what must be done to remove the discrepancy.

WHY THE DISCREPANCY BETWEEN PRACTICE AND IDEALS?

The heading of this section may be a point of argument. Many practitioners could be offended at the suggestion that their practice does not conform to ideals. Their response could include an exposition of the ideals which they believe they meet in their practice. This hypothetical issue cannot be argued here. The point, however, is that while objectives or ideals which are acceptable to some practitioners are being achieved, the practices portrayed in the preceding sections seem to say that we are not aiming to achieve the ideal of preparing individuals to cope with technology/society issues.

This section speculates on this discrepancy. These issues have also been debated and discussed in the literature. Ideals and practice remain inconsistent because:

1. the "technological literacy" effective citizen goal may not reside entirely in the domain of industrial arts;
2. the profession may have failed to gain public acceptance that industrial arts is the appropriate curriculum area to accomplish technological literacy education;
3. the profession has been ineffective in overcoming school curriculum inertia;
4. within the profession there is disagreement about goals and objectives; and
5. public school teachers may not be properly motivated to accept and implement innovative curricula because teacher educators have not been proper role models.

Examples taken from concerns in science education amplify points 1 and 2.

The Technological Literacy Ideal and Public Acceptance

The Education Section of a Sunday Edition of the New York Times devoted several pages to the problems of science education in the United States in Spring, 1979. Industrial arts educators could regard the discussions in two ways. They are comforting if one takes pleasure in observing a display of concerns and patterns in another field which very much parallels conditions and trends in industrial arts; foreboding to the industrial arts educator to learn that science educators' definition of and concern with "scientific literacy" seems to overlap considerably with industrial arts' concepts of "technological literacy." Here are some examples:

1. Fiske (1979a), reports that the chairman, National Endowment of the Humanities, observes that "scientific literacy" depends not only on increased knowledge of science on the part of the general public but also on better training in fundamental skills such as "the capacity to detect logical connections." "When you talk about something like the acceptable risks of nuclear energy you're talking about values, . . . It's not only how much physics you know but whether you have access to a philosophical tradition and a body of allusions that allow you to transcend technical conversation. This is where training in literature, languages, and the classics is as important as training in science. The most important tool is a critical attitude."
2. According to Smolowe (1979), science educators insist that the importance of "scientific literacy" is underrated. They stress that not only are most of the problems confronting society science-related, but that the basics can be taught more efficiently by employing a scientific approach that emphasizes inquiry, discovery, observation, classification, and invention.
3. Michalak (1979) reports on a decline in achievement in science. Part of his article displays several "science" facts under the heading:

Percent of 17 Year-Olds Knowing Science Facts	
Cells are the basic biological unit	80%
Plastics are petroleum products	12%
Cars are the major urban polluter	37%
Kidneys remove waste from the blood	89%
All measurements involve error	12%
Keeping a nail dry will prevent rust	49%

What Browne (1979) says about scientific and technological literacy deserves direct quotation:

Something went badly wrong last month at the nuclear electricity-generating plant at Three Mile Island near Harrisburg, Pa. No one was injured or killed, but before technicians brought the malfunctioning reactor under control, central Pennsylvania had suffered severe economic loss, and millions of Americans had begun to wonder who, if anyone, was to be trusted in the debate over the safety of nuclear energy.

The incident drove home another fear to professional scientists: that most Americans, including many government leaders, politicians and news-gatherers, lacked the basic scientific insight to make intelligent assessments of what was actually happening. "The American educational system failed us at Three Mile Island," lamented one, "and we'd better try to learn something before the next crisis."

In today's highly technological society every American is faced with decisions that require scientific judgments – from personal decisions about the use of saccharin or birth-control pills to social policy on recombinant DNA, aerosol spray cans or the Concorde.

Many scientists fear that, if anything, the ordinary American is becoming less equipped than ever to make rational decisions on such issues. Their fears are essentially twofold.

First, they fear, most people do not have the scientific knowledge necessary to weigh the "risks" that are part of most such decisions. A housewife, for example, generally has no knowledge of the nature of the microwave radiation in her oven, much less whether or not it may be dangerous. A wage earner without special knowledge has difficulty knowing just how great a threat to his privacy is posed by computerized record-keeping.

"The human race has never had such bountiful technological benefits as today. But there has also never been a time when the technological risks were greater," a nuclear physicist said. "It is impossible to weigh benefits against risks without knowledge, and in a democratic society, that means knowledge for everyone, not just the experts.

The problem was dramatically illustrated at Three Mile Island. An entire population seemed for a few days to be floundering in a sea of unanswered questions and anxieties, and in an effort to resolve the problem, newspapers, radio, and television sometimes made misapprehensions even worse. One news agency described the material inside the core of the reactor as "brooding hell-fire," a phrase one scientist privately described as "pandering to panic."

Most scientists . . . agree that science and technology have reached the point where managing its consequences requires not only a rethinking of science education as it is now organized but also a reexamination of fundamental concepts of the scientific enterprise. "The problem is essentially one of national attitudes," said Dr. Richard C. Atkinson, director of the N.S.F. "But it is a profound and urgent problem for out entire society."

Does all this sound familiar? Clever substitution of words here and there and we have the issues and concerns of the industrial arts profession . . . content issues, curriculum issues, purpose, back-sliding issues are all there. But . . . even without substituting words . . . are these reports dealing with technology issues and facts? Isn't that the domain industrial arts has staked out?

Overcoming Curriculum Inertia

In the same article, Browne reviews the major curriculum development efforts in science during the 1960's and 70's. His conclusions may suggest what will happen (or is happening) to industrial arts' efforts during the same period. If the reader accepts the possibility that industrial arts curriculum efforts will go the way of the science efforts, it may be possible that the career education – or prevocational values that have been criticized by some in the profession may indeed be the primary reasons for our curriculum efforts to survive. The tough question may need to be raised . . . is it possible that reliance solely upon the general education values of technological literacy, so similar to the scientific literacy values described by Fiske and Smolow will insure the same fate for the industrial arts curriculum efforts as that suffered by the science "alphabet soup" ventures which Roberts (1979) reviews in the same newspaper.

Roberts adds:

> In the early 1950's with science and technology assuming an increasingly important place in modern society, the National Science Foundation set out to revolutionize the teaching of biology, chemistry, and physics in American high schools. The goal was to transform the focus of learning from the results of science – learning the names of the parts of a frog's mouth, memorizing chemical formulas, or reading about Newton's laws in textbooks – to the way scientists function.
>
> The vehicle was a series of new curriculums that, like the "new math," reflected the view not only of educators but also of high-ranking people who worked in the disciplines involved. The programs bore weighty names like Physical Science Study Committee (PSSC) and Biological Sciences Curriculum Study (BSCS) and soon became known in the trade as the "alphabet soup" curriculums. By the time they were completed the total bill for the federally supported National Science Foundation was $100 million.
>
> What have been the results of this massive enterprise? A quarter-century later the consensus among teachers and supervisors is that, by and large, the new curriculums promised too much. "They were great for the very best students, but they weren't appropriate for the other 90 percent" said Willard Jacobson, chairman of science education at Teachers College, Columbia University.
>
> The failure of the "alphabet soup" curriculums is one of the minuses in the mixed picture that characterizes science education in the high schools now.
>
> Other elements are:
>
> *Teaching has largely slipped back into reliance on textbooks, lectures, and student recitation rather than direct experience.

*Most students – 85 percent by some estimates – are not being drawn into science even in a nontechnical way, and 50 percent take no science courses at all beyond the 10th grade.

*Blacks, Hispanic children, and other minorities – and females – are not performing much better in science education than they were 20 years ago.

*Many teachers are, or feel they are, unprepared to teach on the level called for by the programs.

The "alphabet soup" curriculums tried to change science education by incorporating the latest findings in major disciplines into textbooks and by suggesting teaching techniques that would break the reading-lecture-recitation mold and give students more laboratory and field work. They tried to stimulate students to think not just about the *what* of science, but about the *why* as well.

But the programs began to slip, and the slippage accelerated during the Vietnam years. An antiscience attitude combined with the back-to-basics movement gave science a back-burner priority.

A recent study of pre-college science by the N.S.F. found that most classrooms had gone back to where they were when it all started.

. . . During the post-Sputnik years thousands of teachers enrolled in training sessions to help them with the new curriculums. As the curriculum programs themselves languished, so did training. And, recently, training funds were severely slashed by Congress.

As a result, said Marcile Hollingsworth, science coordinator for the Houston district, "We are getting teachers with narrow backgrounds. We find biology people have little knowledge of earth science, and we need them for our life-science earth-science combination.

There is yet another similarity in the problems of the science and the industrial arts curriculum efforts and that is the problem of adoption of curriculum innovation. The courageous teachers who accept new curricula and undertake its implementation need considerable reinforcement and support over a period of years after first implementation. They may not have gotten such support which is absolutely necessary in the conservative climate of the public schools. This is particularly true in times of economic exigency when it becomes more difficult to justify something "different" – although better – if it costs slightly more money. In recent years, the inhibiting effect of financial exigency upon curriculum innovation has been increased by the back-to-basics movement. Thus, anything appearing costly and which may not immediately appear to improve student's abilities in basic communication (reading, writing, and speaking), and basic computation (arithmetic and some mathematics), is likely to receive little support from educational decision makers (as in the foregoing case in science education).

Confusion About Objectives

Debates about objectives may ultimately yield enlightenment; the positions that leaders take may account, in part at least, for perpetuating certain forms of practice. Obviously, it is more difficult for individuals to choose between contending points of view. There are so many points of view – it is not a matter of choosing between two or three. A brief review of recent (20 years) history illustrates this point.

Some discussions concerning the relationship of industrial arts and vocational education revolve about particular or specific objectives of industrial arts. The guidance goal of industrial arts was not overlooked in the analyses of industrial arts objectives. An example of this view is found in the work of Bateson and Stern (1963) who stress the importance of the guidance objective. The gap between the world of work and industrial education can be bridged if this objective of vocational guidance is kept in mind. They suggest that this objective can be met if proper exploratory experiences in the functions of industry are provided in the school shop and that these would prepare the student to deal more effectively with the problem of occupational choice.

Stadt (1962) and Moss and Stadt (1966) bridge the topics of objectives and philosophy. They suggest that the function of secondary education should be solely general education and the industrial arts, in order to be included in the secondary school of the future, must take on more of the attributes of general education. Some objectives dealing with the development of manipulative skills in the junior high school have been unrealistic, they declare, because students at that level have not attained the neuromuscular development required to master such skills. At the junior high school level, students should have first-hand laboratory experiences with various worker roles as they may be extracted from industrial functions. At the high school level, the study of industry would take on a more abstract, generalized form with possible integration and coordination with the study of business, distribution, and agriculture.[3] They reject the prevocational aspects of industrial arts and observe that the major benefit derived from programs of a vocational nature by most high school students is the general education they accumulate as a result of increased time in school.

Some of DeVore's (1964) views have roots in earlier statements like those expressed in the 1947 proposal by Warner (1965) and those of Olson (1957). DeVore (1964) suggests that industrial arts may have reached the point of maturity where it could organize its knowledge on the level of a discipline and that this knowledge be organized about technology. He defines discipline and technology and points to those

[3]More recently Stadt shows that he does not believe that industrial arts can do this (c.f. pp. 38, 89).

aspects of man that are related to technical endeavors. These aspects – man as a builder, a communicator, a producer, a transporter, a developer, an organizer and manager of work, and a craftsman – would provide the themes around which content for industrial arts would be organized. Micheels and Sommers (1958) directed a staff study at the University of Minnesota which may be considered a benchmark with respect to philosophy and curriculum of industrial arts. While there is little evidence that this program has been implemented, the report itself has significance and may also be considered one of the stimuli for later curriculum development efforts. Out of generalizations concerning a probe of the future, specific assumptions were made by the Minnesota team relating to the social, economic, and technological forces at work which would affect education and industrial arts education in particular. A curriculum for industrial arts teacher preparation was suggested with three cores of experience: (1) science-mathematics, (2) technology, and (3) design. A coordinated flow of experiences between the three areas which would carry over into the professional and so-called general education areas of the teacher education curriculum was recommended.

Svendsen (1961) observes that theory and practice within industrial arts do not completely exploit the potential of the curriculum. Although industrial arts does reflect a vocational emphasis handed down from manual training, a liberalizing emphasis resulting from the Dewey-inspired philosophy, contending with this vocational emphasis, results in a closer relationship between reflective thought and action. Only selected portions of Dewey's theory have become a part of the new industrial arts, according to Svendsen, and there remains a dominance of physical activity over reflective thought. A combination of reflective thought and physical activity is necessary for a liberal study of industry, and an investigation of its technology by problem-solving methods will resist any force which seeks to confine the theory and practice of industrial arts to trade and fabrication activities and knowledge.

Kagy and Miller espouse what may be considered traditional values. Kagy (1967) explored the impact of social and technical forces in contemporary society. He recommends a set of purposes which would include the "arts" in industrial arts. His objectives include: providing opportunity for genuine creative expression to develop the individual's creative potentialities; developing an understanding of the aesthetic evaluation of the environment; enriching the individual's experiences through an understanding of art forms; and increasing the individual's understanding of the arts of the past. Kagy emphasizes the role of the teacher in providing experiences to build student background, which in turn provides the basis for creative expression in industrial arts.

Miller (1968) rejects the point of view that industrial arts should serve only to provide those common learnings needed by all students, or that industrial arts could be adequately defined simply by calling it a phase of general education. He proposes that industrial arts programs should serve five primary functions: interpretative, exploratory, technical competency, preparatory, and supplementary. In explaining these functions, Miller indicates that industrial arts should assist youth to gain a realistic understanding of industry, and should offer students an opportunity to explore tools, materials, processes, and products. Students should have the opportunity to acquire technical competencies as a contribution to self-realization. High school industrial arts programs should serve three preparatory functions: preparation for post-high school education; pre-vocational preparation; and general occupational readiness. In addition to these unique contributions of industrial arts, Miller recommends that the programs supplement other school subjects in the application of knowledge, the development of planning ability, sound work habits, desirable personal and social traits, and the leisure-time application of competencies acquired in the school.

"Traditional" views or perceptions continue to emerge. Two investigations provide insight into how industrial arts is perceived and the problems such perceptions create.

A sample of community leaders ranks the importance of statements about seven facets of the industrial education program in a Q-sort study by Zullinger (1968). The image of industrial education was not especially clear to the participants, who indicated a need for more adequate information about the program. Opinions obtained from a sample of industrial arts, home economics, and business education teachers indicated that industrial education had a lower-than-average status. Zullinger offered several suggestions to improve the image of industrial education and to develop a systematic approach to change the attitudes of the public. Curriculum improvement was considered to be a vital ingredient of the total process.

Backus (1968) investigated the relative importance of the objectives of industrial arts. Statements of student behavior characterizing "ideal" attitudes, concepts, skills, knowledges, appreciations, and values were used to prepare a Q-sort instrument. Industrial arts teachers, coordinators, and superintendents were asked to rate the importance of the student behaviors. Using the data from this and other related studies, Backus compiled a priority order of perceived importance for nine objectives of industrial arts which he used to prepare the statements of student behavior. The composite emphasis indicated as desirable was: (1) habits of orderly performance; (2) shop skills and knowledge; (3) drawing and design; (4) appreciation and use; (5)

health and safety; (6) interest in achievement; (7) cooperative attitudes; (8) self-realization and initiative; and (9) interest in industry.

A questionnaire including 130 statements of beliefs was submitted to a state-wide sample of industrial arts teachers and teacher educators and to nationally prominent industrial educators by Kachel (1967). The three groups were in general agreement on the importance of statements dealing with objectives of industrial arts and appropriate methods of teaching the subject. It is important to note that the recorder advised that the responses did not allow identification of clear-cut patterns of belief with regard to course content and the industrial arts curriculum, or in the evaluation of student progress.

While there appear to be profound differences between leaders, individuals remain rather consistent over the years. Lux has argued against traditional content classifications and against virtually anything which would cause industrial arts to deviate from the goal of technological literacy which he considers foremost.

Thus, Lux (1977) argues against career education

> Career education, like the pursuit of the matehmatics-science integration which preceded it, is not the ultimate development for industrial arts. The only viable long-term goal is one which provides industrial literacy for all to a level which enables mankind to democratically and intelligently use and control humanistic industrial technology which alone can satisfy personal and societal wants for economic goods and for services to those goods, for this generation and for the foreseeable future (p. 11).

While Stadt (1974) agrees with Lux that industrial arts cannot contribute to career education, he also takes a strong negative position regarding industrial arts' adequacy to do what Lux thinks it can accomplish – a position that seems to communicate his frustration and disappointment that industrial arts has not redirected itself.

> To be enlightening and democratic, the career education component at the junior high level must foster exploration *for individuals* across-the-board of human roles in the world of work. Of late, industrial arts has, at most, been concerned with human roles in manufacturing and construction. In fact, this narrow perspective is only a small part of i.a. (industrial arts) experiences. Hobby crafts probably supercede career exploration concerns in i.a.

Stadt continues:

> Contrary to what some self-appointed ideologists submit, industrial arts is not god-given. Witness the facts (a) that many schools function rather nicely without it and (b) that industrial arts has always been willing to hitch onto new foundations, e.g. organismic psychology, core curriculum, the Sputnik craze, the ecology movement, and, now, perhaps career education.

Finally, he concludes:

> A fourth alternative and the one I can accommodate most comfortably is to leave i.a. and homemaking to their non-career related ends and to fashion new curricula and differentiated professionals for career education at the junior high level. Knowing what I do of what is possible in career education, having evaluated a number of large and small school districts for the Illinois vocational education agency, and having more than a modicum of familiarity with i.a.'s one-boy-makes-a-project-from-start-to-finish-with-little-concern-for-procurement-or-marketing-or-sales, I think a fresh start would be best.

Stadt seems to tell industrial arts professionals that they reach for what they cannot and perhaps should not attempt to attain . . . Perhaps he is correct.

Negative Effects of Internal Criticism

The strong argument in support of the technological literacy function can be weakened when the neophyte tries to determine which rationale or strategy to use and he attempts to sort out the very different approaches. The proponents of these different strategies may not have assessed the impact upon the profession of the manner in which the issues are presented. Usually, advocates of a particular point of view appropriately engage in scholarly criticism. They demonstrate that there are content and method weaknesses, inconsistencies, and irrelevancies in industrial arts that they are trying to change. While this could be a wholesome approach and should ultimately yield positive results, the impact upon the practitioner can be totally negative. The newer curriculum proposals may be criticizing much that the practitioner has been trained to do and has probably been doing quite well. His response is not likely to be positive. This condition also applies to teachers of teachers as practitioners.

Competencies and Interests of Teacher Educators

Implicitly and explicitly the philosophers and theorists of the profession criticize teacher educators' practice. They are being told that the things they were taught so well by *their* teachers of teachers – the skills, values, and competencies that they mastered over the years and are now transmitting to young teachers-to-be are void, unrealistic, and of little or no value. The natural reaction of a teacher educator so assaulted could well be different from what the curriculum revisionists intend. Rather than complacent acceptance of such criticism and of the new rationale, the teacher educator may resolve to do better that which he does . . . and to communicate the values, strengths, and contributions that *his* approach has for youth and society. If the leaders of the profession really intend for change to occur and take permanent root, they must deal with this issue – perhaps as a first order of priority. The powerful modeling influence of the teacher of teachers must be taken into account. The teacher-to-be is likely to be highly impressionable and in late adolescence or early adulthood and may be seeking to model after someone . . . often the teacher educator. Ripe for modeling then are the latter's erudition, humor, manipulative/technical skill, (how many teacher educators use their special bundle of manipulative/technical skills to start classes and win the hearts and minds of their students?) and attitudes. All this could be summed up under the term "credibility." The person who is being prepared to teach is not likely to be impressed by or fully accept a technological literacy function . . . and be committed to carry it out if the role model he has come to respect does not manifest behavior that is consistent with the ideal.

Thus, even if the teacher educator verbally and intellectually accepts the new rationales, even if he talks about and advocates new curricula – if he continues to demonstrate satisfaction and enjoyment in traditional industrial arts activities, his students are likely to do as he does and not as he says. Lauda (1978) comments on one manifestation of this condition:

> It has always been interesting to me to see that industrial arts teachers have little trouble in engaging in dialogue with their colleagues about new inventions. Some even entertain such concepts as invasion of privacy, finite resources, mining of the asteroids, etc. Yet, when they enter the classroom such topics are shelved. It is as if they have a sergeant in their pocket bellering, "About-face." There are also those who get involved in discussing the impact of technology but see their role as entertaining ideas solely in graduate classes or in a single general education course. Within these courses they cover such topics as interdependence and finite resources-infinite demands but consciously avoid them in their undergraduate courses.

Lauda's comment, considered with the aspirations of other leaders for new curriculum directions, suggests a concern about teacher education structure which may not have been adequately addressed by the profession.

Also as the move from trade classifications to industrial technology to technological processes is advocated, the leaders of the profession may also be assuming knowledge, skills, attitudes, and values objectives to which curriculum areas *other* than industrial arts may hold legitimate claims and may be in a better position to accomplish. Technology, when seen as a *cultural* force, lies in the domain of the social sciences. As an applied interdisciplinary field it is an extension of the disciplines within science and mathematics.

The foregoing is not offered as an argument *against* upgrading and improving industrial arts content and method. Rather it raises the caution that an entire professional cadre may not be adequately prepared to accomplish the new mission.

Teachers of teachers are likely to be more adequately prepared in a method of educational inquiry. That is, in fulfilling their scholarly obligations on the university level they are best prepared to research, write, and teach about content and instructional method. But this may not be the behavior most appropriate or suitable to establish credibility for the technology/society issues and concerns. The teacher in training may never experience, except through simulation or in other vicarious ways actual technology practice as can be experienced in engineering or applied science fields of study.

TO ACCOMPLISH THE IDEAL

The profession has experienced a wave of recommendations which call for significant curriculum revisions. These are expected to bring practice into conformity with the ideals of the profession. Unfortunately, there have been no concomitant dramatic recommendations about changing the structure or procedures of the profession. Clearly, these are in order. If authorities in the field continue to claim that the profession is non-responsive, in spite of the vast expenditures of funds and human resources of the past two decades, perhaps improper strategies have been employed. Thus, this chapter concludes with speculations on changes which need to be considered. Before launching into these speculations, it should be emphasized:

1. Change *is* occurring in many ways – some as a result of state education department efforts like Steeb's work in the State of Florida (1972). Also, the material under the title *Industrial Education in Minnesota* (1973) represents a unified State Department-university faculty-public school practitioner effort. The mere publication of this attractive document must be regarded as significant movement toward curriculum renaissance.

   Another such effort is represented by the Technology for Society program of the Wisconsin Industrial Education Association (1976, 1979). This program is designed to interest teachers and students through materials produced at University of Wisconsin-Stout. Students in industrial education are encouraged to enter a state wide competition by doing research, development and problem solving to produce a product/solution within themes established each year. For 1979, the theme "Efficient Use of Materials and Processes" included the following categories and problems:

Category I:	Materials Recovery	Problem A:	"Recycling Problem"
		Problem B:	"New Use for Discarded Materials"

Category II:	Research and Development	Problem A:	"Tower of Strength"
		Problem B:	"The Super Toolholder"
		Problem C:	"The Infernal Machine"
Category III:	Processing	Problem A:	"Slippery Corner Slide"
		Problem B:	"No-Waste Bandsaw Problem"

2. While change is occurring, it may be wise for the profession to take caution that in its enthusiasm to fulfill one essential goal that certain other enduring values which industrial arts may be uniquely structured to achieve are not lost and that certain groups within the student population the profession has served well are not forgotten.

To Accomplish Change

While preceding examples from Wisconsin and Minnesota, along with the major curriculum efforts described earlier, remain exceptions, evidence of practice in general allows the following conclusions:

1. Based upon program and course descriptions, the faculty in most teacher preparation programs in the United States may not be projecting to their students a commitment to the principles of the new subject matter and concepts of technological literacy.
2. There seems to be no unified, consistent nationwide effort, supported by adequate funding, to reinforce and sustain teacher's efforts in implementing the curriculum innovations of the 1960's and 1970's.
3. In spite of apparently effective arguments *within* the field of industrial arts where there seems to be at least someone listening, the wider field of educators and citizens whose support is needed, do not seem to have accepted the technological literacy function of industrial arts.

   In this regard it is:

   3.1 Uncertain that it is accepted at all.
   3.2 Uncertain that industrial arts is perceived as the curriculum area which should assume responsibility for the function.
   3.3 Uncertain that industrial arts is perceived very differently today by the lay public and colleagues in other educational fields other than:
   3.3.1 wood, metals, drawing shopwork
   3.3.2 career and prevocational education.

4. Changes in the structure of industrial arts teacher education and in the professional behavior of teachers of teachers are necessary to effect the new direction of the profession:

Industrial arts teacher educators must become models of technologically literate citizens. They must be the epitome in their professional and their personal life of such behavior. It goes without saying that if the profession wishes to break the hold of traditional shopwork areas, it must be done on the teacher education level. Arguments which have been offered and which are likely to be offered, in support of the continuance of teaching highly specific skills, manipulative-oriented courses, center around the public school teacher's *need* to be so skilled in order to teach even the new curricula. While it is true that industrial arts teachers may require these skills to teach the new curricula, it may be necessary to identify alternatives to the present series of skill courses which prevail in most institutions. A teacher in preparation may achieve success in such courses. (S)He may also see and admire the achievements of the instructor in these courses. (S)He may come to enjoy and value this work for its own sake.

If all these good things happen to a human being, why may (s)he not ask, ought it not be appropriate in the public schools . . . why can't I, (s)he may wish to know, facilitate these good things happening to others?

Thus, in teacher education programs, skills of the traditional kind must come to be seen as a secondary or even tertiary function. If the advocates of technological literacy are communicating effectively, they are saying that some of these *skills* remain important and are respected but only as a means to the more important end of teacher administered activities in technological process, inquiry, and problem-solving.

The teacher of teachers must be able to implement and direct such activities, draw upon appropriate skills when necessary, and effectively teach both skills and the primary subject matter so that the teacher in preparation comprehends the role and function of all the elements of the subject matter.

5. Teacher educators must be involved in research and development in technology and must be scholars of technology.

It may be necessary for teachers of teachers and teachers of teachers of teachers to become directly involved in this field of inquiry. In this way they may be able to do what Lauda suggests. They may become credible models to neophyte teachers because not only will they talk about technology/society problems in classes, but their research, scholarship, and instructional activities in the university will be based in the realities of solving technology/society issues. Their students, then, may depart the hallowed college halls ready to do as their mentors *say* and *do*.

An alternative that may be considered in this regard exists in the model of teacher education programs in other disciplines, such as history, the social sciences, and the natural or physical sciences. In these fields teachers in preparation take content courses with individuals who are historians, biologists, physicists, or political scientists. Often the professors are actively engaged in research or consulting in their field, solving the relevant problems, facing the relevant issues. However, students receive their methods of instruction from individuals who specialize in the pedagogical problems related to the field. In industrial arts, the teacher educator fills both roles. While there may be considerable benefit in such a marriage, clearly it becomes difficult for the teacher educator to work in great depth in technology.

The teacher educator functions as a second or third order interpreter of technological subject matter. The nature and structure of his work prevents him from functioning directly in technology/society problems. This is the same structure which educated him and consequently he may not even possess the necessary skills to directly interpret the relevant literature of technology. He may need to rely on someone else's interpretation of the original literature before he can use the content in his classes.

To engage meaningfully in technology/society problems, and to establish a credible base for the teacher in preparation, teacher educators should receive more preparation in science/mathematics/engineering/computers. If the teacher educator cannot be so prepared, then industrial arts teacher education departments should establish strong programmatic links with engineering or industrial technology departments where the major portion of the technology content in the teacher education program would be taken. Faculty in these departments would need to develop strong commitments to industrial arts and its goals. Such major involvement may facilitate such a commitment. The teacher educator would concentrate on the method component of the teacher preparation program.

6. Teachers of teachers must maintain close and supportive contact with graduates of their programs. Even the most effective industrial technology/enterprise/technology curriculum can go "by the boards" in the face of the pressures a neophyte may face.

The inertia of the public schools and pressures for conformity and tradition may be extremely difficult for the new and young industrial arts teacher to overcome. In spite of the highest ideals, and the finest preparation as a teacher, the extraordinary challenge of changing, let us say, a woodworking course to a technology oriented program may be beyond the means of even the above average graduate who may need to overcome:

6.1 Pressure of older industrial arts teachers in the school who may be quite content with traditional courses.
6.2 Challenges to explain to an administrator why tools, machines which are in place and the material ordered by someone else for the forthcoming year may be inappropriate.
6.3 Challenges to explain the new and different activities to students, colleagues, school board members and parents.

Too often, teachers of teachers filled with the enthusiasm for the new curricula, having done an excellent job of training their students within the university, fail most extraordinarily in completing the effort. The student is not armed with necessary skills and strategies to carry the effort forward into implementation. Teacher educators must assert their leadership and whatever respect and authority they may enjoy in the geographic region they serve to prepare the way for the neophyte junior or senior high school industrial arts teacher. They must also continue to provide support for the neophyte's efforts through the years.

7. Teacher educators and the entire industrial arts profession must come to terms with who they are and what they profess to do.

Conclusions based upon adequate research must be reached about the nature of industrial arts content and method. There appears to be more agreement about method than about content. Both traditional and innovative curricula seek to capitalize upon the power of activity-based individual or small group methods of industrial arts instruction. All groups in industrial arts, although there are suspicions about the effects of some innovations, seem to agree on the high interest, motivating reward, feedback and reinforcement of learning that is inherent in the activity method. It keeps youngsters in school; it keeps them learning – even other school subjects; it capitalizes upon our knowledge of basic human needs. But there continues to be debate, confusion and wide diversity about the content of industrial arts. While national leaders and organizations seem to have come to agreement about industrial arts as a general education area which prepares individuals to function as technologically literate citizens, this means many different things to different people, First of all, each of the prominent leaders of the profession has mapped out a different road for the profession to travel to reach nirvana. Second, there are effective leaders who may be correct when they maintain, like Steeb (1972) that prevocational and career education is the proper emphasis and indeed ought to dominate rather than be secondary to the technological literacy thrust. Then there is the position of what appears to be the "silent majority." This group seems to be "saying" by their reluctance to change:

7.1 That traditional courses, activities and goals of industrial arts offer sufficient value to the developing person so that there is no need to develop other new and elaborate rationales to attract the support and respect of other educators.

7.2 That traditional areas accomplish all the things that are necessary for prevocational, career, or technological literacy that other educators agree must be achieved, but nonetheless, maintain that change is needed to achieve them.

7.3 That the technological literacy function is not unique or entirely within the domain of industrial arts. Technological literacy is an appropriate goal for science, mathematics, social studies, and industrial arts.

7.4 That the traditional approach still yields important skills and behavior patterns which can be accomplished quite successfully by traditional industrial arts . . . perhaps more successfully than many other curriculums. These skills and behaviors, include among others: problem-solving, creativity, accuracy, attention to detail, appreciation of craft and workmanship, development of leisure skills and interests, knowledge of basic materials, hand and machine tools, and planning and implementing individual or group effort. These may contribute as much or more to technological literacy than can be expected and are unique to industrial arts in many respects. This uniqueness may not be true of other attributes of innovative approaches.

7.5 Other dimensions of technological literacy are the obligations of science or social science. Since these are curriculum areas which are likely to enjoy more influence within the schools, when they "become good and ready" to undertake the mission of technological literacy – they will succeed and industrial arts efforts will be for naught. Why then ought we not emphasize strength? Why don't our leaders develop the rationales for the psychological, philosophical, and social goals which can be achieved out of our traditional areas. Is it possible that these basic areas are more enduring than the others we reach for – and which may truly be beyond our grasp?

These may indeed be samples of cogent arguments. The supporters of traditional practice, and obviously there are many, are perhaps less reactionary than other members of the profession would have us believe. Obviously, they constitute the silent majority. They seem to be skeptical about the "new stuff." They are confident because they have observed students being motivated and achieving success in their programs. They have been trained to work closely with the student as focus . . . with content usually secondary. And they are resistant to any effort that appears to emphasize content that may forsake the student. After all, that is what has been going on in the rest of the school all these years. It is no shame, they maintain, to be a traditional industrial arts teacher because she/he has never lost the important human dimensions of teaching and learning so rarely observed in the whole school effort.

If there is merit in these arguments, ought not the innovators stop and listen? Generally, innovators have been rather critical of traditional practice – they have maintained that it must be eradicated and replaced.

Is it not conceivable that a marriage between innovative content and traditionalists' values and methods is possible? Might not the innovators be required to demonstrate, better than they have in the past, that they are not eliminating the intrinsic worth of the traditional method? The critical point to be noted here is that the motivation and learning principles inherent in the traditional activity-oriented curriculum and practiced so effectively by the traditionalists could be integrated with the content which is changing *only* to keep pace with the technological society we live in. As an outgrowth of a curriculum and a notion which were originally conceived to be extremely relevant for their time, industrial arts could honor its originators in no higher way than to carry their ideas and concern for the technology appropriate to its time, to the 21st century as their precursors did for the 19th and early 20th century. The early leaders in our profession were able to integrate methodology which still may be useful today, with the content they delivered. Surely we can do no less.

It cannot be said that industrial arts contributes to the solution of technology/society problems. The leaders and scholars of the profession do not directly effect solutions to problems. Although it may be assumed that males who are practicing engineers, technologists, and lay citizens have studied some industrial arts, their later efforts as mature professionals or citizens to deal with technology/society problems cannot be attributed to their earlier involvement in industrial arts. This reporter has been unable to identify any significant research, the results of which would allow any meaningful conclusions in this regard.

All agree that the profession intends to prepare students to understand, appreciate, and act upon technological issues. That the implementation of this intention is the most important undertaking for the profession remains a confused issue. It is idealized as such. Practice does not seem to support the ideal. On the other hand, evidence of practice suggests that other ideals may be more highly valued by many practitioners, public school educators, industrial arts teacher educators, local supervisors, state education department personnel, and students and their parents.

Perhaps the "baby" (the values which have been considered inherent in traditional industrial arts and which may still be relevant in meeting certain human needs) should not be thrown out with the "bath water" (the context which comprises industrial arts originally). Perhaps the field should cherish and nurture that "baby" as it nurtures also the industrial arts response to technological content and change. Perhaps these values could be maintained with the best of both remaining to serve our students.

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part ii

Selected Technological/ Societal Problem Areas

Chapter 4

Materials and Resources

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BACKGROUND OF THE PROBLEM

The Evolution of Industrial Materials

People have used raw materials, in one form or another, for as long as they have existed. For thousands of years, the selected substances came directly from the natural environment, and therefore, the only task was one of shaping the raw material (primarily stone, wood and clays) into useful objects such as knives, scrapers, borers, picks, axes, spears, bowls, and others. Most of these were designed to reduce human effort and/or enhance the living environment.

The assembled bits of historical data also seem to indicate that people learned rather early in their development, that their respective cultures would only be as strong as their ability to use their developing intellectual power to modify or adapt the materials and condition of their environment to substitute, supplement, and/or strengthen their very limited physical power. It nevertheless took over 100,000 years to learn that the earth's crust held many very important raw minerals that could be extracted, processed, and shaped into numerous more durable and effective protective, aesthetic, and labor saving products.

As more of the earth's raw materials became known and the people's technological know-how expanded, new processing systems were developed to convert the earth's minerals into useful materials to meet people's ever-expanding needs and thus further promote their economic and cultural standards. Such evolutionary changes from the stone age to the Bronze, and on to the Iron Age introduced additional technological complexities that affected the development, selection, and use of the expanding range of manufacturing materials. As an example, the growth of metals and their respective alloys opened the era of material specialization and trade. This meant that people, more than ever before, had to depend on the skills and expertise of other people for their materials and service needs.

Metal's major introduction started with the development and manufacture of basic hand tools to replace former less efficient stone. Later the introduction of more complex implements and major fashioning or manufacturing tools supported the fabrication of new more complex tool designs than their predecessors. It was, therefore, natural for the accelerating growth of metals to lead society into what has been identified as the "Industrial Revolution." It helped to create a mechanical world in which human physical power requirements have been reduced to a minimum while the demand for intellectual technological power increased to a point of dominance within the man-made environment.

Modern technology, while still strongly dependent on metals with selected alloyed blends reaching over 30,000 and more in the making, has over the many years experienced equal phenomenal growth in other materials families such as polymer (resins and/or plastics), adhesives (bonding agents of all kinds), coatings, fuels, wood products, ceramics and others. In each of these industrial materials areas, their introduction progressed from the use of natural substances to the development of numerous modified and/or synthetic materials.

As an example, early oils and resins for coating and adhesives came directly from plant and animal life such as seed oils, pitch from trees or products from animals and insects. Today, however, the chemist puts at the technologist's disposal hundreds of synthetic raw materials that can meet a host of domestic and industrial coating and adhesive problems. This degree of complexity and interdependence of the modern world demands that technology, science, and mathematic disciplines develop significant insight into each other's related fields. In many respects modern science has propelled current technology into what has been identified as "The Materials Age." This is the age in which the scientists and technologists cooperatively strive to tailor, make materials to perform satisfactorily within a particular working environment.

This age, then, suggests that industrial educators reevaluate their past teaching patterns and modify their future educational programs to a point that will further help students to better understand the working characteristics of the materials that are suggested to solve the design problems that are often suggested during a typical school year.

The Earth's Material Cycle

It has already been noted that the usable raw materials that a nation has within its jurisdiction is, in effect, one of the major factors that will establish its worth and strength when judged in relation to other nations.

During their early development, some nations or societies were nearly totally self-sufficient in terms of their raw material needs. However, as population increased and technology advanced to meet economic growth and cultural demands, their general material needs increased proportionally. This, coupled with the introduction of the "Industrial Revolution," which led to the development of our current civilization, has created a complex world in which nations are now strongly dependent on each other for some of the raw materials which are no longer available in required quantity within their respective borders. In short, it now appears that no nation or society can afford to close its raw or semi-processed materials import or export doors to the rest of the world and still thrive industrially, economically, and culturally.

As a result of this material interdependency and to avoid material shortages during brief international conflicts or trade restrictions, many nations have instituted stock piling programs that would, hopefully, bridge their shortage gap should trade restrictions occur. These are short term solutions and can also create complex as well as very sensitive international problems.

Historical data also indicates that some raw materials, after being developed for industrial application, were considered as an inexhaustible source and thus conservation programs were nearly non-existent. Some examples of this false sense of future security included such raw materials as the early American forests from east to west, some major ore deposits, crude oil deposits, fisheries, clean water, and others. Often, the highest grade timber or ore were processed and the lower grades were destroyed by fire or left behind to rot or, in the case of ore, as mountains of low grade tailings. While the discarded timber of years past could not be reclaimed, we are now, in some cases, reprocessing old ore tailings to recover that which was considered not worthwhile during its early development. This writer visited such a plant in Butte, Montana. It was reprocessing copper tailings, of past generations, on a profitable basis.

Our evolving material shortages mean that no nation can now ignore the need to establish some type of material conservation and/or recycling programs as well as replanting or reproduction as in the case of plant or animal life.

As the Eras of Abundance Evolves to Scarcity

While space will not permit the writer to explore all avenues that tomorrow's industrial practitioner and educator may have to understand and help solve, researchers have speculated and presented some conservation and recycling avenues that future generations must introduce to extend their dwindling supply of basic raw materials.

In the final analysis, conservation must be one phase of the total industrial program. Our nation's people and its educational institutions must also work toward the development of a workable salvage system. For example, current data indicates that our yearly material waste includes, in part:

46 billion food and beverage cans
48 billion glass and plastic bottles
100 million automobile tires
6 million automobiles
Untotalled millions of tons of paper products.
And the list of other solids goes on and on.

In addition, nearly 15% of the fossil fuels (liquids and solids) that are used for all purposes are discharged into the environment in their raw, semi-burned, or semi-chemically altered state. This type of material waste cannot be ignored. Recycling of used and/or discarded products is receiving considerable attention. Methods are being explored to economically convert discarded products into new usable raw materials (various metals, chemicals, papers and others) that can be blended with the normal materials that are being manufactured. Such a recycle program will, in effect, not only conserve raw materials, but will also save considerable energy when using salvaged products to develop new usable materials. For example, the energy cost to reprocess iron is approximately 20%, 5% to recycle copper and 1.5% for magnesium, etc.

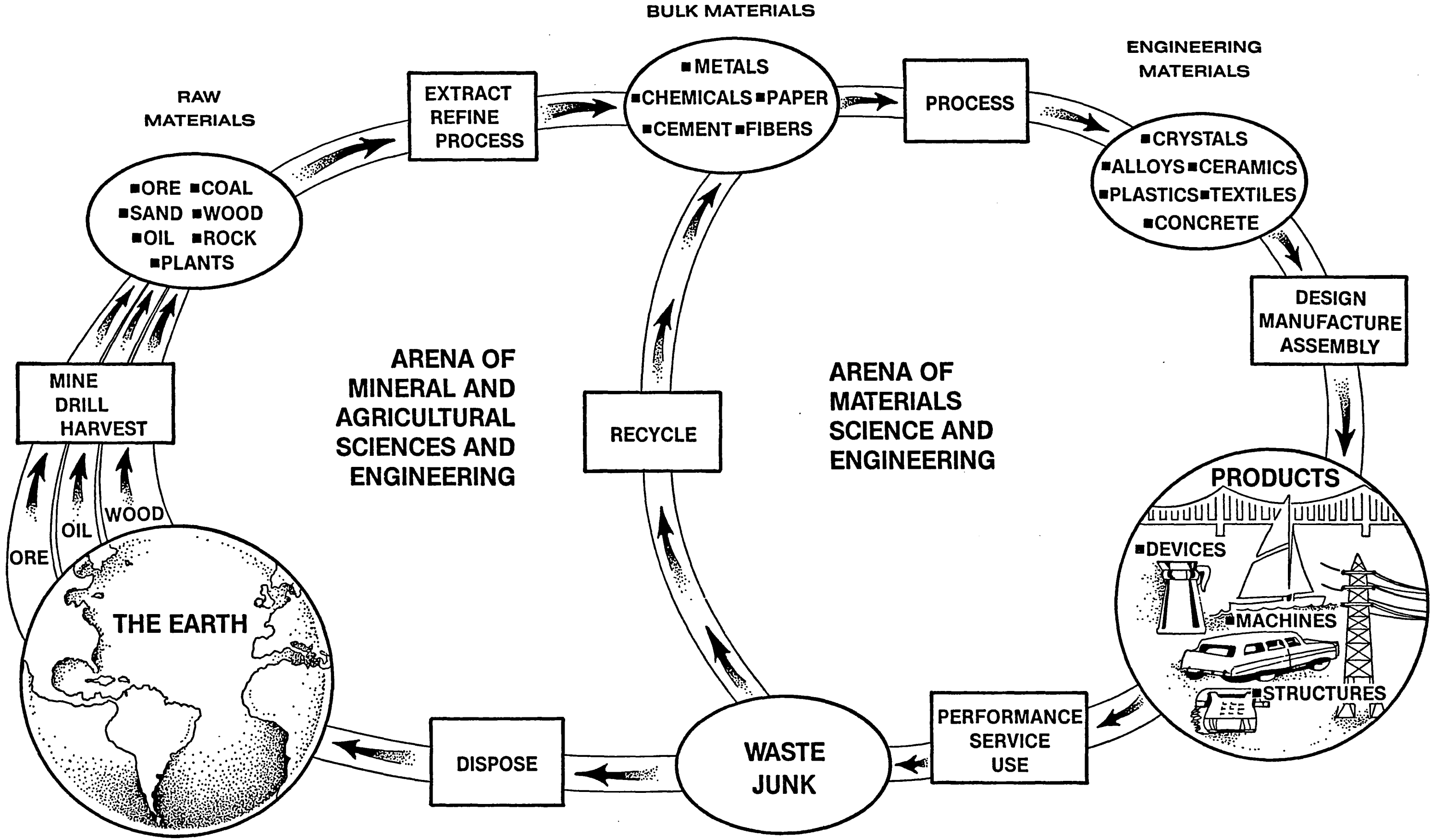
We also know that the era of large wood waste burners have passed into history due to new uses for these materials. In a like sense, the era of large garbage landfills near every major city is also fading into history as new uses for such materials emerge.

Figure 4-1 developed by the "National Academy of Science" presents a "materials cycle" system that warrants additional careful study. In order to establish a meaningful raw material and conservation system, it requires the cooperative effort of industry and government with the expert guidance of mineral and agricultural scientists as well as the engineering and materials science professions to direct the use and control of materials when placed in the manufacturing stream.

Recycling used products is only one future avenue. We know that as societies progress toward the year 2000, the awareness of some dwindling material supplies will become much more apparent. Current research data is already telling us that:

1. By the year 2000, industrial conservation activities and other related involvements are expected to increase by three fold.
2. We can also expect a much closer interworking relationship between Science and Technology, thus creating a more effective team effort that should solve many of our current material conservation problems.

Fig. 4-1. The Total Materials Cycle.



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3. A drive to greatly reduce and in some cases, eliminate hydrocarbon solvents as part of various printing ink and coating (paint) systems will have reached a high level of refinement. This will conserve millions of gallons of organic solvents per year, and at the same time greatly reduce air pollution due to current solvent vapors.
4. The polymer industry will have matured to a point whereby a minimum quantity of resin will be mixed with a maximum quantity of filler, aggregates and reinforcement fiber additives to conserve resins and also develop a more versatile and stronger engineering material. Also agricultural byproducts such as corn stalks, straws and cotton stalks may very well become raw materials for some polymers.
5. Nuclear power may become a major source of electrical energy, thus conserving precious hydro-carbon fuels and promoting cleaner environment.

The materials cycle concept mentioned earlier portrays a material usage philosophy that merits support by everyone. In addition to such a material usage cycle, a reassessment of actual material needs must be performed so that the initial raw material input is carefully evaluated and held to a level that will assure society with an adequate supply in industrial materials for many generations. While we know that depletion of such materials as sand and rock cannot easily happen and that wood and other plant life can be replaced by proper harvesting and replanting, such materials as metal ores, coal, oil and natural gas are not easily recreated and thus should be carefully monitored.

In short, a recycling program in itself will not stem the current growing scarcity problem. In addition to a well developed recycling program future generations must:

1. Introduce a material usage program that will include material selection in terms of its lowest possible volume and/or weight that will meet the product's physical and mechanical requirements.
2. Develop new extra high strength steels, above 200,000 psi, thus conserving basic ore supplies.
3. Introduce and/or extend more efficient metal manufacturing techniques, such as the growing powder metal industry, thus reducing waste and energy required to reprocess trimmings from dies and various other shaping tools.
4. Use adhesives as an added industrial fastening system, to include the manufacturing of many equipment parts. The adhesive system may be used as the binder of readily available earth materials such as asbestos fiber, glass spheres, inorganic ground particles, carbon fibers, and others.
5. As more is learned about the true air pollution problem, materials that contribute heavily toward polluting the environment will be

replaced with more desirable compatible materials. As mentioned earlier, the undesirable hydrocarbon paint and printing ink solvents are, in many instances, being replaced with water as the solvent. This type of coatings application method will change, rather drastically, the pollution problem caused by organic solvents.

6. The polymer industry is already expanding its material blending program by introducing polymer alloying and more extensive use of fillers and/or reinforcement additives. Also the addition and continued development of controlled foamed systems is gaining acceptance as a cost and material saving system. These changes in operational philosophy are, in effect creating materials that are better suited to higher stress applications and compatible with other materials such as metals and wood.
7. Hydrocarbon fuels (natural gas, oils and coal) are still the dominant energy generating materials, however, by the year 2000, increasing scarcities throughout the world will further promote the use of other supplementary energy generating systems. While, as of this date, nuclear power appears to be the most logical candidate, it is not, as yet, a widely accepted system. The technologists and educators must become deeply involved to help solve the energy problems that are sure to emerge.

PRESENT STATUS

Our Current State of the Arts

A review of the working structure of modern industrial organizations would reveal that a number of industrial departments cooperate and coordinate their individual efforts toward the basic objectives identified by the business establishment. These often include the design, development and manufacture of products that must perform satisfactorily in a given environment.

A dynamic organization will include departments that are somewhat interwoven with other departments and often involve *pure research, applied research* and various levels of *engineering* and/or *technological operations.* All of these operations become the backbone of the industrial organization and cooperatively play a very important role by employing phases of *applied science* and *technology* to solve their numerous material selection and manufacturing problems.

The Material Phase

The importance, breadth, role, and complexity of modern materials have been identified as our most recent major technological revolution. It has also been said that the *"Materials Age"* is the age in which man may be called upon to tailormake materials to perform within a particular operational environment. Therefore, to understand and work effectively within a modern industrial environment, it is extremely important that the practitioner (in education or industry) develop significant insight into the science of modern materials. The era of being concerned only with observable forming, shaping, blending and/or joining problems has given way to the inclusion of a more comprehensive study of the materials in terms of their microscopic and macroscopic structure as well as their working characteristics, thus aiding the designer to better understanding the various performance parameters.

As mentioned earlier, even though our industrial organizations are still strongly dependent upon various metals and their respective alloys, other materials such as polymers (resins and/or plastics), adhesives (bonding agents of all kinds), ceramics, coatings, fuels, lubricants, wood products, etc., have over the years experienced phenomenal growth and industrial acceptance. In each of these industrial materials fields their introduction progressed from the use of natural substances to the development of many modified and/or synthetic materials to meet the ever increasing demands of our modern world. Thus, the modern technologist can now reach into his materials pool of special substances and select that which will render predetermined services as never before in history.

Materials Selection

It is also important to note that an understanding of the materials being considered and ultimately selected is a very significant part of a modern industrial organization. Departments charged with this responsibility devote considerable time to the selection of appropriate materials to assure satisfactory product performance when exposed to its known operational environments. Several articles on "*How Materials are Selected*" by H. Clauser, R. Fabian, and J. Mock, in *Materials in Design Engineering,* July 1965, present a very excellent and meaningful pattern from concept formulation to manufacturing. These presentations should be of great interest to industrial educators and should be reviewed in detail. A few fragments from the *Materials in Design Engineering* articles will provide some reinforcing insight.

> "Like most engineering efforts, material selection is a problem-solving process." Much as been written on problem solving, and the major steps involved have been expressed and designed in many different ways. However, there is a general agreement that the major steps are:
>
> 1. Analysis of the problem
> 2. Formulation of alternate solution
> 3. Evaluation of the alternates
> 4. Decision

When these are applied to the material selection process, the steps become:

1. Analysis of the material requirements
2. Selection of potential material candidates
3. Evaluation of candidates
4. Selection of the candidate material that best meets the requirements

This writer suggests that since a review and understanding of selected pure and modified substances is an important phase of modern industry, it should, in a like manner, become an equally important and integrated part of the industrial arts curriculum offerings.

Moving from project design to project manufacturing, employing readily available material at hand is, at best, poor practice. Such laboratory patterns leave little or no time for the necessary and important series of meaningful educational sessions designed to bring into focus the vast materials pool and relevant variables that materials exhibit when subjected to their various operational environment.

FUTURE TRENDS

Some Historical Data

Current and projected trends toward solving materials problems have evolved over the last 100,000 years from a simple task of using nature's available materials to one of working toward creating materials to solve a particular operation or product need. Material problems may involve temperatures from the cryogenics (very low) to temperatures that would gasify normal carbon steels. Stresses that may be in excess of 500,000 psi, severe corrosion environments, and many more, are often a part of the problem to be solved. Historical data will indicate that material selection was, for many years, confined to what was available and, unfortunately, this type of material selection often reduced the service life of the manufactured product. This can be easily noted if we visit museums or salvage yards and evaluate the full performance life of many past home applications, automobiles, electronic components, industrial plants, etc. It does not mean that the modern technologist's materials problems are solved because there are still many unsolved problems. Corrosion damage alone is said to cost United States consumers in excess of 30 billion dollars per year and is still classified as one of the major current and future problems.

Today and Tomorrow

The flow of new or modified technological data appears as a never ending overwhelming flood. Published reports have indicated that technological and scientific papers being printed around the world every 24 hours would fill more than seven sets of 24 volumes of Encyclopedia Britannica. When looking at this mass of new scientific and technological information from another vantage point, we learn that a single year's output of over 60 millions pages would easily keep an average person reading 24 hours a day for some 465 years. As we further evaluate the flow of current data, we can easily surmise that solutions to many current problems may very well be among some of the above mentioned research reports that have not yet found their way into the accepted industrial stream. We can find such examples in our past history. For example, silicone materials were synthesized and remained as a scientific curiosity for over 30 years before becoming an accepted industrial product. It is now a multi-billion dollar industry as well as a very critical material for some high and low temperature problems. Also, some silicone compositions have been formulated as excellent water repellants, lubricants, elastomers, sealers, and others. Thus, when evaluating our current materials problems, it is quite possible that some excellent new materials ideas for future products application may be buried in the mountains of technical data now available.

During this modern age, industrial people have not, as yet, found a simple inexpensive method to store and retrieve new data when desired. Millions of dollars by government and industry have already been committed to develop workable computer data banks that are so cross-indexed as to make the system worthwhile.

Another evolving trend that may very well become a significant positive or negative part of our future material selection and use policy involves the wide range of government regulations. For example, current regulations to improve the automobile's miles per gallon are already causing the industry to carefully reassess the selection of materials for future vehicles. To reduce vehicle weight, which ultimately translates itself into more miles per gallon, is already causing the use of stronger, lighter weight metals. Many plastic or other low weight materials have already replaced former metals parts. For example, Ford Motor Company is currently developing a carbon fiber, plastic bonded body along with other weight-saving materials that will reduce vehicle weight by 1200 pounds, without sacrificing the usable vehicle space or body strength. Its major goal is reduction of weight and corrosion, and, in turn, increased fuel economy and vehicle life.

Even glues, once used to only hold wood and paper products, and not very effective if exposed to a wet environment, have achieved such a high degree of sophistication that their future, as industrial fasteners, is very promising. They are being used to hold secondary aircraft parts as well as its surface aluminum skin. Other recent articles describe the use of a special adhesive in the hospital operating room. After the operation, a layer of adhesive is applied, the incision is pressed together and in a few seconds the mending job is finished. This means that the era of suturing in surgery is being invaded by a modern industrial synthetic adhesive system.

Since the trend is one in which science and technology are committed to each other and will work toward tailormaking materials to work within a particular environment, the future designer and practitioner must fully study and understand the environments within which a product must work and then, if need be, work with other material specialists to develop the necessary material that will perform effectively within that known environment. As mentioned, the era of reaching for an available substance is giving way to the careful matching of materials to known operating environments.

Due to the growing complexity of material science, engineering schools in various parts of the nation have been establishing complete disciplines to deal with an understanding of a wider spectrum of material science that also incorporates material selection.

In an effort to encapsulate future trends, a number of papers in various science and technology journals speculate with their readers the possible technological changes that may be expected during the next quarter century. A few observations that may be of interest to the educational planner are presented below:

1. A much closer marriage between Science and Technology is expected in order to create a team effort that can make almost anything possible.
2. Our waste and pollution problems will generate some very strong industrial and educational driving forces toward solutions. Modern materials of all kinds will be a part of this problem.
3. The drive toward reducing air pollution will also generate a drive toward the development of many new organic and inorganic nonhydrocarbon-solvent-carrying coatings that can be deposited at their respective vapor temperatures to help solve new protective and decorative problems.
4. Metal cleaning, coating, and finishing systems are being redesigned to simplify cleaning through use of lower temperature alkaline oakite systems.
5. Direct inorganic film deposition employing sputtering, ion, vapor and plasma spraying are gaining in popularity.
6. Steel making will have improved to a point that 400,000 plus psi strength may become a reality. We are already reading about super plastic metals that can actually be blow-molded into new shapes. By using stronger metals, raw materials will be conserved as well as providing savings in manufacturing costs. In addition,

simplified casting and shaping methods will also reduce manufacturing time and energy requirements.

7. Metals exhibiting nearly 100% memory shape-recovery with stress load of over 50,000 psi are a reality and will, hopefully, help solve some product problems.
8. The powdered metal industry, introducing new innovative powder and sintering methods, is expected to open many new additional metal fabricating avenues at a lower energy and material cost. Savings in basic material of over 50% and 50% in energy have been realized.
9. The polymer industry is already expanding their material horizon by introducing polymer alloying and more extensive use of filler and/or reinforcement composites. The extensive use of composites should reflect a considerable saving in the more costly polymer resins.
10. Modern adhesive materials are not receiving considerable attention as they are helping to solve many industrial fastening problems at a saving in product and manufacturing costs.
11. Nuclear power, as one of our power sources, now at about 2% is expected to exceed 20% by 1990. If we consider future power growth, generation of energy by the year 2000 will be expected to represent an energy output greater than all the 1955 power sources combined. Again, what role must the technologist and educator assume as this new giant grows in our midst. Will the nation see fusion nuclear systems become a reality by the year 2000?
12. Some studies are already underway to redesign products, particularly automobiles, so that they can be economically recycled after their useful life has been spent.
13. Energy costs will play a dominant role in all phases of manufacturing. Already, the heat treating industry is introducing greatly simplified systems to gain the required objective and, at the same time conserve heat, energy and labor. A newcomer, laser heat treating, is coming of age and will play an important future role in the heat treating industry.
14. All phases of corrosion are receiving considerable attention. A recent review indicated that corrosion of metal equipment is costing U.S. in excess of $30 billion dollars per year: up to $14 billion in automobiles, $8 billion in government property, $4 billion in electric generating equipment such as boilers, heat exchangers, valves, piping systems, etc.
15. Non-metal composite fibers such as graphite, boron, glass and others bonded by a strong adhesive polymer system are replacing many metal parts. Within the automotive and aircraft industry, this will mean less fuel to carry the same pay load.

16. Coal gasification systems above and below ground level will have reached a high level of refinement, thus supplementing the dwindling supply of natural gas and oils. A considerable effort is already being expended to effectively remove sulfur and other undesirable impurities from coal and some heavy fuel oils.
17. Paint systems that will act as fire retardents when exposed to elevated temperatures are already finding their way into the market place. Such a material will greatly reduce fire hazards and in turn promote added savings of raw materials and product life.

INDUSTRIAL ARTS ACTIVITIES

Industrial Arts Philosophy

For many years *problem solving* has been identified as an important part of a dynamic industrial arts program. A 1968 AIAA brochure described industrial arts as that phase of the educational system that helps students, *through the use of applied science and technology,* to more realistically understand the *theoretical* as well as *practical* operations of modern industry. These blocks of study are said to be fundamental to a technological society.

A more in-depth review of the pros and cons reveals that most professional and industrial people concur that this phase of the educational institution can contribute measurably to the students' education if they are taught about various significant fundamental technological concepts that are a part of their technological heritage.

While some educational problems do exist at the operational level, the profession's leadership still believes that industrial arts can and must strive to meet its philosophical objectives.

To accomplish its established goals, educators, at all levels must structure their course content to permit teachers and students to probe beyond the *"what to do"* and *"how to do it"* levels of operation. Probing and discussing the relevant *"Technological and/or Scientific Why"* seems to be an educationally lucrative arm of a well developed industrial arts program. As a result of a strong commitment, many concerned industrial arts educators are, therefore, striving to promote a composite program that will permit the probing and discussing of related material science phenomena. Programs of this nature should truly promote problem solving experiences related to many aspects of *design, material review and selection and operational processes.* It would likewise incorporate meaningful applications of the principles of applied science as it relates to many current industrial operations.

If tomorrow's industrial arts classroom is to reflect the technological problems of the future, its teachers must also accept the fact that no single department or offering within the educational environment can stand alone, just as no single part of an industrial establishment can survive or progress without the cooperative help of other segments of its total organization. Such cooperative team effort, integration, collective action, coordination, or call it what one may, must become a contributing part of tomorrow's educational system. It also seems significant to suggest that the modern industrial educators include *scientific, mathematical and technological* study of data that are an integral part of the total industrial environment. It is with this thought in mind that this writer suggests that educators teaching communication, mathematics, science, and technology should also strive to develop stronger interwoven or intertwined teams directed to helping young people better understand their technological world. *Industrial educators will agree that tomorrow's world needs the flexible person, the intelligently mobile person, the one who can land on his feet when his job becomes technologically obsolete.* To educate for flexibility, educators must distinguish between *training* and *education.*

To *train* is to emphasize fixed responses: to stress immediate goals which often have a low ceiling of possible growth. This is possibly the only way to help the person that has limited reasoning capabilities; however, even here, his educational program should not be presented as a closed loop circuit. The doors toward even limited reasoning should always be kept open.

To *educate,* however, is to foster limitless growth and life-long learning. This is the most fertile ground for tomorrow's educator. Thus, if the educator is concerned with a broader spectrum of education, it appears to this writer that the student should be encouraged *to look for and talk about* the "*why*" behind every "*what*" and "*how*" when involved in classroom or laboratory activity. In many ways, he must strive to develop a more meaningful operational bridge between the broad dynamics of industrial related problems and the industrial arts classroom.

It, therefore, means that classroom material should be designed to challenge the talent of every student. The following system represents a plan to establish varying levels of instruction in industrial arts in an effort to meet the varying needs of individuals taking industrial arts courses.

1st Level: Assigned Objective
The learner is given a step-by-step operation sheet. Basically one of learning to read and follow instructions and developing certain required skills. (We may consider this a cookbook type education.) This writer believes that this would be most appropriate for students who have limited reasoning capabilities and would terminate formal education at the high school level.

2nd Level: Assigned Objective
The learner is permitted to review the assignments and note how the objective may be accomplished by exploring several methods and selecting one to follow. Understanding and working with technical equipment should not present a problem. Reading and industrial math capabilities should be requirements. This type of student should grow educationally to a point that some community college education would be possible for him.

3rd Level: Assigned Objective
This should be developed for the probing mind and should involve such judgments as: (1) Why is the assignment being considered? (2) Possible environments surrounding the suggested problem. (3) Selection and understanding of appropriate materials and operations for the job. (4) Selection of *how* and *why* the needed operations may be accomplished. (5) General evaluation.

The student interested in the more complex phases of the industrial environment would find this avenue most interesting.

The advantage of the above system, it seems to this writer, even if taught by the same teachers, could more clearly define the educational goals and, as a result, clarify course content. If industrial arts educators, in general, are asked to work with the so-called low achiever, then the administrators and counselors should so indicate and the total course content should be structured to help these young people.

In short, it is well known that industrial arts teachers represent a body of knowledge that will enable them to develop programs that will challenge students at all levels of abilities. All modern industrial educators should, therefore, develop courses of study (perhaps in the form of separate tracts) to compensate for the widespread individual differences that are a part of every school. This writer believes that the diagrammatic presentation, Fig. 4-2, by Dr. W. Wolansky, with one of his graduate students, does represent a modern point of view.

Material Oriented Data

The importance, breadth, role, and complexity of modern materials have been identified as our most recent major technological revolution. It has already been said that the "Materials Age" is the age in which industrial practitioners may be called upon to tailormake materials to work within a particular environment.

To understand and work effectively in a modern industrial education environment it is extremely important that the education practitioner also develops significant insight into the science of modern materials. The era of being concerned only with observable forming,

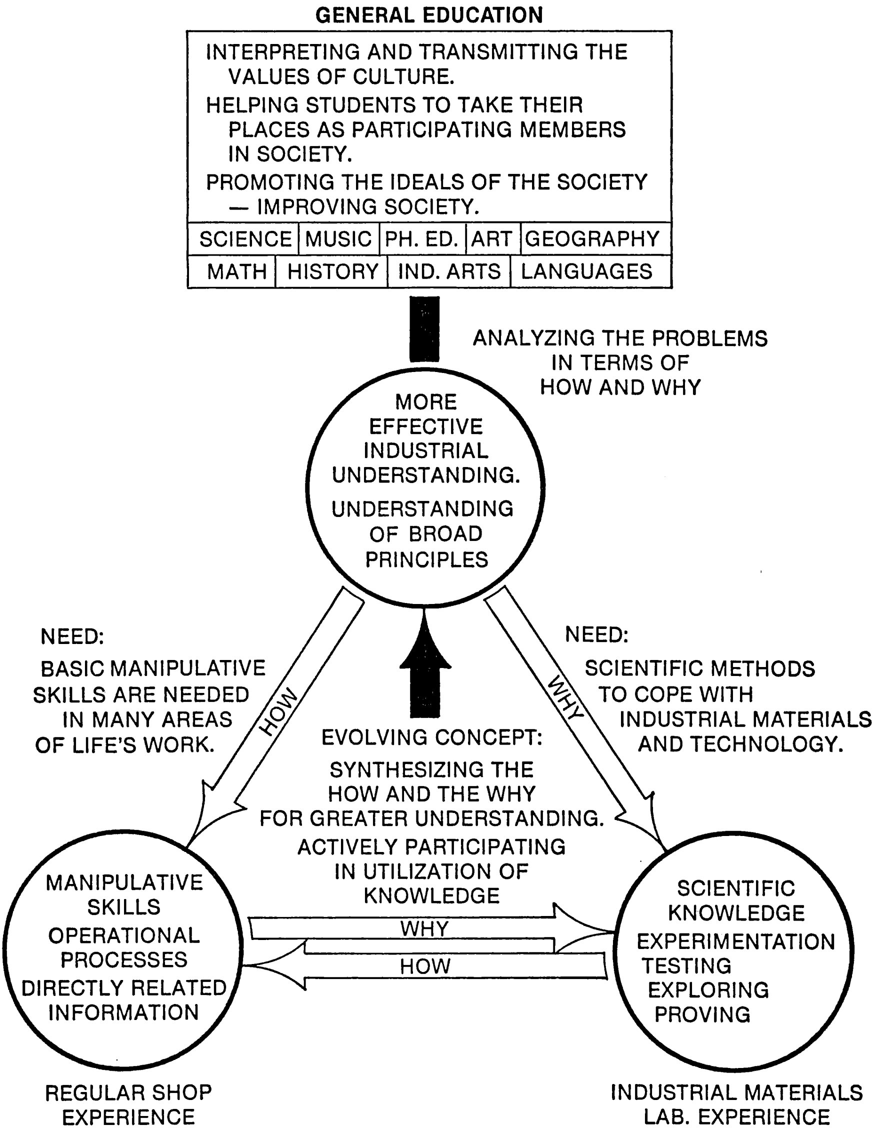

Fig. 4-2.
Evolving Industrial Arts Concept.
Balance of "How" and "Why."

shaping, blending and/or joining problems has given way to the inclusion of more comprehensive study of the materials in terms of their microscopic and macroscopic structure and their overall performing characteristics in addition to their ability to resist degradation within a known environment. As has already been mentioned, materials such as metals, polymers (resins and/or plastics), adhesives (bonding agents of all kinds), ceramics, coatings, fuels, lubricants, wood products, fibers of all kinds and others have, over the years, experienced continued modification. It, therefore, appears that students should learn how materials progressed from the use of natural substances to the development of many modified and/or synthetic materials to meet the ever increasing demands of our modern world.

An understanding of how materials are considered and ultimately selected is also a very significant part of a modern industrial arts study program.

Like most engineering efforts, material selection in an industrial arts laboratory should be a problem-solving process. As with the industrial environment, the industrial arts educator should also strive to follow simple patterns such as:

(1) Analysis of the material requirements for the designed project.
(2) Selection of several material candidates that may be suitable.
(3) Evaluation of candidates in terms of performance and classroom or school limitations.
(4) Selection of the candidate material that best meets most established requirements.
(5) Manufacturing steps.

As noted, since a review and understanding of selected pure and modified substances are an important phase of modern industry, it should, in like manner, become an equally important and integrated part of the industrial arts curriculum offerings when selecting materials for suggested problems or projects.

Moving from project design to project manufacturing, employing readily available material at hand is, at best, poor practice. Such laboratory patterns leave little or no time for the necessary and important series of meaningful educational sessions designed to bring into focus the relevant variables that materials display when subjected to their various operational environments.

Suggestions for Teachers in Designing Learning Activities

Since the area of materials science is one of the major phases of modern technology, it should be developed to provide useful long-range learned concepts about the materials that are a part of the numerous products that serve people. Thus, if the educator is interested in promoting the broader aspects of education, his students should be encouraged *to look for and talk about the "why" behind every "how"* when involved in classroom or laboratory product design and/or manufacture.

In order to better understand some of the ultimate educational goals, this writer will suggest some basic examples of common "How" and "Why" in the form of open-ended statements that could become an integral part of a typical industrial arts class offering. It is hoped that this will provide the interested educator with some additional points of view.

The writer believes that a more comprehensive class offering of this nature, if adequately covered, should *send the student home with a more meaningful and interesting technologically oriented story* to tell that will, in effect, be related to the broader phases of his industrial world.

SOME HOW'S AND WHY'S OF GENERAL INTEREST

All people studying about the working parameters of materials should also extend their study to include the internal and external characteristics of the substances in question. This should permit the development of a more realistic study and search pattern of the basic substances he may be using during future years. The basic question is often – "Why did material specialists select a particular material for a given application whether it be solid, liquid or gaseous?"

Often a laboratory exercise will provide students with the added insight and a more realistic understanding about the material in question.

1. *The microscope permits the student to probe and observe changes that are existing or are taking place that are beyond his normal ability to observe.* Purchased or borrowed equipment will allow students to review the fascinating miniaturized world thus permitting them to better understand such material problems as wood cellular structures; metal granular patterns before and after plastic deformation; various corrosion problems; fungus problems; cellulose distribution such as in paper, coating, and adhesive bonding problems; heat-treating problems and many others.
2. We all would agree that science is the foundation of many of our activities; thus, a more realistic and meaningful understanding of such characteristics as density, thermo-conductivity, coefficient of expansion, electrical conductivity or resistivity, and others are necessary insofar as the materials the student is working with are concerned. For example, we say that wood is warm and metal is

cold. Why? We know that saucepans, on the one hand, must transfer heat energy from the oxidizing gases or high resistant electrical wire through a material to the foodstuff, while at the same time, its handle must resist rather strongly the flow of heat energy to avoid skin damage to the hand that will be used to transport it from one location to another. (The why's behind such phenomena can be numerous.) The basic structure of the materials we use must first be understood to reach for appropriate answers.
3. Some materials are easily absorbed while other adsorb to a surface and some reject such materials as adhesives, coating, dyes, inks, and others. The how and why behind rejection, adsorption and absorption can be a fascinating study for our young people when related to work that is being done in a typical wood, metals, electronics, plastics, graphic arts, and other laboratory.
4. Studying some why's behind the mechanical properties of the materials the student uses for his projects can give meaning to many additional phases of our industrial world. Such characteristics as tensile strength in its annealed and hardened condition, range of plastic deformation, elastic or plastic elongation, hardness, cold and hot workability and others would present students with interesting avenues for discussion that are very definitely related to what he sees on T.V. or reads about. Aerospace vehicles, underwater mechanisms, constructed buildings, and bridges, automobiles and numerous other devices are excellent examples for discussion.

Pertinent How's and Why's Related to Metalworking

All students, irrespective of their long-range objectives, should become familiar with the broad field of metals. This should involve an understanding of the ferrous and nonferrous families and some of their unique working characteristics when shaped into useful objects and/or exposed to various environments. Any number of laboratory problems could easily be developed to gain a better understanding of *how* and *why* these materials are selected for their various product roles.

In addition, the students who plan to specialize in the metals area should do more extensive research in order to better understand the reasons why various alloy compositions exhibit different physical, mechanical, and fabricating properties. As future specialists, these people should also be expected to become involved in some general metallurgical study involving a more extensive understanding of the metal's composition and how it may be reviewed when exposed to various heat-treating operations. The mounting, polishing, and observing of their internal structures, after heat treating or work hardening, under high magnification should be included.

Metal specialists should also assume the responsibility of becoming familiar with the use of various metals handbooks that are available. These references can be used to secure detailed data of such metal families as cast irons, carbon steels, stainless steels, tool steels, as well as the nonferrous groups such as aluminum, copper, nickel, magnesium, titanium, and others.

Some specific lab sample problems that the student studying metals may select are listed below.

1. *Quenching Solutions to Harden a Metal.* Study the effect of a number of different quenching solutions upon the hardness of various steels. Quenching solutions could be: hot and cold water, soluble oils, oil, salt water, etc.
2. *Age Hardening.* Develop an age hardening problem and study the how and why behind the action.
3. *Case hardening.* Develop some case hardening problems using modern case hardening compounds: measure depth of penetration, hardness change, heat treating problems, etc.
4. *Microstructure.* Prepare some of the above metal samples for microstructure examination and study. Note differences of a sample when annealed and when hardened to its maximum.
5. *Physical and Chemical Properties.* Review the similarities and differences in physical and mechanical properties of common ferrous and nonferrous metal families.

    Ferrous metals: cast irons, carbon steel, other alloyed steel, stainless steel, special steels, etc.

    Nonferrous metals: aluminum, copper, lead, magnesium, tin, nickel, zinc, titanium, and their respective alloys, etc.

    (a) Develop some metal problems that will enable the student to adequately understand considerations and/or terms such as hardness, elasticity, strain, yield point, plastic strain, impact strengths, thermal expansion, thermal conductivity, electrical conductivity, and others.
    (b) Develop a problem involving hot and cold working of metal, strain hardening and recrystallization including conditions of grain growth.
    (c) Select several metals of equal cross-sectional area and determine their percent elongation. Can elongation and ductility be thought of as the same property?
    (d) Select a number of metals and test for their relative magnetic attractive powers as well as for their residual magnetic characteristics.
    (e) Heat conductivity of metals: By means of a thermometer and clock timer, determine the rate of heat transfer along several dissimilar metallic rods of the same diameter.

6. *Stress-Strain Relationships.* Review and understand the reasons for stress-strain consideration. Using some samples, develop some stress-strain curves.
7. *Phase Diagrams.* Plot and follow a phase diagram using a bimetallic alloy such as tin/lead solder. Review and understand what its major parts refer to and their value to the user of such an alloy.
8. *Corrosion.*
   (a) Set up a sensitive voltmenter to determine which of two dissimilar metals, in an electrolyte, is anodic. Record the voltages produced by at least six pairs of dissimilar metals. Compare the results with the electrochemical series chart.
   (b) Have students develop several problems that will further permit a study of the mechanism of corrosion. Look for common types of corrosion around your everyday environment. Can it be described, and might it have been further controlled or reduced? How?
   (c) Review methods used or general practices that tend to work toward "designing for corrosion protection" – *How?* and *Why?*
9. *Testing for Fractures in Metals.* Select a number of metallic specimens which include at least two known metals that often possess fineline fractures.
   (a) Study the principles of "Magnaflux" testing in the handbooks and then develop a simple lab set-up utilizing these principles.
   (b) Become familiar with the use of one of the several surface testing aerosol test solutions: cleaner, penetrator and developer.
10. *Residual Stresses.* Discuss the how and why related to the introduction of various residual stresses during a processing period. How can such stresses be controlled or reduced?
11. *Powdered Metallurgy.* Develop several problems that will allow an understanding of advantages and disadvantages of various powdered metallurgy problems. Such points as raw materials, blending techniques, compacting and sintering are open for study.
12. *Others.* Metal related products or operations such as cermets, memory alloys, high velocity forming, chemical milling, magnetic forming and others should also generate interest within any materials study course.

Some "Hows" and "Why's" Related to Wood Products

The study of wood and wood products can be as short or as intensive as the future needs of the individual person suggests. In most cases people think of wood as the study of lumber products that are derived from the basic plant. However, modern technology has brought into play numerous additions and/or modifications and, therefore, necessitates the study of a broad segment of wood products rather than thinking in terms of solid and crossbonded (plywood) material.

Teachers, designers, and industrial people should have a basic understanding of the internal physical, cellular, and fibrous structure of wood, thus helping the interested person to better assess a problem when this material is used in its unmodified and modified state for the numerous tasks that are to be accomplished. It is, therefore, necessary for the students and/or teachers to select appropriate lab problems that will permit them to study the following characteristics about wood materials:

1. *Physical Characteristics.* Develop samples of the cell structure of several selected wood species and review these under the microscope thereby developing a knowledge of the material's physical characteristics.
2. *Spring and Summer Growth, Effects of Moisture Change.* Observe the differences in cell structure and cell mass that exist between spring growth and summer growth. Having done this, attempt to relate the changes that moisture inflows and outflows will cause on the dimensions of the wood cell thus understanding shrinkage and swelling problems. Also observe additional resin deposits and other deposits in heartwood as opposed to sapwood.

   Compare the radial and tangential shrinkage of plain and quarter sawn wood. Obtain specimens from a freshly-cut tree or branch and note its dimensional changes as it loses its moisture.

   Make a microscopic examination of wood cells: face, edge, and end grain cuts. Compare cell structure in relation to the annular ring.
3. *Surface Characteristics.* Select a variety of common wood specimens and observe the similarity and dissimilarity in texture, decorative features, density, working qualities, etc.
4. *Load Capacity.* It is possible by using an available press to determine load carrying values for the various available wood samples. Many good samples can be obtained for the asking where new buildings are under construction.

   Compare the compressive and tensile strengths of plywood, particle board and solid wood stock of equal thickness and dimension.

   Determine the compressive strength – grain pattern relationship for several hard woods and soft woods.
5. *Structure.* Structural problems can be developed, thus giving the student a better understanding of this family of materials when used in the construction of a cantilever beam or other type of supporting structure.

6. *Laminates.* Review plywood and other laminated structures and understand the *how* and the *why* behind the construction and strength characteristics of these materials. A number of lab experiments, including an understanding of bonding problems, can be developed using various types of laminated structures. This important field in the wood industry has grown tremendously in the last several decades, especially since the development of near perfect waterproof glues and more effective use of wood particles as a part of the wood sheet industry.
7. *Resistance to Environmental Conditions.* Students should develop an awareness and an understanding of fire resistance, moisture resistance, abrasive resistance, as well as mold, stain and insect protection materials. The modern wood users, especially when developing structures for general public usage, are called upon to treat their materials in any one of several ways. The student studying these materials must, therefore, know about these problems. He should know how surface treatments, shallow depth absorption treatment and deep impregnation treatments are accomplished.
8. *Particle Boards.* Modern wood technology has also moved into the use of chip or fiber particles to develop many types of fiber board, particle board and the such. The student should know the basic structures of these materials and some of the advantages and disadvantages that they exhibit as materials of industry.
9. *Paper Products and Structure.* We know that paper products are an important part of the wood industry. During the last four decades a large segment of the packaging industry has moved from solid wood to paper products. Why? All people should develop an awareness of how and why paper products have shown such phenomenal growth.

   Make a microscopic examination of the structure of papers.

   a. Is there any resemblance of a "grain" structure?
   b. Is the tearing force equal in all directions?
   c. Does paper tear straighter in one direction than in another? Why?

   Useful data in reference to high, medium, or low quality paper products for all purposes and their respective bonding agents and filling agents should be understood by everyone learning about paper materials. The selection of paper, from social communications to commercial art to shipping wet lettuce, demands knowledge of its end use before proper selection can be made.
10. *Cost Control Wood Selection.* Teachers should not overlook wood grades that are in common use thus describing the general role and costs of each. The user of a wood product can often initiate some cost control by carefully selecting an appropriate species and

grade for the particular task. As we all know, grades for a particular species can often run less than $200 to more than $1600 per thousand board feet. No one should select clear stock to manufacture articles that require parts under two feet in length.

11. *Moisture Content.* Determine the weight-percent moisture content of several different wood samples taken from normal commercial outlets. Use two methods and compare results.
    a. Direct reading using standard moisture meter testing its various surfaces.
    b. Oven dry technique: In an oven at a temperature below the charpoint of the wood (100°C), drive out the water until a constant weight is obtained. Calculate the moisture content.
12. *Fire Retardation.* Study the effects of sodium silicate (water glass) upon the burning rate of wood. What other chemicals are suitable as fire retardants?
13. *Creosote Treatment.* Creosote wood by means of vacuum pressure changes. At a low air pressure, evacuate the air from the wood cells of a specimen submerged in creosote. Slowly increase the air pressure to normal atmospheric pressure. Why did the creosote penetrate the wood cells? Of what value is this type of wood treatment?

The Growing Polymer Industry

The entire Polymer (Plastic) Industry has undergone a complete revolution during the last several decades. Actually the term plastic leaves much to be desired since it identifies a material that displays a degree of plasticity or internal movement when subjected to a stress. A person working with ceramic materials, is in effect, working with a plastic mass during the forming stages providing, of course, that his clay mass contains an appropriate quantity of water absorbed and/or adsorbed by the clay particles. It, therefore, is more appropriate to identify plastics as polymers, thus including a large number of the organic materials. These, in turn, can be modified in a variety of ways through the introduction of organic, inorganic or a combination of these additives, to form a mixture that exhibits the physical and mechanical properties suitable for the job at hand.

The student interested in polymers could spend many hours looking at and reviewing detailed data without really understanding the mechanisms that permit him to work these dynamic substances. On the other hand, if he gains an understanding of the working characteristics of the major polymer families, he will be in a better position to find detailed data and gain needed knowledge for a given task within a reasonable length of time. In order to do this, it is necessary that the individual interested in polymers concern himself with the molecular configuration and work mechanisms at the almost atomic level. An understanding of monomers and the mechanisms of polymerization or chemical linking is extremely important for him to grasp. It is equally important that he understand how each major family's molecular structure is brought together especially during the period when the material is formed into a usable product. In so doing, such terms as polymerization by addition and/or condensation will be understood. Likewise, the differing mechanical properties of linear structures, branched structures, moderate cross-linked structures and major cross-linked structures will be meaningful. This will bring such terms as thermosetting and thermoplastic mechanisms into focus and thus permit the student to understand other properties such as flexibility, plasticity, creep characteristics, crystallinity, memory properties, fibrous properties due to linear orientation and others.

The user of polymers should likewise concern himself with the value of these materials as pure substances and as modified substances, including plasticizing additives, filler agents, coloring agents, composites, foaming agents, and others. An understanding of the working characteristics of these materials, as mentioned above, is needed in order for the student to communicate effectively with the fabricator, the designer, the blender and other users of these materials.

Such a learning environment should have a library with pamphlets and books that will permit reinforcement and a better understanding of polymer families. A sampling of classroom and/or laboratory exercises are listed below.

1. *Electrical Properties.* Plastics belong to the group of *electric insulators,* and many of their applications such as hand tools, distributor parts, vacuum tube bases and electric wiring utilize this property.

   a. Determine the maximum voltages that some thin plastic films can withstand before puncture occurs (dielectric strength). Does the time of exposure to a high voltage affect the observed values of dielectric strength? (This type experiment requires extra safety consideration.)
   b. Students in electronics could set up equipment to test plastics for their:

      (1) arc resistance
      (2) insulation resistance
      (3) effects due to water absorption

2. *Inertness.* Many plastics exhibit excellent resistance to chemical and/or solvent attack, while others quickly decompose when exposed to certain solvents, acids and/or bases.

   Select a number of plastics samples and expose them to common solutions and note their reactions.

Caution: The instructor must approve all heating or mixing problems *before* any chemical or solvent is used, and most of this type work must be under an exhaust hood.

3. *Exposure to Sunlight.* Determine the effects of sunlight and/or intense ultraviolet light upon a number of different plastic materials.
   a. An exposure rack on the roof of a building or suitable yard provides a sunlight and weathering environment.
   b. A mercury vapor lamp may be used for accelerated ultraviolet light testing of plastics.
      Caution: Considerable heat is produced by a mercury vapor lamp, therefore, be sure flammable materials are at a safe distance. In addition, the ultraviolet radiation emitted from the lamp may be harmful to the eyes and skin – use safety shield and glasses as directed by safety procedure.
4. *Exposure to Heat and Cold.*
   a. Subject a selection of plastic strips to an extremely low temperature. Check for changes in physical properties, e.g., flexibility, hardness, etc. Dry ice can generate temperatures to below −20°C. Dry ice in acetone to −50°.
   b. Subject a number of plastic materials to immersion in boiling water. Check for changes in physical properties and absorption of water.

Modern Adhesives — Glues or Industrial Fasteners

Modern adhesives are no longer materials that are only used to hold paper and wood parts together. Any substance that is capable of holding two or more materials together in a normal environment, is an adhesive. In many ways these are industrial fasteners that, when used properly, undergo physical and/or chemical change thus bonding the attached parts together. Students should understand the mechanism of adhesion within the full operational environmental range. Two major concepts that must be thoroughly understood are:

1. *Adhesion* refers to the attraction of one family of molecules to another family of molecules. In other words, it is important for the adhesive, also called adherent, to thoroughly wet the materials to be bonded, called *adherends,* before setting (hardening) takes place.
2. *Cohesion* refers to the attracting molecule-to-molecule forces that any material will exhibit. For example, the cohesive strength of an adhesive can change drastically during its setting period while the cohesive strength of the materials being bonded will remain the same.

Researchers have indicated that if an adhesive system exhibits complete compatibility with the adherend and has achieved high wetting when applied on the adherend, then the strength of the joint is as strong as the cohesive strength of the adhesive film or the cohesive value of the basic adherend.

Since adhesives, during their setting period, must undergo a physical and/or chemical change, it is important that students understand what is happening when these changes are taking place. The more significant adhesive family setting changes are as follows:

1. *By solvent release* — No chemical reaction takes place. This is often referred to as a drying action.
2. *By chemical condensation — polymerization* — Adhesive system may be activated by heat, catalystic action or both. Crosslinking of molecules occurs and a byproduct is liberated during the curing action.
3. *By polymerization only* — Adhesives may be activated by heat and/or catalystic action. Crosslinking of molecules takes place and *no byproduct* is liberated during this curing action.
4. *By a combination of one and two* or *one and three* above. A solvent is released (absorbed or evaporated) before one of the several chemical reactions can take place.
5. *By vulcanization.* A crosslinking action involving elastomeric (rubberlike) adhesive systems.

As noted, it is extremely important for the student studying adhesives to understand these various setting methods and how and why they may work to his advantage or disadvantage when bonding materials together. For example, bonding impervious materials such as glass and metal with a bonding agent that must dispose of a solvent would be poor practice since the avenues of escape for the solvent would only be along the edges of the bonded mass. On the other hand, the same adhesive would be suitable if a fibrous material such as wood or paper were used because the solvents would have an escape route through the fibrous mass.

Some Adhesive Selection and Operation Considerations are Provided.

Modern adhesives are complex materials and blending for particular adherends and environments are now common industrial practices. Some considerations are listed below.

1. The stresses that the adhesive joint will be exposed to must be known.
2. The environments that the adhesives will be exposed to are an important consideration. These may include temperature ranges, exposure to chemicals, destructive rays, humidity, etc.

3. The adhesive system must be compatible (mutual attraction between adhesive and adherend) and suitable with the physical and chemical nature of the adherend's surface that it must bond to.
4. The practitioner must strive to match the coefficient of expansion of the adherends and adhesive system being considered to reduce undue stresses during temperature changes.
5. The time span between application and setting is often an important economic and/or manufacturing consideration.
6. Types of joining problems must be understood. Its simplicity or complexity often determines the method of material application.
7. The dispensing equipment that will be required to deliver the adhesive to the adherend's surface (brush, trowel, dip, spray, rollers, extruders, etc.) becomes a part of the total operational problem.
8. If large quantities are dispensed by special equipment, such other considerations as ease of preparation, dispensing problems, active life of prepared batch, ease of clean up and others should be taken into account.

Adhesive manufacturers have grouped the major adhesives to help identify them in terms of their similar composition.

Adhesive Families

1. *Glue* — These are basically protein materials of natural origin – byproducts of animal and marine life, milk, soybean, corn, and others.
2. *Pastes and Mucilages* — These are basically starches, dextrin and gums from various parts of plant life.
3. *Natural Resin* — Another group of natural materials such as *resin, shellac,* and *asphalt.*
4. *Inorganic Adhesives* — The most common inorganic adhesives are sodium silicate (water glass), litharge-glycerin blends, and magnesium oxychloride.
5. *Rubber Base Adhesives* — From natural reclaimed and synthetic rubbers. Among the most versatile and widely used. Some vulcanizing and non-vulcanizing types are available.
6. *Thermoplastic Resins (Synthetic)* — Nonchemical reactive i.e., liquified by heating and also often by the use of an appropriate solvent. They include:

   a. Cellulose derivatives
   b. Acrylic family
   c. vinyl group
   d. polyamide
   e. others

7. *Thermosetting Resins (Synthetic)* — Chemically reactive family of adhesives – most common:
   a. phenol-formaldehyde
   b. urea-formaldehyde
   c. melamine-formaldehyde
   d. polyester resins
   e. epoxy resins
   f. silicones
   g. furane resins
   h. polyurethanes

In addition to the above groups, manufacturers often employ many additives such as plasticizers, extenders, wetting agents, liquifiers, solvents, fibers, fillers, and others to modify the adhesive system for a particular job.

As has been noted, modern adhesives are complex materials and should receive more than a casual comment when being used for a particular industrial arts assignment.

THE COMPLEXITY OF MODERN DECORATIVE AND PROTECTIVE COATINGS

It would be extremely difficult in a short statement to identify the complexity as well as the evolutionary changes that the coatings industry has undergone. The varnish composition of yesteryear was quite different from the varnish of today. Teachers and students dealing with coating problems should, as mentioned in all other material situations, strive to understand the composite structure. Many laboratory problems may be developed to gain added insight for intelligent usage.

1. Every school should have an outdoor exposure testing rack.
2. The "why" behind runs, peeling, film thickness, blistering, poor adhesion, poor covering, gloss, reflectancy and many others can be introduced and understood.

Even though the compositions of modern coatings are rather sophisticated mixtures of various synthetic and natural compounds, we will note that there is a tendency to use terminology and names in describing these materials that have been used and accepted for many, many, years. Thus, the term varnish today may mean something different than the term varnish of yesteryear. The term latex for years meant rubberlike, however, when carefully evaluating many of our latex compounds, we learn that they include many plastics (polymers) compositions as well as rubberlike materials. Therefore, it is the responsibility of the user to become familiar with some of the basic characteristics of the particular coatings he has in mind. The selection, of course, will be determined by many factors. Coatings may be developed to be used for the following reasons:

1. As a preservative.
2. As a protective material.
3. As a decorative material or combination protective and decorative material.
4. As a fire retarding material.
5. As an aid to illumination or as a reflecting agent.
6. For sanitation purposes.
7. Applied as a contributor toward building staff morale.
8. Color coding for safety designation or communication.
9. As a combination of any of the above.

Many lab tests can be developed that will provide students with added insight in terms of the performing characteristics of coating systems.

1. *Color* — Color and color tinting experiments could be easily developed to provide a better understanding of coloring problems.
2. *Covering Power* — The covering power of various pigmented coatings will quickly tell the user how thick the coating must be before total opacity has been reached.
3. *Coating Formulation* — Even though complete formulations used by coating blenders are not readily available, some classroom formulations can take place. Such data as covering power, drying time, adhesive quality, gloss and reflectance, hardness, flexibility and others can be developed.
4. *Gloss and Reflectance* — A meter that will test gloss and reflectance can be a definite asset to a class lab.
5. *Film Thickness* — Understanding maximum film thickness when the film is in a vertical position and does not sag is significant to a user. Film thickness also plays a significant role in terms of opacity, wearing characteristics, flexibility and others.
6. *Exposure Tests* — As mentioned earlier, outdoor test racks are a definite asset to the classroom. For a suitable test program the several racks should have southern, eastern, and western exposure.
7. *Abrasion Tests* — Simplified abrasion tests will provide added insight about the quality of a coating system.
8. *Viscosity* — Viscosity tests are related to the coating's spraying, brushing and rolling characteristics.

Some How's and Why's About Fuels and Lubricants

The study of fuels and lubricants without also discussing typical fuel and lubricant using equipment becomes somewhat meaningless since one phase of study is an integral part of the other. The typical automobile, one of the major users of fuel (about 60 billion gallons) and lubricants, can easily be identified as a physics and chemistry laboratory on wheels that also commands a great deal of student attention. Educators who take advantage of this built-in student motivator can easily develop course content that will provide students with considerable insight about the operational problems presented by fuel and lubricant using equipment.

Fuels. The burning of fuels, to meet our energy needs, is only one phase of our fuel and pollution problem. The chemist may identify the combustion or burning of hydrocarbon fuels as a form of rapid oxidation and may be viewed as follows:

$$\text{Hydrocarbon fuels} + \text{Oxygen from air} = \text{Carbon dioxide gas} + \text{Water vapors} + \text{Heat energy to do work}$$

If our hydrocarbon fuel (solid, liquid, or gaseous) were free of impurities, and the equipment assured total combustion under all operating conditions, the air pollution problems would no longer exist, the exception being nitrogen compounds.

The major educational variable is, therefore, "Why do fuel using mechanisms perform as they do?" Students would quickly learn that most fuel and oxygen (air is only 20% oxygen) delivery systems have not been perfected to the point of metering exact air to fuel ratios during all operating conditions. This is particularly true with the automobile and should be able to generate a great deal of interest in an automotive class.

Lubricants. Most of our lubricants are also basically hydrocarbon materials that, in most cases, have been blended with other materials and/or chemicals to perform satisfactorily in a given situation. Their fundamental task is one of reducing friction when parts are in motion.

Since lubricants are available as solids, semisolids, liquids and in some special situations as gaseous materials, students need to know how to evaluate a lubrication problem and understand why, at times, the proper selection is rather critical and can be the difference between success and failure. For example, a door lock lubricated with a liquid lubricant can ultimately lead to failure. Why?, etc.

Variables such as viscosity, pressures, temperatures, speed environments (open or sealed environments), exposure to gases and fluids, and others also become a part of such a study.

While machining fluids (cutting fluids) are often classified as lubricants, they should receive added attention by machine shop people. Often the working environments these materials are exposed to are very severe and added study as to "How" and "Why" is justified.

Other Materials To Be Considered

In presenting the above families of materials and suggesting some educational avenues for teachers and students, the writer hopes that the remarks are to be viewed as a philosophical guide and that such a guide would be of value if the educator wishes to develop a course of study involving some materials not mentioned in this brief review. Such material families as concrete (cement plus aggregate), natural fiber, synthetic fiber, insulation, and others could be developed rather easily.

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Chapter 5

Energy

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"What the mind conceives and believes, it can achieve......" Anonymous

Scenario: It was June 12, 2000 – a day that everyone will remember. This was the day that the power stopped throughout the world. Although the continents had been "gridded" together in 1990 to stave off such an emergency, the energy forecasters were finally proven right as everything ground to a full stop.

The energy bank computer at the world Power Control Center had just printed out its last words:

.... Zero Natural Gas .... Zero Fuel Oil .... All other readily available energy sources depleted.... Alternative energy sources too small to pick up the load ....

Cause of the massive power failure was attributed to being "just too many people and not enough energy to go around." It sees that everyone wanted energy, but no one was willing to sacrifice for it. A few people remembered the earlier prediction that the world of 2000 would be needing at least 2½ times the total capacity of 1980, or a total blackout would take place. But government, business and most of the people wanted to continue with their "fuelish" ways because they believed there wasn't really an energy crisis at all. Others believed that if technology could create the crisis, then technology alone could correct it. Obviously both groups were wrong because we are now back to rubbing two sticks together to produce heat for our homes. Most people now believe that we should have tried to shape the future instead of letting it shape us as it has.

It is only a couple of years since the blackout of 2000. However, things have changed radically. Cars, trucks and busses have long since disappeared from the streets and highways. Any energy that was left has been directed for government use so that nations can survive until newer energy sources are found. Most everyone has moved to the city from the suburbs and our lifestyle is now one of subsistence farming wherever we can. There is no heat for the winter again this year, but we are gradually getting used to it. When will it all end? If only we had started to work on the energy problem 25 years ago, things would not have been so bad today.

One nice thing about it, though, is that the air seems cleaner and fewer people are coughing . . . . .

BACKGROUND OF THE PROBLEM

Introduction

Why does the energy problem still remain one of the most vexing questions of this decade? What prevents government from taking necessary action to solve the problem? Is Big Oil the culprit? Or, is it Business? Or, the People? These are questions that need to be answered if we are to avoid a June 12, 2000 scenario – a nightmare life without enough energy to go around. As the world's most technically advanced civilization, what course of action should we take?

The Good Old Days

The earliest humans used the same energy forms as the other species with which they competed, depending solely on the products of the sun's energy for existence. Muscle was the principal energy source of primitive man until he discovered fire. With fire he produced tools as extensions of the human organism, thereby taking a giant step toward becoming technology man. See Table 5-1., Energy Chart.

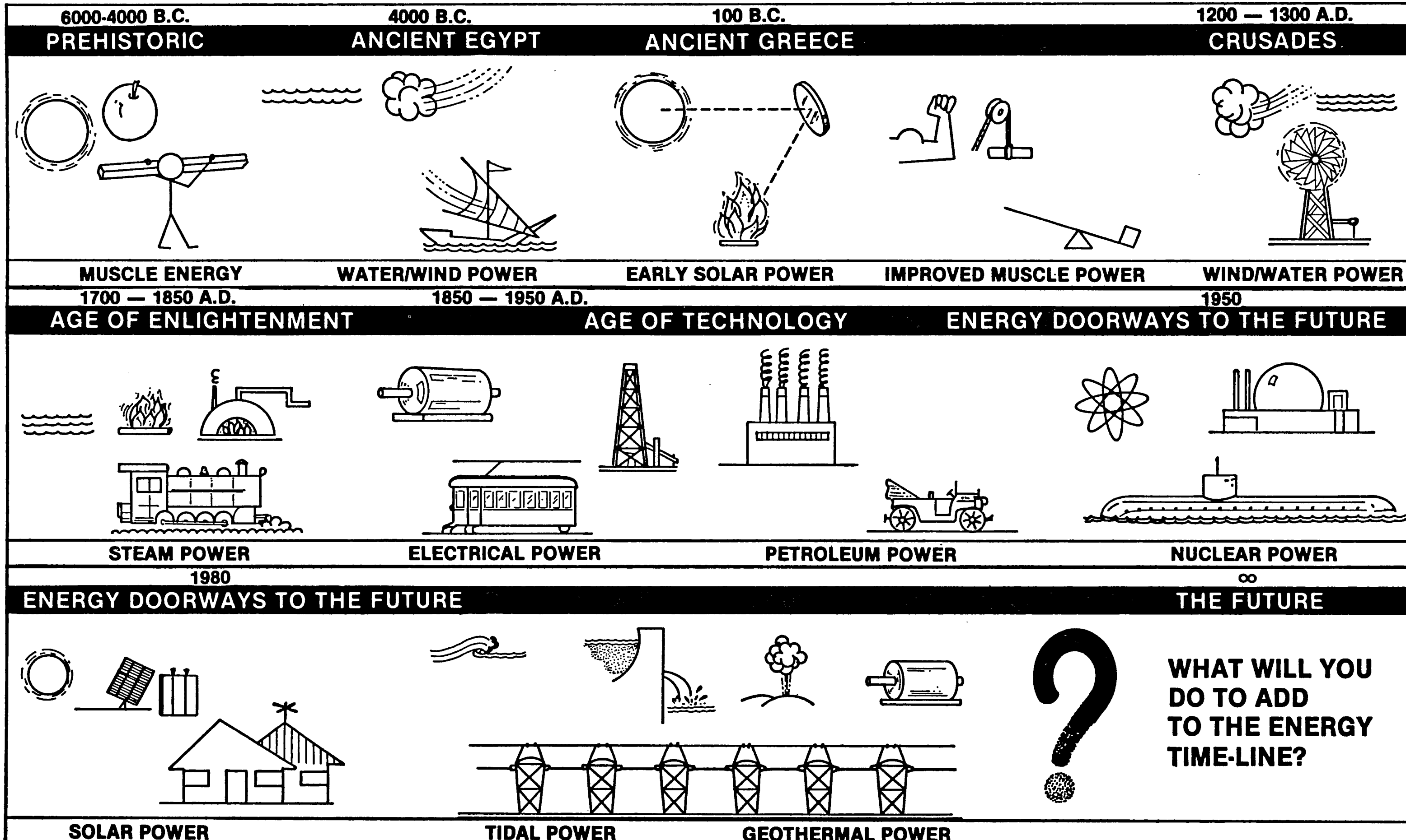
At first, man used wood and burned it to produce the heat he needed. With the discovery of coal he learned to invent machines that burned it to produce other forms of energy. Later came the discovery of petroleum and natural gas along with the technology for using these new fuels.

Boundless Supplies

Back in the "good old days" the world was brimming with fossil fuels and the industrial system grew at a tremendous rate. Coal, oil, natural gas and electricity made from them had become so inexpensive to develop, process and transport, that their prices had only a minor impact on the consumer's costs. These abundant fuels helped change our earlier agricultural techniques by substituting petroleum-based fertilizers and pesticides, by providing elaborate packaging and huge transportation systems to rush the products to market. Individual transportation systems were born which soon reshaped our cities into decentralized urban land settings.

As our energy-intensive culture expanded, the productivity of labor multiplied which increased the gross national product and boosted our

Table 5-1 Energy Chart



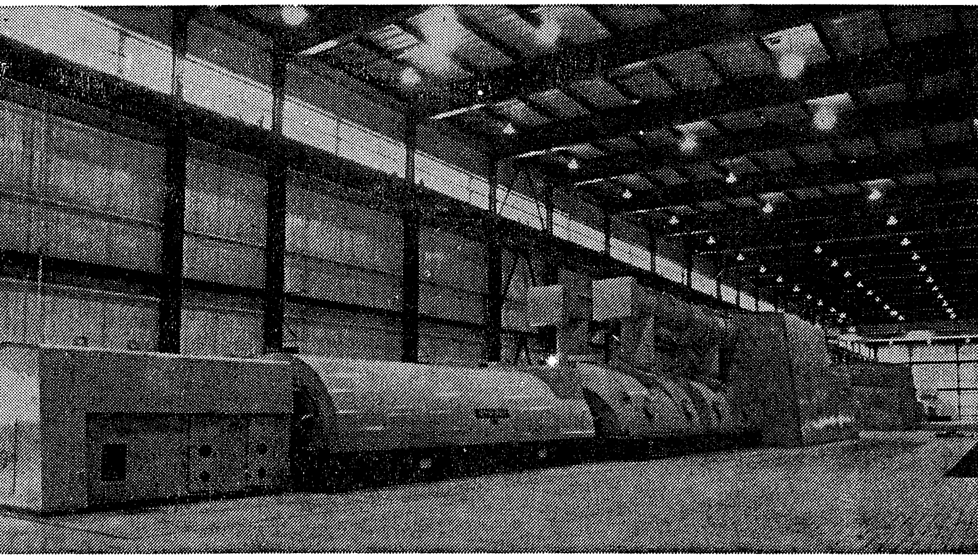


Fig. 5-1. Department of Energy
Generator Room of a Modern Electric Plant.

Present technology enables coal to be burned without the dirt and pollution problems which formerly characterized the use of coal. There is enough coal in the ground for the next 200 years.

standards of living to new heights. These energy sources now accomplish 99% of the production work in factories, refineries and mills as compared to 1% for human labor.

As our economy grew, we saw several changing patterns of use of our primary fuels over the past hundred years or more. Wood was the primary fuel until the 1880's when we began to use coal more and more. In 1950 we witnessed change from coal to cleaner and cheaper oil and natural gas. This lasted until 1973 when we experienced our first real energy crisis.

The Industrial Revolution

Increased Energy Demands. Ever since the industrial revolution started, our appetite for energy has been growing along with our expanding population. By way of comparison, our population grew by 35% during the last two decades while our *per capita* energy consumption grew by 46% for the same period, thus multiplying our energy demands.

New Life Styles. Energy has contributed much toward our high standard of living and is actually considered a necessity of life by most people. One of the best examples of this is our modern car. The automobile has really reshaped modern American life, transforming our landscape and environment as well as our work and social worlds. We depend on our cars to get us where we want to go, when we want to get there.

During the past two decades, Americans have doubled the number of miles they drive to work from the sprawling suburbs and tripled the number of cars on the road.

About 80% of all U.S. families own automobiles; more than 90% of intercity travel is by automobile; more than 1,000 billion motor vehicle miles are logged each year; and nearly 90% of all commuting workers use automobiles to get to and from work. People not only want the convenience of the automobile, they aren't about to give it up. Unfortunately, many people feel that "if the energy crisis is real they want to get their share before it is all gone."

Advancing Technology: As time progressed, both industry and household added more and more energy consuming machines and gadgets to their inventory, often for convenience rather than for energy efficiency. As an example, trucks supplanted railroads, computers replaced accountants, cars sent trolleys to the museums, and farm machinery outdated the farm hand.

We now lead the world in the use of other high energy consuming products such as air conditioners, dishwashers, clothes dryers, power lawn mowers, etc., and plan to operate them as if the energy supplies are endless.

Unfortunately, this process cannot be sustained forever because petroleum based energy resources are nonrenewable. Fortunately, coal is more abundant and can easily meet our other energy needs for the next several centuries, but not without cost to our environment.

Imported Supplies: To keep pace with our fuel needs of the mid-1970's our imports of oil increased while our domestic production began to decline. The reason given by the economists was rising exploration and production costs coupled with our environmental concerns and geological facts relative to our limited known reserves.

Most of the energy used for our industrial expansion has been fueled by natural gas. This resource has been imported from Canada via the pipeline and from the Baltimore Canyon, but this represents only a small percentage of the anticipated requirements. New technologies have made it possible to produce and transport liquified natural gas from such places as Algeria, Indonesia and the Middle East. But this only adds to our balance of payments deficit.

Energy Literacy Need: Clearly, there appears to be a lack of understanding or "energy literacy" on the part of the American public as to why we need to conserve remaining energy resources as we try to rapidly develop alternative energy sources to augment our dwindling supplies and rising imports.

Unfortunately, the energy crisis has been talked to death with few Americans really believing that we are near the end of the flow. The paradox is – no apparent shortage – no credibility in the minds of many people. Most people now believe that we should have tried to shape the future instead of letting it shape us as it has.

PRESENT STATUS

The Problem

Our energy problem has been thirty years in the making. We have refused to listen to the warnings of our energy experts and continued to waste and consume our energy supplies at an alarming rate. It took the 1973 Arab Oil Embargo and the Winter of 1977 to draw our attention to what the geologists have been saying for years. We almost saw a different type of "gas war" when the OPEC nations threatened to cut off the supply of oil to the world.

Statistics

The days of cheap, abundant fossil fuels are over, yet these fuels provide the U.S. with over three-fourths of the energy used in 1980. In its place we now see our domestic sources drying up, higher price tags on all of the petro-products we have come to depend upon, and the U.S. bidding with the rest of the world for foreign supplies.

Statistics show that at the current rate of consumption of crude oil, the U.S. will deplete its known supply of oil reserves and estimated future discoveries by 1995. Although many alternative solutions have been proposed and explored by government and industry we are still far away from any real solution to the escalating energy problem.

The same picture is evident on a global scale. According to studies by the National Research Council's Committee on National Resources and Environment, "world resources of petroleum and natural gas (including both discovered reserves and undiscovered recoverable sources) will be seriously depleted by the end of the century if present trends of world production and consumption continue."

Energy Dilemmas

Our current energy dilemmas primarily involve social, political and economic issues of the day.

The nature of world politics and economics has changed drastically in the past decade. We have seen the balance of economic power shift from industrialized countries toward less developed suppliers of oil and other raw materials. The developing OPEC nations literally have the world "over an oil barrel" because they account for over half of the world's output of oil.[1]

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[1]OPEC includes 13 nations: Algeria, Ecuador, Gabon, Indonesia, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, United Arab Emirates, and Venezuela.

The Arab Oil Embargo of 1973 was a near disaster for those oil dependent nations that must import up to 90% of their oil supply. Many alerted their military forces and some might have attacked the OPEC countries had not the embargo been lifted. Unfortunately, there are no short- or medium-term substitutes for oil in our technical inventory other than conservation until such time as another or many energy efficient alternative(s) can take its place. A slowing down of energy use would buy some time to arrive at the best options for all of us. However, the economic impact of slowing down or "zeroing of our energy growth" opens up new economic problems. To what degree energy growth can be moderated without detrimental effect is a big question.

Economics of Oil Production: Oil production is a "capital intensive" business and dependent upon investors anxious for a high rate of return. When domestic production from old wells peaked in 1970, capital investment began to look elsewhere for better returns. Domestic production costs could not compete with those in Venezuela or the Middle East, therefore more and more capital was invested in developing foreign oil sources rather than domestic ones. Many economists see the energy problem as one of price and not necessarily geology. For example, the market-place theorists reason that if the price is high enough then enough oil and gas will be produced for those that can afford to pay the higher prices. They would also argue that the higher oil prices would serve as an incentive to develop the alternatives as well as produce more energy-efficient machines. It all boils down to who is producing the data and from which source are they quoting.

The free market supporters argue that any government regulation would upset the supply-demand curve and that this would cause the energy sector to cease exploration, thereby raising prices to meet the current energy needs.

Because of the nation's deeper concern for a secure source of oil and the rising costs of imported oil, domestic exploration for new oil has increased since 1976 and it has resulted in the new finds on the Alaska North slope, and the Baltimore Canyon. However, the costs for exploration and production of these wells are much higher than from our regular sources in Louisiana, Oklahoma and Texas and the remaining resources are finite. To complicate the problem the lead times between initial exploration and peak production averages about 10 years.

Energy Waste: Progress is not without cost. Although tremendous amounts of energy are consumed each year by this nation; over 60% of it is wasted as heat through inefficiency. The prime example is fuel for produced during combustion are nitric oxide (NO) and nitrogen dioxide (NO_2).

Nitrogen oxides, in high concentration, can be fatal to humans and animals. However, the level of nitrogen oxides is not high enough to transportation in which only 25% of the energy content is actually used to produce mechanical motion.

Producing electricity is also a very wasteful process. It takes roughly three units of fossil fuel energy to produce one unit of electrical energy – the other two units being lost as heat.

Energy Pollution. "More is better" is not always the best solution for every problem, especially the energy problem. For example, every step in the production and processing of the energy cycle throws out large quantities of chemical, thermal, and radioactive wastes. The burning of fossil fuels in particular adds dangerous contaminants to our atmosphere which causes respiratory infections, and deterioration of our materials. As our need for energy increases, we are going to have to make some difficult choices such as who will pay for the increased costs of pollution elimination.[2]

Equipment Redesign. Our work saving appliances at home and work are other examples of wasted energy. Although it is possible to increase the energy-efficiency of such devices, it does make them more costly to produce. A comparison of the trade-off between cost vs. energy-efficiency of some redesigned home appliances is charted in Table 5-2.

Table 5-2
Appliance Cost vs. Energy Efficiency Trade-off

Appliance	Percentage More Efficient	Additional Cost
Refrigerator-freezer	39	$45.00
Freezers	28	38.00
Dishwashers	25	24.00
Room air conditioners	28	65.00
Color TV sets	54	0.00
Black/white TV sets	186	0.00

[2]Energy pollution, considered to be a modern problem, was probably worse in ancient times. Autopsies on mummies from various parts of the world have found heavy deposits of carbon in their lungs, presumably caused by smoke from cave and tent fires. According to historians, a shortage of fuel supplies has been a continuing problem since 2,500 years ago. It seems that there was a shortage of energy in those days in the form of wood to heat homes, baths and greenhouses. Therefore, the early Romans and Greeks designed their houses to take maximum advantage of the sun and leave wood ear-marked for shipbuilding. It is interesting to note the analogy here – 2,500 years later, we may also have to concentrate on the solar energy path to conserve our current short supplies in fuel.

Policies of Energy

Unfortunately, the political picture is still very cloudy. Many ideas have been advanced but few have really been successful.

Project Independence. Attaining energy self-sufficiency for the U.S. by 1980 – proved to be a dismal failure. The government, after years of trying, has yet to produce a coherent national energy policy. Without such a policy the difficult questions of energy cost, alternatives to be developed and environmental conflicts to be overcome will be around for a long time.

In their National Energy Plan the Department of Energy has suggested some solutions to our energy dilemma. See Table 5-3.

On the international scene we have been somewhat more successful. A new 18-nation cooperative energy agency was created in 1974

Table 5-3
Some Solutions to the Energy Problem

Highest Priorities	Conservation	Increasing Energy Supply
Near-term (Now until 1985)	Construction and consumer products. Industry become energy-efficient. Transportation efficiency. Convert waste to energy.	Use of coal by all of the utilities & industries. Use nuclear converter reactors. Enhance recovery from old oil/gas wells.
	Increasing Energy Supply	**New Technology**
Mid-Term (Period 1986-2000)	Gaseous & liquid fuels from coal. Oil shale.	Geothermal. Solar heating & cooling. Waste heat utilization. Electric conversion. Energy storage.
	New Technology	**New Technology**
Long-Term (Period 2000 +)	Solar electric systems. Breeder reactors. Laser fusion.	Biomass fuels. Hydrogen energy systems. Electric transport. Energy transmission & distribution systems.

to: (1) share oil during future emergencies, (2) cooperate in energy conservation, and (3) take positive action to develop alternative energy sources. Inasmuch as all nations have a stake in energy, a policy of energy interdependence on a global scale has been suggested as a method of establishing "mutual dependence" between oil producing and oil consuming nations. Its success or failure remains to be seen.

Energy Options

We are still in the position of not being free of foreign oil imports without a drastic change in our life styles, attitudes, and economic well being. Whether we like it or not, we do need to hold the line on expanding our energy-intensive standard of living. We do know that conservation of energy is a step in the right direction, but are still undecided on how to effectively implement it.

Conservation. "A barrel of oil saved is a barrel of oil earned." This paraphase of Franklin's famous statement is particularly true because saving energy is one area that is under-utilized today. Stated another way, it costs less to save a barrel of oil than it does to produce one through new technology.

Energy conservation is not easy because it is generally based on the voluntary action of individuals, governments and industries. Yet many of the conservation methods cost nothing, are easy to accomplish, and do not require the development of any new technology. Some of these well publicized methods are: *for the individual,* turn down thermostats, establish and ride to work in car pools, selectively buy only energy-efficient products, use returnable bottles, and observe the national speed law. *For governments,* new building codes that stress energy-efficient homes and buildings, defer taxes on energy-efficient home improvements, and require improved performance in cars. *Industry* could redesign its equipment and home appliances to higher energy-proficient standards as well as standarize on products while recycling wastes.

While some form of national energy conservation may have to be mandated, drastically reducing our consumption of energy could have economic repercussions because energy and the Gross National Product are directly related. What happens to one directly affects the other in much the same way. The only feasible solution seems to be finding an acceptable way to coordinate our energy supply and demand while we wind up our high technology to produce new alternative energy sources for the future.

FUTURE TRENDS

Technical Partnership

There is really no technical problem that American technology, ingenuity and enterprise cannot solve is it really wants to – energy notwithstanding. Technology created the crisis and technology can help eliminate it as well – but it needs an equal partnership with mankind. Solving our nation's energy problem will take the combined efforts of government, business, industry, the academic community, and most importantly, the American people. Without this combined effort working toward a common goal, we can expect a period of growing economic stagnation, extensive unemployment – and a drastic change in our life styles.

The Energy Future

The energy future hinges on three principal factors. They are supply, demand and costs. We know that complete oil independence by the year 2000 is an unrealistic objective because we will always be dependent upon foreign oil imports.

The expert energy forecasters disagree about when the final global energy "crunch" will come. It all depends, they say, on how much petroleum remains, when the crossover point is reached between supply and demand, and the price when the demand exceeds the world supply. Other experts say that unless positive steps are taken soon, the global oil crossover point will occur in the mid-term period of 1985-1990. Although some oil will still be around in 2000, we won't be burning it for fuel. Rather, we will limit our use of it to manufacturing petrochemical-based plastics and synthetic products. In the time remaining, we need to prepare for the transition from the cheap petroleum era to the more expensive high technology era.[3]

Needs Assessment

Econometric Forecast. How much energy do we really need? According to energy models developed by organizations such as the Ford Foundation, Edison Electric Institute, and the Federal Energy Administration, our average domestic energy needs for the future are as follows:

Year:	1985	2000
Quads:[4]		
1. High Energy Use	110.27	186.4
2. Moderate Energy Use	97.07	142.0
3. Curtailed Energy Use	93.50	104.5

To meet these anticipated future needs we need to develop and/or expand all of our alternative energy sources.

[3]Author's Note: I hope my hydrogen-fueled car is fully developed by that time. In the interim period we may all be driving our cars fueled by wood pulp, corn stalks, grain, sugar beets and potatoes.

[4]The quad is the generally accepted unit for expressing large amounts of all types of energy. It stands for one quadrillion (10^{15}) British Thermal Units. A BTU is the amount of heat required to raise the temperature of one pound of water one degree Fahrenheit.

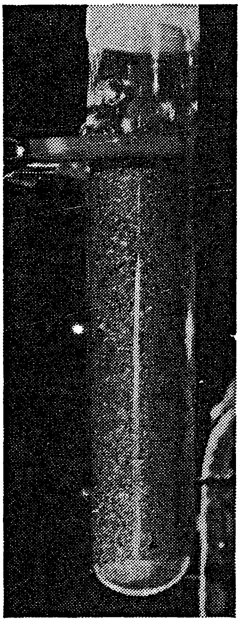
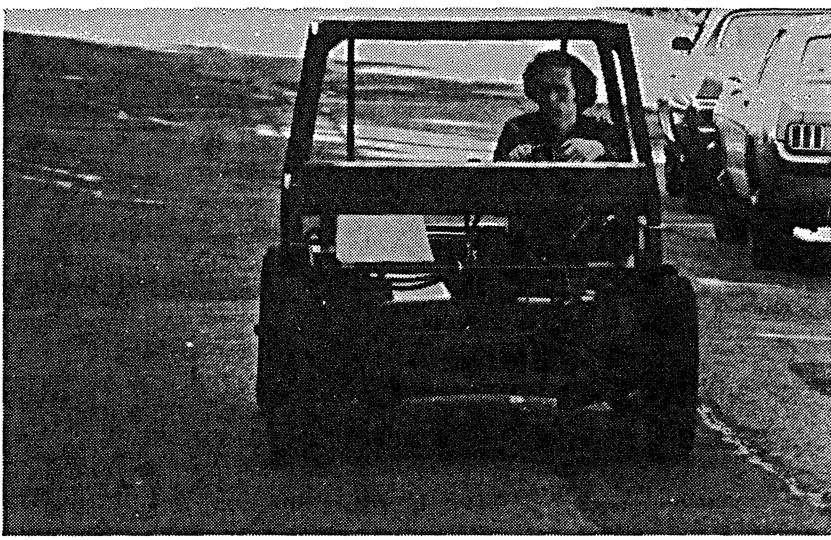


Fig. 5-2.
Test Tube Filled with Iron Titanium Hydride Which is Capable of Storing Tremendous Amounts of Hydrogen Gas.

Hydrogen is one of the most abundant elements on Earth and can be produced through the simple electrolysis of water.

Hydrogen can be made practical for most all types of transportation, and may even be used to produce electricity by a fuel cell directly in the home. Engines and appliances now burning fossil fuels would require relatively minor modifications to use hydrogen.

Energy Research & Development Administration



Department of Energy

Fig. 5-3.
Testbed Electric Vehicle for Full Scale Dynamic Tests of the Power Coupling Between the Roadway Power Source and an Electric Vehicle.

The coupling will be done magnetically, i.e., inductively so that the power will be transferred with no physical contact with the roadway.

Energy Alternatives

The bottom line "solution" to America's future energy problem appears to be the sum of its near and mid-term alternatives. See Table 5-4, Inventory of Energy Sources.

Our current energy alternatives are coal and nuclear power. We also have the technology available to make liquid hydrocarbons from oil, slate and coal.

For the near term period we need to convert coal to synthetic oil and gas, enhance our production from old oil wells, conserve energy to prevent waste, increase the use of nuclear power and increase the efficiency of all our new energy-consuming products.

For mid-term alternatives, we need to move forward in our development of solar heating and cooling, geothermal energy, oil shale, biomasses, breeder reactors, laser fusion, thermonuclear research and thermal gradients of our oceans.

Research on the long-term alternatives must start now if they are to be ready by 2000+. Renewable sources such as solar energy technology and ocean thermal conversion systems hold great promise for large scale production of energy. Others such as wind, and biomass conversion systems will help; however, this represents only a small potential to meet future U.S. energy requirements.

Fuels. Production of alternative fuels may help a little during the short-term period. One such fuel, gasohol, is a blend of 10% distilled organic alcohol and 90% gasoline and could help to stretch the world supply of petroleum until our other alternatives catch up with us.

Synthetic oil produced from shale and coal may be expected to account for 2% of our total oil supply by 1990. However, the conversion of coal to oil carries the added danger of adding large amounts of carbon dioxide to the atmosphere thus producing many tons of carcinogenic chemicals in the atmosphere. The consequences of this interaction is not really known at the present time.

Our domestic reserves of coal are abundant and will supply about 2/3 of the fuel requirements for electric utilities by 1990.

Solar Technology. Our best option appears to be the rapid development of solar technology while the fossil fuels are still available to us.

The biggest problem with solar energy is that the equipment is expensive, the maintenance is high, and it is not competitive with standard heating and cooling units in its present design form.

With aggressive Federal support and industrial cooperation, solar technology (solar electricity from photovoltaic cells, solar heating and air conditioning systems) could be market competitive in ten years and reach its full potential of supplying a quarter of all world energy requirements by 2000.

Table 5-4 — An Inventory of Energy Sources

	Potential for Future U.S. Supply[1]	Status of Technology[2]	Economics	Environmental and Health Impacts
NONRENEWABLE SOURCES				
Oil	8-35 yrs.[3]	Highly developed. Emphasis on improving inground resource recovery and offshore exploration and drilling.	High capital costs, especially for new technologies.	Offshore: oil spills, blowouts, Refineries: minimal air and water pollution, industrialization. Transportation by tanker and pipeline damaging to environment.
Oil Shale	Double the proven[3] reserves of domestic petroleum	Pilot model studies, both mining and in situ, completed.	Current technology not cost effective unless price of oil exceeds $21 a barrel.	Disposal of large quantities of spent shale; water scarcity; air pollution; possible carcinogenic effects on workers.
Coal	600 years[3]	Highly developed. Need for improved pollution control technologies.	High pollution control costs.	Soil erosion and stream pollution from strip-mining; acid mine drainage; hazards to miners; air pollution (SOx,CO_2) and possible "greenhouse effect."
Coal Gasification	—	Pilot stage.	High capital costs. Not cost effective unless price of oil exceeds $15-$20 a barrel.	Except for SOx and metals, impacts of above are magnified; possible carcinogenic effects on workers.
Natural Gas	13-30 yrs.[3]	Highly developed.	Low cost due to controlled prices; minimal pollution.	Pipelines use large land area. Liquified Natural Gas (LNG) transport and storage may be hazardous.
Uranium Fission (LWRs)	30 yrs.[3]	Developed.	Operating costs competitive with fossil fuel plants; construction costs higher; future costs of uranium uncertain.	Storage of radioactive wastes; possibility of reactor accidents; thermal pollution.
Plutonium Breeder (LMFBR)	Very large	Experimental.	Costs of uranium reprocessing, storage, decommissioning plant sites unknown.	Same as above; possible explosion; nuclear proliferation, sabotage.
Fusion	Very large	Experimental.	Low cost fuel; high cost equipment.	Possible leakage of tritium; radioactivity produced in reactor materials but less radioactive than LWR or LMFBR fuels.
RENEWABLE SOURCES				
Hydroelectric	Small	Highly developed.	Most potential sites already developed; high construction costs.	Damming affects land use patterns, fish and wildlife habitat, availability of water.
Geothermal	Small	Developed for dry steam; pilot stage for wet steam and dry rock reservoirs.	Capital and operating costs competitive with fossil fuel plants.	Land subsidence, minimal air and water pollution.
Wind	Small	Storage technology uncertain.	Capital costs uncertain.	Land use, aesthetics; possible weather modifications.
Solar Heating/Cooling (H/C)	Large, but limited, by market potential	Commercially feasible.	Cost competitive with electric h/c systems; installation costs decreasing; indirect savings in pollution.	Aesthetics; possible weather modifications.
Solar Electric	Very large	Experimental.	Not cost competitive.	Same as above.
Bioconversion	Small	Highly developed for small-scale timbering, organic waste burning.	Large-scale systems not yet demonstrated as cost competitive.	Aesthetics, impacts on land and water use, air pollution.
Ocean Thermal Energy Conversion (OTEC)	Large	Experimental.	High capital costs.	Aesthetics, possible climatic changes, navigation hazards.

[1] It is difficult to characterize the potential for nonrenewable sources in the same way as for renewable sources. Estimates for nonrenewable resources are based on proven reserves; estimates for renewable resources as well as the plutonium breeder and fusion are characterized as small or large potential in comparison with our total energy use.

[2] The more experimental the technology, the less is known of its potential and its impacts.

[3] Based on proven reserves at current rates of consumption.

Breeder Reactor. Compared with other means of electric generation, the breeder reactor is comparatively clean. It uses a mixture of uranium and plutonium and, therefore, poses the problem of disposing of nuclear wastes.

Lockheed Missiles and Space Co., Inc.

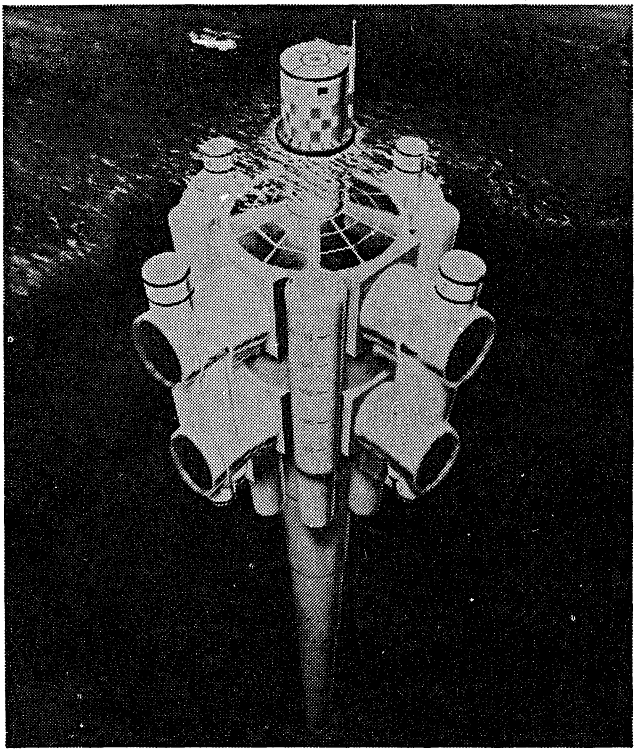
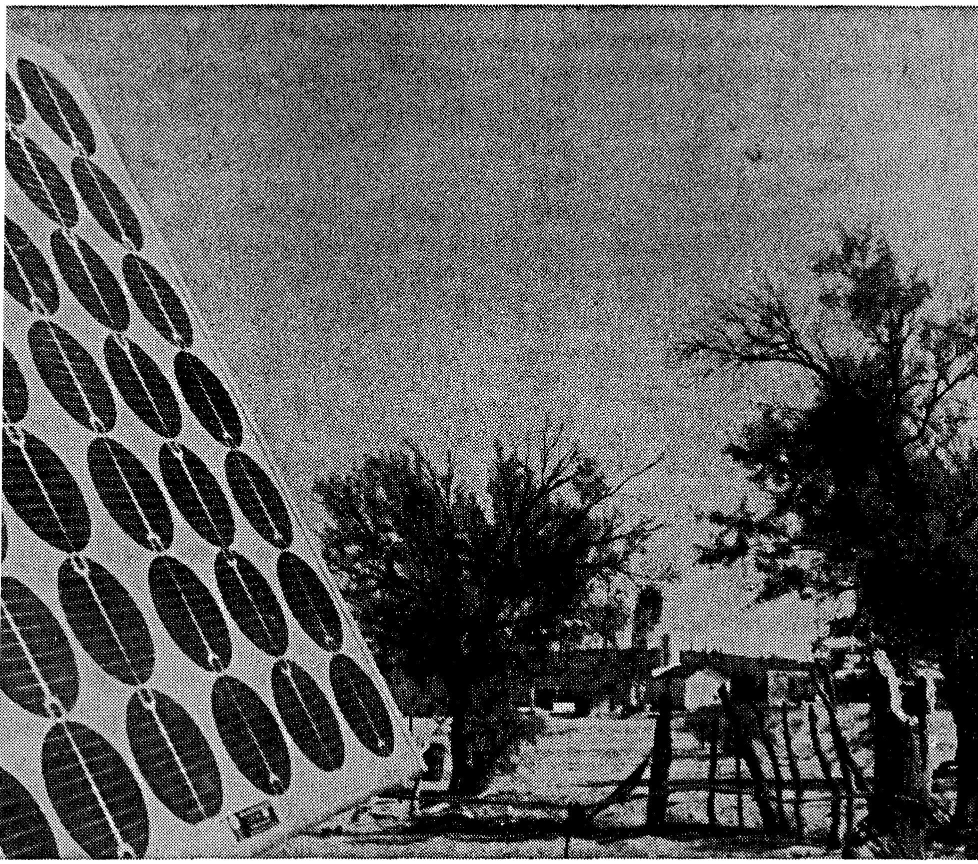


Fig. 5-4.
Electrical Generating Platforms Floating Beneath Ocean Surface — One Method of Tapping the Sun's Energy Stored in the Sea.

The oceans collect and store solar radiation as heat energy in the upper surface layer. Their thermal gradient is large enough for a fluid, like ammonia or propane, to be vaporized at the higher temperature and condensed at the lower. The vapor turns a turbine, which drives a generator to produce electricity.

It is 250 feet in diameter and 1600 feet long and weighs about 300,000 tons. It is designed to send 160 million watts of power ashore to distribution networks — enough power to fulfill the needs of a city with 100,000 residents.

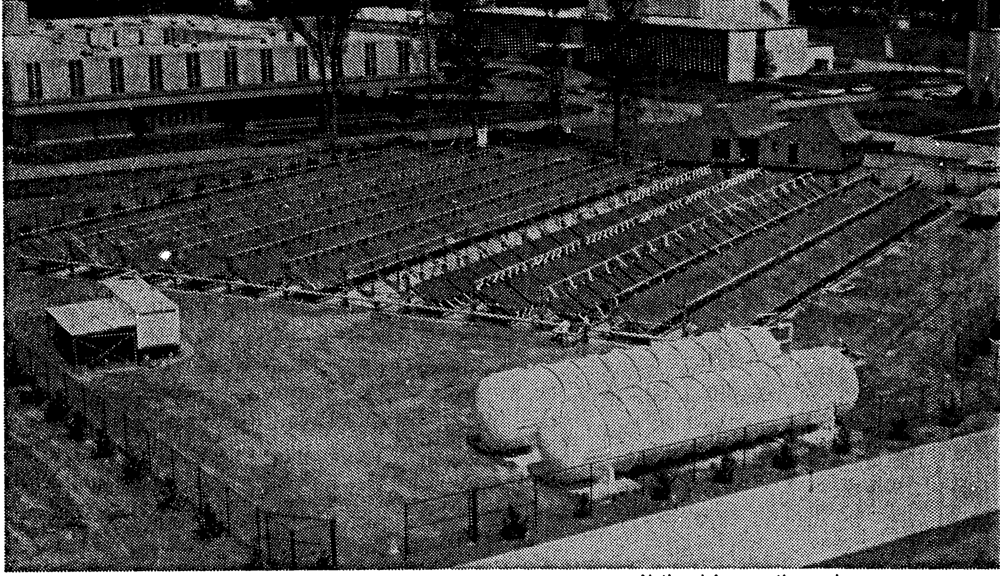


National Aeronautics and Space Administration

Fig. 5-5.
World's First Solar Electric Village Power System.

Funded primarily by the Department of Energy, the Schuchuli Photovoltaic Village Power Project is managed by NASA/Lewis as part of the Department of Energy's National Photovoltaic Conversion Program.

The new 3500-watt (peak) solar electric power system will provide Schuchuli's 96 residents with sufficient electricity to power 15 4-cubic-foot refrigerators, a standard wringer-type washing machine, a sewing machine, a two-horsepower water pump (5000 gallons per day) for the community well, and 40 fluorescent lights for the 15 homes, church, feast house, and new domestic services building in the village of the Papago Tribe of Arizona.

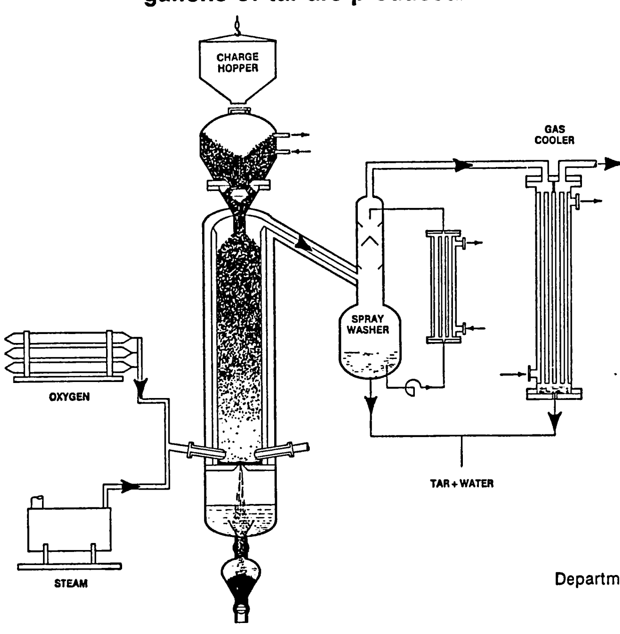


National Aeronautics and Space Administration

Fig. 5-6
Solar Collector Array at Langley's Research Systems Engineering Building.

This system supplies 75% of the energy used to heat and cool commercial type buildings as shown at top left. The Langley solar energy single residence home is shown in right of center. The system's storage is in the two tanks at bottom center.

Fig. 5-7.
A schematic drawing of a coal gasification plant. For every ton of coal gasified, about 37,000 cubic feet of gas and seven gallons of tar are produced.



Department of Energy

Electricity Generation

Hydro. Hydroelectricity, which receives its energy from a mass of water flowing in a down hill direction, produced 17% of the country's electrical energy needs in the 1970's. Although all of the possible sites for hydroelectric development haven't been fully exploited, most of the best sites already have. Therefore, it is very doubtful if a major expansion of this renewable source will be seen in the immediate future primarily because of opposition on environmental grounds.

Geothermal. Although the feasibility of producing energy directly by geothermal means has been proven as feasible for some locations, it can produce severe environmental side effects. For example, some of the geothermal reservoirs emit hydrogen sulfide gases which, when concentrated, can be a severe health hazard. In any event, this source of energy would provide only a small proportion of the total needs at best.

MHD. Although the principle of magnetohydrodynamics is a century old, the basic concept may be used to generate clean and economical energy for the future. Using coal, MHD generators would use half as much water as conventional electrical generating plants yet have enough heat in the system to produce steam for a steam generator. In effect this would enable a utility to produce more power with less coal thereby increasing output efficiency up to 50% – compared to 38% for conventional oil or coal fired plants and 36% for nuclear plants.

One 1,000 megawatt plant would provide enough energy for over 500,000 homes!

MHD method of generating electrical energy is still in the early research stage and probably won't come on line until 2000+.

Biomass. Producing fuel from plants is no more difficult than producing beer from hops. The photosynthesis process is currently being

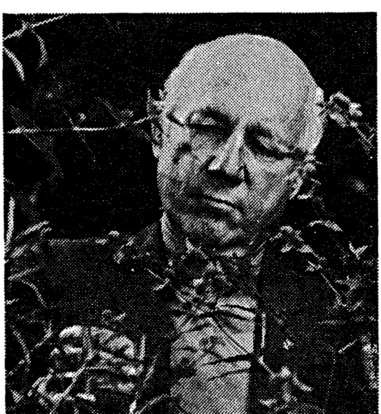


Fig. 5-8.
Biomass.

Dr. Melvin Calvin of the University of California-Berkeley examines Euphorbia lathyris, a member of the poinsettia family. In a study for the Department of Energy, this weed that grows wild could be cultivated on semi-arid land to produce petroleum.

Department of Energy

examined as a future annually renewable resource for energy by Melvin Calvin, a 1961 Nobel Prize winner for Chemistry at the University of California at Berkeley. This process may take two forms. They are, (1) the production of fermentation alcohol from sugar cane, and (2) the direct photosynthetic production of hydrocarbon from known plant sources. Calvin stated that his studies indicated that some green plants can produce up to 10 barrels (or 420 gallons) of oil per acre each year. We may see huge "green plant" factories exclusively for the production of hydrocarbons for fuel, fertilizers and other synthetic materials. This could be the start of the first "Gasoline Plantation." This biomass development could be the start of a new synthetic process which would liberate us from the agricultural limitations and more directly convert solar energy directly into hydrogren, using sea water as its raw material.

Another plentiful biomass material with potential for energy generation is garbage. It has been estimated that Americans produce over 400 billion pounds of garbage each year. In addition to garbage producing natural gas on a large scale, animal manure appears to be a feasible and cheap source of fuel for parts of the country. In Texas 500 tons of cattle manure can be converted into five million cubic feet of methane gas, enough to supply 5000 homes in the winter with heating fuel. Methane gas is produced by anaerobic bacteria which grow in the absence of oxygen. The product of the bacteria's metabolism is methane. The cost of producing methane by the anaerobic method is now competitive with natural gas obtained from well heads.

Wind Energy. Wind energy holds many advantages for us. It is clean, free, renewable, easily produced and predictable: it is estimated that at least 20 to 40 percent of the nation's total energy supply could be provided by wind energy generating systems. The problem is to build a dependable system that can supply energy when there is little or no wind. Despite modern technological innovations, practical wind turbines are still limited to a standard one Megawatt power output. As energy costs rise the economic feasibility of wind machines becomes more cost-effective as an alternate source of generating electricity for small and medium-sized communities and farms.

Energy storage is an essential element for wind, solar and photovoltaic systems. Many new storage techniques are being developed for delivering energy when the wind is not blowing nor the sun shining.

Power from Space. In the future era of high energy technology we will probably see a network of huge orbiting satellites, each one 10 miles long and supplying the electrical energy needs of our major cities. Through grids, the network of energy satellites would generate a major portion of the nation's energy requirements. A prototype of the jointly sponsored NASA/DOE Satellite Power System is projected for 1995.

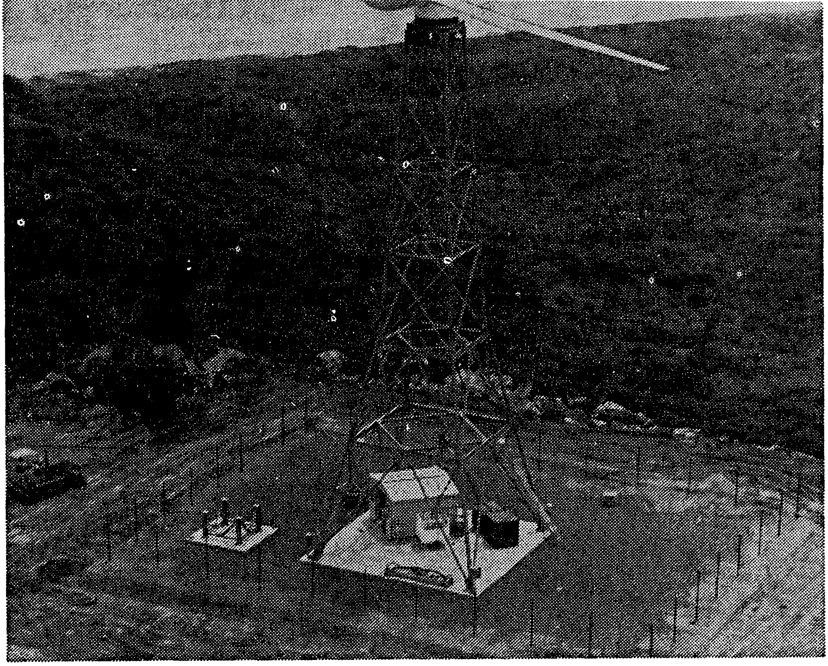


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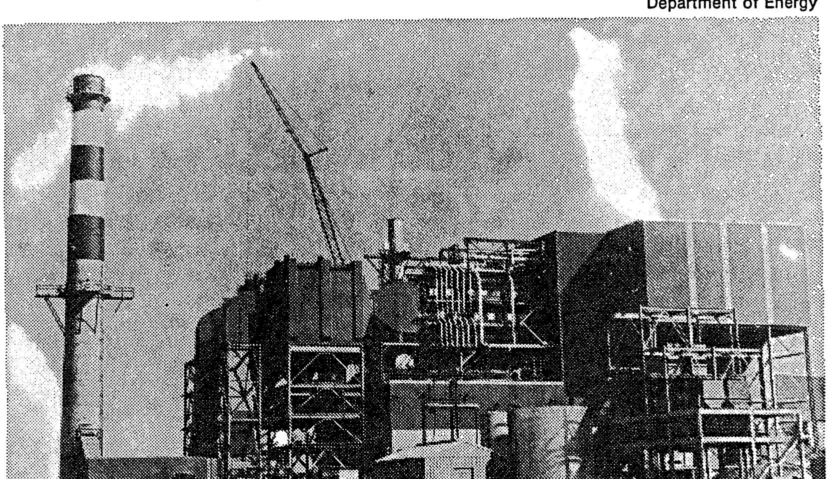
Fig. 5-9.
Wind Energy.

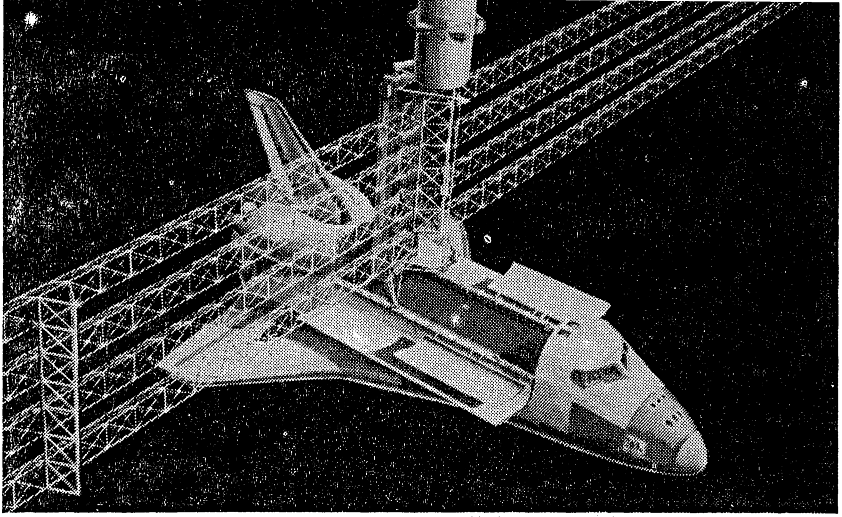
A large, modern wind turbine generator located on Culebra Island, Puerto Rico, has two rotor blades spanning 125 feet, which produce 200 kilowatts of electric power in winds of 18-34 miles per hour. The machine, designed and built by NASA's Lewis Research Center in Cleveland, Ohio, is expected to provide the equivalent of about 20 percent of Culebra's electric power demand.

Fig. 5-10.
Refuse to Energy.

The plant is designed to burn garbage. The heat from burning trash will produce steam to provide energy to generate electricity for a manufacturing plant.

Department of Energy





National Aeronautics and Space Administration

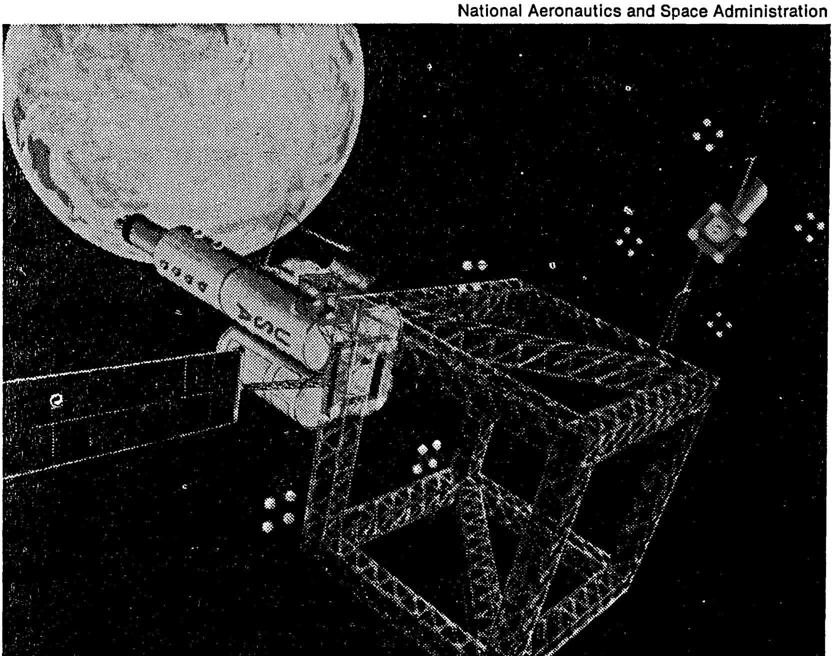
Fig. 5-11.
Shuttle Space Manufacturing.

This artist's conception depicts a beam builder (B-2) fabricating a cross member to be joined to the four longitudinal members of a large structure in earth orbit, which is a development step for proposed space solar power systems. The Space Shuttle Orbiter would serve as both a means of transportation and a work base for the construction.

Fig. 5-12.
Solar Power Satellite.

An artist's conception of the Solar Power Satellite structure, solar cell panels, and reflector panels being fabricated. The Solar Power Satellite will be located some 36,000 miles above the Earth.

National Aeronautics and Space Administration



The Bottom Line

Although we temporarily solved the energy crisis, we still have the energy problem. It would seem that our predicament was brought on by misdirected technology and use of our energy resources. For years, we have relied mostly on our least abundant source and least on our most abundant source – coal. The time to switch has come.

We need a strong national commitment to energy conservation during the interim period, while we gain time for our technologies to wind up to high gear. Conservation measures need incentives to be successful, and not exhortations alone.

We are in great need of one National Energy Policy instead of the fragmented efforts of over 100 governmental agencies concerned with various aspects of the energy problem.

We need to develop "energy literacy" in our population. We must provide more and better information about energy technology for our students. By wise use of technology, which requires technical understanding and cooperation from government, business, and the public, we might eventually arrive at the best and most promising approach to help solve many of our present and future problems.

INDUSTRIAL ARTS ENERGY-RELATED ACTIVITIES

The following are suggested instructional strategies that are realistic and hold interest for Junior and Senior High School students. No special facilities are required for any of these activities. Modeling techniques and handouts will suffice for most activities suggested.

A. For Junior High School Students:

Energy Concept	*Strategy*
The Dilemma	On the basis of your current knowledge of the energy problem state your opinion of the following: a. Is there really an energy crisis? b. If so (or if not) who is to blame? c. Who are the big users of the energy pie? d. What can everybody do about it?
Technology Research	Develop a chart that will trace the history of energy development down through the ages. Present to the class.
Measurement	Electricity is probably the most accurately measured purchase you will every make. For the next two weeks, read and record AM and PM meter readings at the same

	time each day for your home or school. Plot readings on a chart. Calculate the cost of the kilowatts used during the reporting period. Share findings with class.
Measurement	Heat one pound of water to increase its temperature one degree Fahrenheit with one type of energy source. How long did it take? Select another energy source and heat a different pound of water by the same amount. How long did this take? Which energy source produces one BTU the fastest? Why?
Supply/Demand	Visit your local power utility and determine the demand curves for their system for a specific period. Chart and analyze your findings. Try to ascertain their costs for producing one kilowatt of power. Later, ascertain the cost to the customer for one kilowatt of power. State your conclusions.
Sources	Solar Fuel: Obtain a thermometer and measure the sun's heating power each hour on a clear day (both winter and summer). Chart results. Fossil Fuels: Place small amounts of different kinds of fuels in bottle caps or similar containers. Ignite one at a time and have students analyze in terms of incomplete combustion (residue), flash point, heat produced, pollution (smoke particles), etc. Chart results and draw conclusions.
Conversion	Devices: Design, fabricate, test, and report upon the effectiveness of the following techniquies: a. Cook hotdogs in the sun. b. Produce steam to do work. c. Wind device to produce electricity. d. Electric bike using a battery. Large wattage bulbs use more energy than smaller wattage bulbs. Obtain a 25 watt bulb and try it out in different fixtures in your home. Were you able to change many of your light fixtures to 25 watt bulbs – permanently?

Research	Develop a small working model of a solar powered sea water desalination plant and demonstrate its effectiveness to the class. Research and fabricate a small model of a "gasification of coal" plant. Label and color code all parts. Explain its operation to the class.

B. For Senior High School Students

Energy Concept	*Strategy*
The Dilemma	Using library resources, research the energy problem and present a report to the class outlining your views of our current energy dilemma.
Supply/Demand	Energy demand depends upon such factors as population growth, economics, environmental considerations, political, social and technological aspects. Develop a plan on how we can live with less energy without disturbing any one of these factors too much.
Codes and Regulations	Research the thermal-efficiency standards for lighting and building construction for your city, country or state and report findings to class.
Insulations	R-numbers determine the value of a substance in reducing winter and summer heat losses. Using waste materials, such as sawdust, paper, etc., fabricate several test panels and establish the R-value for each. Compute relative costs vs. commercial products and present your findings to the class.
Increased efficiency	According to the experts one-third to one-half of all energy produced in the world is lost to friction. One solution advanced was the use of synthetic lubricants. Select some simple piece of equipment or machine and try to reduce the frictional losses. Demonstrate your solution to the class.
Conservation	Industrial: Develop a device to trap the sun's energy and transfer it to a small demonstration kiln for drying hardwood. Explain your process.

Devices: Design, fabricate, test, and report upon the effectiveness of the following techniques.

a. Solar water heating for lab sinks.
b. Air turbine to do work.
c. Solar powered model car.
d. Model solar power house.

Sources

Combining Hydrocarbons:
Produce and test in a small gas engine the following blends of "gasohol" using a distilled organic alcohol and gasoline mix. Record results on a chart. Determine optimum range of blends you would consider using in your car.

a. 10% Alcohol; 90% Gas
b. 15% Alcohol; 85% Gas
c. 20% Alcohol; 80% Gas
d. 25% Alcohol; 75% Gas
e. 30% Alcohol; 70% Gas

Compare emission and performance standards.

Fossil Fuels:
Determine which class member can devise a method of boiling a small soup can or beaker of water with the least amount of fuel.

Fuel-Using Habits

Survey:
With another team member to help count, stand on a busy street corner for 30 minutes and record the following data for later analysis.

a. Number of gas-guzzlers observed?
b. Number of small cars observed?
c. Number of people in all cars observed?

Technology

Design a device to convert the D.C. output of a solar cell to A.C. and display waveshape on an oscilloscope. Demonstrate your device and describe your technique to the class.

Life-Style Modification

The question of limited availability of future energy sources coupled with high fuel costs could change our life style considerably. Discuss such changes in terms of the following parameters:

a. Modes of transportation
b. New technology
c. Standard of living
d. Influences on construction standards
e. Business transactions
f. Individual mobility
g. Urban and rural life
h. Capital investments
i. Political implications
j. Social changes
k. Effect on environment
l. Leisure activities

Assessment of Alternatives	Conduct a technology assessment of any one of the future energy resources in terms of pollution, environment, and implications for humankind, etc. Report your findings to the class.
Simulation	Research and construct a desk top Energy Technology Simulator that will register the amount of energy resources available for five-year periods from 1950-2000.
Future	Design an off-shore floating nuclear power plant model to include the reactor, turbine hall, control room, living quarters, water in lake and discharge tubes, spent-fuel pit, transmission cable to shore, mooring caissons, and breakwater-caissons.
Research	NASA/DOE have an orbiting Solar Power System on the drawing boards to supplement tomorrow's power needs. Develop a model of a satellite that would convert solar energy to electricity and beam it down to a model receiving station and distributing system.
	Organize a research team to convert a stock Volkswagen chassis to a two-passenger, deepcycle electric vehicle capable of going up to 50 miles on one charge. Test vehicle and publish a paper on the project and results obtained.
Scenario Writing	Inventing alternatives: Write a scenario of what you believe everyday life will be like based on one or more of the following predictions.

	Prediction	*Year*
	Petroleum Ranches	1990
	Space materials for energy	2000
	Lunar colonies	2010
	Anti-gravity vehicle	2024
	Extra-terrestrial communications	2026
	Direct mind-to-mind	2030
	Direct knowledge implantation	2050

Vision

What if:

a. Gasoline costs $50.00 per gallon
b. Oil went up to $10.00 per liter
c. Grease jobs were $25.00 each
d. Tires were $150.00 each
e. Price of small cars up to $20,000 each.

What will your generation do to add to the energy-time line?

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Yen, James T., "Harnessing the Wind," *Spectrum,* Institute of Electrical and Electronic Engineers, New York, N.Y., Vol 15, No. 3, March 1978, pp. 42-47.

Resources

Brochures, Charts, etc.:

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Other:

35mm slides, Filmstrips and Books on Energy and Environmental Developments. Catalog available from James L. Ruhle and Associates, P.O. Box 4301, Fullerton, CA 92631.

Film: 16mm, 28½ min. color film entitled, "Challenge of the Future," available free from ERDA, Administration, Film Library, P.O. Box 62, Oak Ridge, Tenn. 37830.

Devices:

Simulator: An Energy-Environment Simulator is available from Energy Information Services, Inc., 229 Seventh Avenue, New York, N.Y. 10011.

Solar Information:

National Solar Heating and Cooling Information Center, P.O. Box 1607, Rockville, Md., 20850. Call Toll Free (800) 523-2929.

U.S. Dept. of Energy, Office of Public Affairs C-460, Washington, D.C. 20545.

Additional Alternative Energy Information:

There are several NASA Centers which are actively involved in research and development of alternate energy systems. For example, NASA Lewis Research Center in Cleveland, Ohio, has been doing research for many years on large wind generators, solar cells for terrestrial application and solar panels for heating and cooling applications. In addition to the 100 kw wind generator at Lewis Plum Brook Station they're managing to construct an operation of several larger units through a cooperative program between private utilities and the Department of Energy.

NASA's Marshall Space Flight Center in Huntsville, Alabama has been managing the application of solar panels to residences. Both NASA Langley

Research Center and Goddard Space Flight Center also have solar energy projects underway.

For additional information on alternative energy systems, write to the Public Information Offices at the following NASA Centers:

National Aeronautics and Space Administration
Washington, D.C. 20546

Ames Research Center
National Aeronautics and Space Administration
Moffett Field, CA 94035

Hugh L. Dryden Flight Research Center
National Aeronautics and Space Administration
P.O. Box 273
Edwards, CA 93523

Goddard Space Flight Center
National Aeronautics and Space Administration
Greenbelt, MD 20771

Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, CA 91103

Lyndon B. Johnson Space Center
National Aeronautics and Space Administration
Houston, TX 77058

John F. Kennedy Space Center
National Aeronautics and Space Administration
Kennedy Space Center, FL 32899

Western Operations Support Office
National Aeronautics and Space Administration
P.O. Box 425
Lompoc, CA 93436

Langley Research Center
National Aeronautics and Space Administration
Langley Station
Hampton, VA 23665

Lewis Research Center
National Aeronautics and Space Administration
21000 Brookpark Road
Cleveland, OH 44135

George C. Marshall Space Flight Center
National Aeronautics and Space Administration
Marshall Space Flight Center, AL 35812

Michoud Assembly Facility
National Aeronautics and Space Administration
P.O. Box 29300
New Orleans, LA 70129

National Space Technology Laboratories
National Aeronautics and Space Administration
Bay St. Louis, MS 39520

Chapter 6

Housing

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BACKGROUND OF THE PROBLEM

At this juncture in time, less than twenty years to the 21st Century, many Americans find themselves and their families enjoying excellent housing. It has been estimated that nine out of ten American homes have indoor bathrooms. Electricity reaches 99.8 percent of the homes while running water is piped indoors to 92.7 percent of the houses. Affluence has enabled a number of industries to concentrate on various home-oriented products. Production and sales of housing are major components of economic life and fluctuate with the general business cycle.

Yet, even in this era of unprecedented national wealth there are citizens dwelling in homes that are inadequate by modern standards. This problem of unavailable and inadequate housing is not new. Strauss (27,1) opens his treatise on housing thus: "From the dawn of history until today the housing problem has been with us." His sentiment is common among housing experts who generally agree that the problem is a worldwide phenomenon.

For members of the developed world the problem of housing differs from that of less-developed countries. The problem in developed nations lies in the centers of population, the urban city. New York, Paris, London, Moscow, and Tokyo have similar problems of overcrowding and substandard housing for a large segment of the inhabitants. Assessment of housing for the continents of Africa, Asia, and South America reveals a different set of problems. Worldwide analysis reveals poor housing in all geographical areas from Recife in Brazil to Bombay on the Asian continent.

Specific problems of housing in America range from those of providing housing for the urban poor to establishment of agencies to facilitate housing for the aged. Other problems include providing housing for native American Indians, for the rural poor, for the handicapped and sick, for the mobile citizen and his family, and for the young family. Solutions and alternatives are both diverse and complex.

The fact that new units are being built constantly is no insurance of housing adequacy for the year 2000. It is anticipated that technological changes in the coming two decades may necessitate major renovation work in existing units. The tasks facing present day man may be drastically different than those of the future. However, the lesson of history suggests that housing problems shall occupy the time of societies of the future. The question advanced here is: Will industrial educators be able to make the necessary choices as to the learning experiences which will best serve children and adults in adjusting to the future?

A dilemma confronting the industrial arts educator is the abundance of information and options available from which decisions regarding housing will be made. Whereas educators of an earlier period emphasized housing based upon family-oriented society, the trend of expanding the number of lifestyles does in fact pose a problem in the selection of content. This expansion of acceptable lifestyles as reflected in housing patterns may necessitate reexamination of the curriculum.

The changes in societal mores related to family, work, sex roles, recreation/leisure, and transportation may have a far-reaching repercussion in design and technical treatments. Requirements of residential retirement villages will differ somewhat from young family suburban developments. City townhouse design catering to urban professionals may call for other features in the building process. A lifestyle based on hedonism may require features in housing focusing on leisure pursuits.

Lifestyles in large measure foster consumption patterns of homeowners. Allocation of housing in America is somewhat dependent on the socio-economic status of the consumer. Partly through free choice and in part by chance, the selection of housing in America reinforces the manner in which citizens conduct their lives. The division of housing and other human pursuits on the basis of function has resulted in new building patterns. Thus, there have emerged cities that are devoted to leisure, others to business, and still others devoted to the housing of families.

Transition in lifestyles has been characteristic of the population. Housing programs of fifty years ago are not adequate to meet the needs of present-day America. For example, half a century ago young adults, especially women, migrating from rural areas into the large cities were often domiciled in residential clubs and dormitories. During that period it was the familiar "Y," Eleanor Club, Arlington Farm, and other "home-away-from-home" for American womanhood. Residential patterns of modern young adults are somewhat different; the growth of apartment living is planned to cater to the mobility, recreational, and social needs of tenants. The common social hall, swimming/health facilities, parking areas for automobiles, and coin-operated laundries are familiar features of apartment dwelling which either were absent or optional in the housing schema of a generation ago.

A perusal of content in the industrial education curriculum suggests the core of housing materials and information focused on an idealized version of adequate housing, that of small town and suburban America. This narrow view is reflected in the activities and content that incorporated the single family home with two or three bedrooms as the initial point of study. To this base the student was taught to think in terms of the recreational needs, the storage of automobiles, the need for shelter for a dog, and the placement of such items as a lawnmower and other garden tools. Basically, a generation of students learned about the virtues of a single lifestyle while the possibilities of other modes of living were neglected.

CURRENT STATUS

The problems in current housing of the population and the diversity of requirements for modern living does not diminish the fact that most of this nation's housing is the resultant of human dedication to erecting habitable shelter. It is the exception when shelter classified as housing has not had the touch of human manipulation in the construction or remodeling process. There are small pockets of people that utilize natural shelter as their home, but for modern American families the question of housing generally includes the element of some human management. The practices of "street sleeping," "cave dwelling," and other forms of housing falling below the minimal acceptable standards in America are not prevalent nor a common occurrence.

American housing can be as simple as that which is planned, financed, and constructed by an individual or it can be as complex as that requiring the efforts of many people. Too, materials range from the primitive and raw to modern sophisticated man-made compounds. These materials are represented by raw earth, uncut stone, and rough timber on the one extreme to plastics, rare alloys, and adhesives on the other. The dominant feature of modern building is the dependency on a number of intermediary bodies to process, manufacture, and distribute the materials that go into the building of a house. In an earlier period the family and local community dominated the thrust in the labor utilization process; today the allocation process calls for the marshalling of many hands with differing skills. Fluctuations in the labor market can curtail activity as easily as the lack of materials in the process of modern construction.

The raising of a home in pioneer America was primarily a problem of construction. The crucial question centered around the problems pertaining to the availability of materials and the adequacy of the artisan. Today the problem differs somewhat in that the technical construction problems are not as crucial as other requirements in the building process. The preliminary processes preceding actual construction are often as time consuming as the building process and may necessitate long hours of tedious labor. Codification of building requirements has led to the need of individuals with skills in developing environmental impact statements, subsidy and loan projections, and other technical requirements in the clearance process. Growth of public housing, renovation projects, historical site preservation, urban homesteading, and other contemporary alternatives have generated need for individuals with new skills.

If future practice will follow that of the past, man will continue to be primary initiator and maker of houses. As in the past, houses will reflect the requirements of man and his society; it will be through his ingenuity that homes will be uniquely human in time and place. The school industrial arts program does have some responsibility in assisting children to be equal to that task.

Housing the Affluent and the Poor

Affluent Americans are well housed by any standard developed to measure quality of housing. For those who can afford to bear the costs of housing, there are many options. Apartments, townhouses, condominiums, cooperatives of various kinds, and single residential dwellings are available on the market for those who have the economic means. Second and third homes in form of summer cottages, ski/winter cabins, lodges for the outdoors person, retreats, and other kinds of shelter are part of the variety being marketed in the housing pattern. Geography is only limited to the planet earth.

Today, housing for the affluent is being found in greater numbers outside the urban core. This practice differs from an earlier period which found many affluent families residing closer to the center of the city. The improvement of transportation has enabled the growth of residential housing far from the centers of work and business. Since the termination of World War II, there has been an exodus of middle class families from the cities into the developing suburbs which fringe the core areas. The movement, when translated into numbers, is staggering. In the period from 1950 to 1960, over a million white, non-Puerto

Rican, residents moved to the suburbs of New York City. The demand for new dwellings sought by the migrants to the new suburbs has, as yet, not been met in full. The scope of new starts in housing is an immense undertaking when one views the growth of suburban areas such as Orange County, California and other centers of in-migration.

The flight of the affluent to the suburbs has led to problems in transportation, education, health/medical facilities, and government. The net effect of this movement away from the hub that is the city has contributed to the rate of decay of a number of American cities. The poor have been relegated housing in the city. Further, the totality of housing schemes for the poor has been less than adequate. Public-funded housing projects designed to bring dignity to family living and individual residents have not made appreciable gains. A large proportion of the poor continue to suffer the deprivations brought about by overcrowding and deteriorating facilities in unhealthy environments.

Unlike housing of the affluent, the problem of the poor in many cases is that even low-cost housing is beyond their economic means. It is a fact that a large proportion of the available income of the poor is expended on food and housing. The inability to afford better quality housing is compounded by the high tax rates in cities, the lack of maintenance in the dwellings, and the low return rate from rent of low-cost housing.

Elimination of condemmed housing units without replacing those which are demolished further narrows the options open to the poor. The growing trend toward demolition followed by urban renewal projects has displaced numerous poor people. Wholesale displacement has led to scarcity of affordable rental units and has contributed to the practice of overcrowding. While it is true that cities such as New York have lost millions in population to the suburbs there has been a simultaneous movement of migrants into the vacated areas. Many of the new residents in the cities border on the poverty level and crowding into inadequate housing is a logical response to meet the economic realities of the situation. Extremely high land costs in the urban core automatically eliminate ownership of homes for a large majority of the destitute. For most of them the role of tenant is a fact of life.

To ease the problem of housing among the poor, both state and federal government have allocated funds for housing projects. The Community Development Block Grant (CDBG) Program under Title I of the Housing and Community Development Act of 1974 has been a major source of funding projects designed to stem the tide of poor conditions of housing for families living below the poverty levels. Despite the infusion of federal dollars the status of housing for the poor remains grim. Major building projects unfortunately require (1) equally large condemnation and demolition projects to clear out unsafe and old structures, (2) the rebuilding of old waste removal, water, and utility systems, and (3) immense planning with regard to services such as transportation, health, and education. The high cost of construction of housing for the poor is, in part, the result of the need to improve the outdated delivery services of cities in general.

Housing strategy for the poor is complex and the few successful ventures have been affected by many contingent factors. The range of strategies encompasses those advocating direct subsidies to the poor to that advocated by others calling for outright neglect. Still others have advanced a plan that is premised on subsidizing the rich to start the "chain of moves" wherein the poor will eventually fill the units vacated by those who occupy the slot in the economic order above them. A policy of housing has not been developed which has been acceptable to all. Whether the rich should be subsidized or whether the poor should be given preference is open to debate. It is clear that this problem will not be a simple one to solve.

Crisis in the Cities

The housing problem has reached crisis proportions in some cities of the world. In the United States the problem is more acute in the older cities of the East and those of the Midwest. The passage of time has rendered block upon block of residential units unfit for human habitation. Many of the older cities have utility systems that cannot carry the services required of modern day living. Demolition of substandard housing unfortunately eliminates from the city's inventory the available stock of units as well as the needed taxes to provide various services.

Inadequate housing in deteriorating neighborhoods contributes to the process of expansion of slums. The demise of large sections of central cores of cities has led to the isolation of the poor. Inability to bear the costs of transportation to the new places of business located out of the blighted areas has deepened their sense of frustration. The cycle of decay leads to a point where wholesale urban renewal programs become necessary. The cost in human lives and dignity is high, losses which contribute to the woes of society.

The squalid conditions of housing are reflected in turn in the drop of quality of the neighborhood businesses and public services. Abandonment of housing and businesses in many cities has become commonplace. Schools, churches, and other public places often show signs of wear and neglect. It is to correct this situation that novel ideas for rehabilitation have been generated. Urban homesteading has been tried in a number of cities in the East. However, if city life in blighted areas is to improve more massive programs must be initiated.

Sternlieb made a thought-provoking point when he said, "If a gross simplification may be permitted, the problem of the slums is one both of plumbing and morale." (28,335) Further, he suggests past solutions have focused primarily on plumbing while overlooking the problem of morale and attitude. The amenities of new public housing and other facilities are somehow poorly coordinated with available jobs for its dwellers. Solution of urban problems in the slums is likely to continue to fail by pursuing a policy of producing new housing units without a change of a more hopeful future for its inhabitants.

The cost to cities with severe housing problems is estimated to be very high: increased welfare costs, more fire and protection services, an overburdened court system, additional social services, and unpaid taxes. The loss is amplified as uneasy businesses and industries relocate while other businesses curtail the size of operations. Commerce within the cities drops as the per capita income drops. Extreme deterioration in housing contributes to the general breakdown of human relationships both in and outside of the family. Severe hardcore slums tend to drag peripheral neighborhoods into their sphere.

The poverty areas in many cities make up a substantial proportion of the location of housing for the poor. A commission report of 1968 (17,378) noted the city of St. Louis had 38.0 percent of the total area of the city in the poverty classification of which 87.0 percent of the population was nonwhite. In the same report, Birmingham, Alabama had 45 percent of the city classified as poverty stricken; Detroit with 24.8 percent was another city with a high poverty classification. The figures of the study led the commission to note that in most cities studied, the nonwhite population occupied those areas in greater numbers than whites. It was also noted that substandard housing comprised about 75 percent of the housing in the poverty areas.

Cities once thought to be exciting and desirable places to live are now being described in some instances as unsafe, dirty, and miserable. The cost of land and its acquisition, labor costs, the tedious process required to obtain clearances from public agencies, and the indirect costs to store and transport materials and supplies all work against the rebuilding of housing by small entrepreneurs. Construction of housing in cities is most profitable in large scale undertakings. Multiple-story housing, as opposed to single dwellings in renewal areas, has become common because of the economic factor.

To the credit of American cities and their inhabitants, the efforts to rejuvenate the status of housing and life in general still continues. Both the federal and local governments in many of these embattled cities have initiated numerous projects to thwart the forces of decay and destruction. The faith in the idea of the city by its inhabitants may be the most valuable asset in the revival of urban America.

Housing: Energy, Water, and Air

The closing of schools during the winter of 1976-77 because of the necessity to conserve fuel for home heating in Columbus, Ohio is typical of the problem that faces the nation at present. School buildings in Columbus were closed because of the fuel shortage but the ingenuity and will of the population saw to it that education continued in various places, including the homes of its citizens. The energy crisis directly affects the housing of the population. Dominating the day to to day conversations and popular press are the descriptions and reasons whereby heating residences can be made more efficient and more effective. Terminology such as insulation, R factor, and degree days has become part of the language of consumers. Homeowners and housing specialists are being asked to consider solar heaters as an alternative energy producer. In the State of Hawaii television advertisements sponsored by a gas company request consumers to consider purchasing solar panels for hot water heating.

Energy costs to maintain heating in housing have risen appreciably in the past few years. The bulk of the nation's homes still utilize either oil, gas, electricity, or coal as the source of heat. For some city dwellers steam generated through central stations provides warmth. As yet, housing in the United States cannot claim to have an economically significant number of homes utilizing solar heat. Windpower and fusion reactors are still experimental in terms of large scale application. The utilization of energy for heating starts after the occupancy of constructed housing and it is in this area that indicators show the average family to be consuming more energy than past generations to maintain a household. Besides heating and air conditioning, the activities of the average household require energy for food preparation, grooming, entertainment, reading, and even sleeping. The extent of energy utilization is of concern to planners. Most predict new sources must be developed and consumption curtailed to some degree to maintain the existing social system. Solutions to the energy problem range from controlling population growth to the establishment of communities in space. Projects are being proposed for the development of geothermal stations, ocean water generating plants, large scale use of fuel cells, laser units for energy development, and garbage conversion plants. With all the activity of seeking new sources of energy, the paradox is that simultaneous efforts in the marketplace continue to foster new products for greater utilization of the commodity that is energy.

A second resource which is of concern to Americans is that of water. The abundance of winter rains and snows of 1978 have replenished the almost dry water supply areas that serve the populated region surrounding San Francisco. Still, both the quality and quantity of water have continued to be of concern to residents. In densely populated areas of this country the water problem is becoming a priority item. Both drought and flooding continue to be problems for Americans. Agencies representing the federal, state, and local governments are all on record as being as cognizant of pollution and other water related problems.

The concentration of population has led to the lowering of water tables and destruction of environment which in the past slowed the process of erosion and flooding. Residential use plus the enormous amounts required to maintain the wheels of industry have had a detrimental effect on the quality of water available for consumption. Wastes from industry have polluted some major sources of water necessitating the enlargement of water treatment plants and development of new water sources. In many cases the damage of the past decades will require many years of continuous monitoring to reverse the polluted situation.

Most water-related housing problems are in the realm of supply, pollution, and flooding. In this era of the 1970s all problem categories have affected some Americans directly. Damage caused to housing due to flooding of rivers and tidal basins points out the need for more active study and procedures to minimize housing and property damage. The effects of water-related damage can also be noticed in the number of mudslides and erosion of property that have been documented in recent years.

Drought conditions in many parts of the west indicate the precarious balance between life and death due to the quantity of available water. Better contingency measures are needed to insure adequate supplies of water in the nation. The supplies from which households now draw their water are distant from the population centers. Regional approaches toward such problems are mandatory. It is estimated that the daily consumption of water by households will be approximately 39 billion gallons a day. (23,68) The amount is small when compared to that used by industry and agricultural interests. A major task faced by society is developing a policy toward water which can assure adequate water for all.

A third resource directly affecting the quality of life of large number of households is that of air. The quality of air in the urban industrial areas has become enough of a concern that in many cities the communications media announces what is known as a pollution index as a part of the daily information to the public. The increased utilization of various chemical products in the processing of industrial materials and the burning of coal and petroleum products as fuel have left some cities with air that smells of sulfur dioxide and other noxious fumes. Unburnt automobile residues have become the "smog" that permeates the sky in many cities. Studies have shown that traces of lead and other chemicals in addition to solid wastes are continually being discharged into the atmosphere. It is common to experience in some residential areas the sensation of watering of eyes by virtue of being in a polluted environment.

It is predicted by some scientists that the pollutants in the air have lowered the temperature in some localities. This change in temperature may be of greater consequence as wind currents, precipitation, and other weather conditions are affected in the future. The great amounts of carbon monoxide being released into the environment should have some effect on maintaining a balance between the availability of oxygen and carbon dioxide to sustain life in both plants and man.

Besides sulfur and its compounds, carbon monoxide, carbon dioxide, and particulate matter being discharged into the air there are other pollutants such as fluorides, and chemicals from fertilizers, pesticides, and fungicides that are constantly being utilized. The aggregate of all this activity is the increase in hazardous conditions for the householder. Pollution reports and government standards regarding use of possible pollutants are indicative of the magnitude that this problem of clean air poses.

The resources available to man have been exploited previously without regard to the possible detrimental effects of their use. The degree of pollution and decay of the environment has forced man to reconsider and appraise the relationship between his style of life and his habits of consumption of resources.

FUTURE TRENDS

Only the most optimistic of forecasters anticipates there will be adequate and improved housing for everyone by the year 2000. Analysts point out that by the end of the century many of the present houses will be in need of demolition or repair. The situation will be that a large number of houses will be twenty-five years or older and will require additional attention in form of renovation and maintenance to meet the requirements that are anticipated.

With the world population expanding at an alarming rate the need for new housing will continue. In addition, the replacement of old housing to meet the standards of year 2000 and beyond will also require the labors of more massive efforts into planning and construction. It is expected that the quality of housing will be improved across the world. However, distribution will continue to be a major problem unless there are fundamental societal changes in government and economic policy. Futurists predict that 500 years from now the housing problem based on scarcity shall not be as crucial as it is today. It is this transition from a housing poor planet to a housing adequate planet that humans must address efforts to.

To the year 2000, which is but a short time of this transition period, it is anticipated that the outward features of houses and other dwellings will not change appreciably. The Dean of the School of Architecture of a leading school in Canada predicts the cosmetic features of housing, the outward appearance of a house, should not change drastically. His views are echoed by many other designers. King-Hele describes the British reluctance to change thus: "Men have built houses with earthenware bricks for 5,000 years, and at least in Britain bricks look all set for another few centuries of use." (15,92) On the other hand, it is countered that much of present housing will be removed from the scene because most of today's housing is designed to last for the length of the mortgage. This pool of decaying housing will enable the rebuilding of units suitable for the demands of the future. It is argued that the future technology coupled with the change in the economic and social system will result in massive changes in design. However, change in design and function will not be the major concern for many people; for a substantial proportion of the world population, finding adequate and affordable housing will be the primary concern.

Should the present spiralling costs of land, labor, and materials of the housing industry continue, large numbers of people will not be able to afford to purchase homes. Social scientists have predicted that the deepening cleavage between income groups will continue and result in a greater market for rental housing. The proportion of single dwelling detached homes will fall from the three out of four to that of one in two by the turn of the century. By year 2000 multiple family dwellings will constitute a large part of the building and rental economy.

Housing as a worldwide concern assumes importance as the time perspective is projected more closely to the present. The short-term outlook is bleak whereas adequacy of housing is projected as a probable occurrence for inhabitants of the 22nd Century. Variables such as a change in population growth or breakthroughs in technology may accelerate accommodation of all peoples in need of housing. Reorientation with regard to economic and social policy may also hasten the process of providing housing in a more equitable manner. The intervening years of the near future, especially those of the next few decades, should provide the base from which a long-term housing strategy can be put into operation.

New Dimensions in Organization, Planning, and Development

To meet the demand for housing in the immediate future a number of schemes have been advocated. In scope these range from urban redevelopment projects for housing the poor and aged to that of building complete new towns and cities as have been raised in Reston, Virginia and Columbia, Maryland. The functions of these grandiose and creative developments are best exemplified in the organization that is Disneyworld, a leisure-oriented community. Projects such as the growth of the space complex outside of Houston have added a huge inventory of homes besides generating jobs directly related to the space efforts.

Characteristic of the new housing industry is the scale at which projects will be pursued. Single, small scale operations in the housing sector will continue, but the bulk of building will pass through the administration of large corporations. Planning and financing will require the employment of sophisticated techniques and tools in the decision-making process. Forecasting of economic trends and world events will be crucial factors in decisions with regard to building. The size of operations will require teams of lawyers, social scientists, technologists, and economists, often from many parts of the world, to determine the feasibility of proposed projects. Use of the computer and other recent innovations in communications will enhance the process of building.

The model for the organization of manpower to deliver services required in the housing market will be that of the multi-national corporation. Efficient manpower organization will be mandatory to coordinate scheduling of land acquisition, clearances for construction, material allocation, and labor as building is phased into the operational stage. The requirements of maintaining reasonable cash flow to insure maximum profits also mean the employment of specialists. It is through the corporate model that resources will be made available in the necessary quantity to enable entry into speculation of large scale housing projects. Too, the corporate model should enable the initiation of production on a large enough scale to meet the mass consumer needs of the future. In short, housing in the future will have a smaller proportion of the business handled by the single contractor.

As it is the practice within the framework of some present conglomerates there will be work in various phases of building and selling/renting handled by subsidiaries of the parent corporations. Such controlled practices of management will ensure the maintenance of uniformity, predictability, and availability of services and goods of the housing industry. A classic case of high degree of standardization can be seen in the growth of the mobile home industry where systemization characterizes the industry.

Unlike the post World War II housing projects where thousands of similar homes were built in projects or the somewhat varied homes built in more recent housing ventures, the homes of the future will feature more alternatives in both materials and designs than in the past. The results of planning will accommodate the needs of consumers from all walks of life and tastes; housing will be built to meet the economic demands represented by the full range of people. It has been predicted that there will be more intervention by many agencies in assuring better housing for the consumer.

The futurist choosing to take a longer view foresees a population housed under conditions which merit some study. For one, the plane that is used for housing on earth at present shall be extended to both below the surface of the earth and to that area extending skyward. Cities below the waterline, as being contemplated for Tokyo, is an answer to the congestion found in many large cities. Below ground structures have been designed to save energy, a commodity that is of extreme concern at present. Too, by going underground, valuable land above ground can be used for other purposes. The extent of underground structures will dwarf whatever exists at present.

As for extension of housing and cities skyward, the present limits are just the beginnings of the expected growth in direction of future cities. Total cities are envisioned in the sky complete with transportation systems, waste disposal systems, and the like. Ideas have been broached to suspend housing in space with appropriate life support apparatus. Cities and food producing areas under bubble-like capsules are part of the vision.

Mason, writing in the Futurist (19,235), described a number of possible modes that may provide alternative sources of housing. He described these to be aerotecture, biotecture, agritecture, chemitecture, videotecture, and other modes of equal fascination. These are all distal possibilities in housing and require further technological development to become a reality. For the immediate future, the housing situation will not be alleviated utilizing the ideas as presented by Mason. The application of present technology and the innovations seen to be at the disposal of man need to be exploited and refined to a greater degree to achieve better results in solving housing problems. During the next two decades the role of educators should include the study of the possible world of the future as well as the present status of the art.

Wholesale changes of premises girding modern and future society may result in drastic changes in the physical solutions of housing. Since housing is a reflection of values held by society, fundamental shifts in views may affect the behavior of citizens with regard to the organization of shelter. If housing of large numbers of people in completely new environments will be necessary, government subsidies or other financing will become a pronounced practice. Huge sums ranging into the billions are projected as minimums for initiation into space habitation. Such large scale undertakings will require pooling of all available resources. In thought and practice, societies may be totally different from that of today.

Homo sapien historically has organized himself to live on earth in many ways. He has sought dwelling as a hermit at one extreme and has taken refuge as a member of a dependent commune at the other. The only sure thing about the future of man's response to housing is that it will be emanating from himself. His futures dwell from the depths of the ocean to habitation in space. Some see cities of immense size springing from the earth while others wish for a life in a quaint home surrounded by verdant countryside. The development, organization, and planning of housing of the future will be as varied as those who now dwell upon the earth.

Housing: Emerging Materials, Techniques

Practices in construction show changes as well as similarities in processes of work when comparing the past with the present. The increase in the requirement of housing and the apparent decrease in the traditional materials of construction will result in a movement towards utilization of new synthetics and materials. This use of new materials will also alter the building processes in construction. Many of the traditional materials are being improved to meet the specifications of modern production. Breakthroughs in chemistry and physics are resulting in new building products which should enhance the housing industry of the future.

Among the materials becoming available for large scale use are those that can withstand heat, those that are stronger, and those that wear better than previous materials. Materials becoming more prevalent in the construction industry are composites, plastics, high grade ferro-concrete, and the new metal alloys. The development of filament wound systems using boron, carbon, and graphite provide craftspersons with materials with added strength and flexibility. Large modular components such as bathrooms, wall sections, and other large items have been made possible through refinements of molding laminates of fiber and resin. It has been noted that among the materials which drastically changed construction has been the introduction of panels of paper impregnated with resin.

The marketing of foaming resins with the ability to form smooth skins show great promise as a building material. Combination of various materials in sandwich form will further expand the possibilities for building. Research in concrete has enabled designers to expand the dimensions with regard to form and shape. The aggregate gains in new materials in housing should lead to units with new form and design features.

The new materials have been followed with new processes in application and fabrication. Molding and moldmaking have become important to the process of production for the housing industry. In turn, the inroads made by refinements in the machine tool industry, such as irregular shape cutting by use of continuous spools of wire, have made it feasible to produce more intricate molds. Refinements in the process of extrusion, weaving, and forming have enhanced the capability for greater production at affordable levels. Processes such as spraying and blowing are fast becoming part of the process of construction. The increased use of new adhesives and finishes has changed the process of fastening and finishing of buildings.

Whereas recent generations studied materials in categories such as forest products and metallurgy, the crossing of lines of inquiry has resulted in new disciplines from which to view the physical world. Materials science as a discipline has emerged and encompasses both the organic and inorganic substances. Research has enabled the development of ceramic magnets, heat resisting plastics, paper-cored furniture and walls, and a host of new products. The advances in housing have come in form of roofing of better quality, carpets of exotic synthetic materials, flooring of more varied materials, better plumbing materials, and smaller and more efficient units for heating.

Wall panels that provide light and heat should be commonplace by year 2000. Solar heaters that are relatively few in number should be more common and efficient at the turn of the century. Glass which will change in tint will be available for home consumption; cleaning processes will be a part of the housing package in the future. It is also anticipated that refrigerators will decline in size due to better processes for food storage and preparation.

By the year 2000, housing construction will rely on the computer to provide answers in the sequence of building to a great extent. The laser or an improvement will be a common tool. Many of the skills required today will be obsolete but building skills of a new kind will be a necessity for raising a house. Some futurists are predicting that apartment units will be bought in a supermarket or department store and plugged into a core as is being done in Tokyo. Others claim that improvements in production of component parts will make interchanging of rooms or other smaller units of a house more simple, thus enabling expansion or contraction of sizes of housing units. The reliance of closer tolerances and standardization will enable the mass production of components. Unit designs will result in more rapid erection and remodeling. Further, the design of homes will require less maintenance *via* improvements of products or through the development of new products to withstand the rigors of human habitation.

Ultrasonic devices, materials with built-in adjusting mechanisms, improved appliances for food preparation and storage, noncorroding utility lines, and environments to suit the tenant are envisioned for the future. Some futurists are projecting the use of cells grown to specifications as possible material for building. The field of biotecture may produce greater dividends if advances made in the sciences can be accelerated. Others foresee housing developed from the gains made in the relatively promising field of cryogenics. Still others have suggested that chemitecture shall be the basis for building of the future. Housing of the distant future in some ways is dependent upon the thrust the present population prioritizes as an area in which to expend resources and energy in research.

In addition to the advances in materials and processes, the form in which construction has taken place has changed and will continue to take different forms according to futurists. These changes will require that society be organized to meet the challenges of providing housing for a population which will demand a number of different kinds of dwellings. The task of providing adequate housing for the population by year 2000 will require skills in organization of people to cooperatively engage in a formidable undertaking of planning, constructing, and distributing on a scale of great magnitude. Whereas wood and earth were the basic building blocks in prior efforts in building, the future will require materials to be more refined and predictable. Rough hewn logs and simple bricks of mud will give way to laminates and silicates with built-in characteristics desired for the housing imagined by man.

Futurizing Through Action

The education of tomorrow's citizens requires situations for development of skills and attitudes for a future that will be characterized by rapid rate of change. Preparation of year 2000 necessitates youth be provided opportunities to actively hone skills necessary for survival in a highly scientific-technological society. It is premised that thought accompanied by action will best fulfill the prophecy of the future. The material future will require more rapid translation of ideas into tangible products. In housing this situation reduces the lead time of production of housing for people from the stage of ideation and planning. More important the future will require that the decisions be made with greater precision and clarity.

Today's youth will be called upon to make choices with regard to housing and building construction in a few decades, if not sooner. Therefore, educational experiences which will allow them to study and make decisions when faced with a number of alternatives must be a part of the socialization process. They should be made aware that the accelerated rate of change is a characteristic of science and its application will increase the processes of construction options open to them. It should be made explicit to them that discontinuity between that which is experienced in school and the world of the future will be a distinct possibility. Students should be made to realize that the study of the future of housing is an attempt to minimize the discontinuity between school experiences and that which will be experienced in adulthood. A most important attitude to be nurtured is one which calls for active participation whether student or adult.

The study of housing of past and present societies though important must be augmented by studies of the future. The slower rate of change in technological practices of the past is not a condition available to those who will live in the year 2000. Housing problems will be better served by those with open minds to the options open to society. Curriculum focusing on the study of housing viewed solely from the perspective of a resident living in this present era will not serve youth fully.

Industrial Arts content of the future will include areas of inquiry which were previously considered outside the legitimate domain for the subject. Housing, whether categorized as a subset of construction or a discrete subject, should be approached more broadly than now practiced. By expanding the perspective, the curriculum will promote the concept that the study of housing ought to include the problems of land use, economics, health, and social policy. This posture will include the consideration of the factors of space, population, food sources, geopolitics, and social problems. Teachers will find that in order to operate effectively in this context they must be provided more opportunities for upgrading at both the preservice and inservice levels.

Curricula that stress the study of the past may not provide the child with sufficient and appropriate information to make necessary adjustments in the future. Study of Indian housing may be interesting but not crucial within the context of the space age. Scenarios must be developed in which students may use their imagination coupled with assimilated information to cope with projected problems. Behavior which in past generations was assessed as fantasy must be supported and provided a forum. It is in this manner that speculation can be combined with hard fact and substantive theory to enable students to control their expected futures. Skills in forecasting methods should be systematically taught. Inquiry into new fields of study should be encouraged and techniques of application of new materials and processes should be an integral part of the educational process.

The environment in which educational activities will take place should be expanded to include the greater community. For school age children, options must be identified in the community where they may engage in meaningful activities with regard to the process in which housing decisions take place. Educators need to support ideas such as weekly columns in the school newspapers authored by students on the subject of the future. Students should be active participants in the planning process of proposed public buildings and projects. Opportunity should be available whereby they can participate in hearings and other housing related meetings.

Active participation in projecting the future should enable students to gain some confidence in controlling their destiny. The application of idealized futures in form of simulated projects may be more valuable than discussions in the traditional mode. The experiences of "living" in a student-made capsule for a week provide insights to problems encountered in initial space colonization and travel, especially experiences of social relationships, waste removal, and requirements to maintain health. Too, active participation provides clues as to the direction in which society desires to pursue. The future in many ways results from the self-fulfilling prophecy of the present. It is to the advantage and responsibility of those charged to direct the educational program of children to assure energy and resources are allocated to areas of study which will have the best probability to benefit mankind.

LEARNING ACTIVITIES FOR STUDENTS

The crucial task facing educators is that of translating stated goals into specific learning activities. Activities, both in class and outside the schools, are the important links between that which society professes as ideals and the behavior which will be ultimately exhibited by the student as a result of the socialization process of education. The activities selected should be based on the assumption that citizens of the future ought to be given opportunities to practice skills of thought and action to meet various conditions of anticipated living.

In American society it is the child who is least inhibited in the act of futurizing. From the world of Buck Rogers to *Star Wars,* youth have fantasized being a part of the future world of space. Captain Nemo has fascinated children and some adults to the possibility of life in the undersea world. Unfortunately, children often speculate and project their futures with less information than their adult counterparts. This being the case, the activities for children should be designed to result in more and better data from which they can make better decisions on housing. Units of study which are carefully planned, such as developing a report of housing in space, should lead to greater confidence of their skills. Information should be introduced systematically whereby lessons may be more meaningful in the development of the child's repertoire of skills in futurizing.

Learning to live in a cooperative context will be a future requisite in life, and thus, educational activities should be planned with this in mind. The development of skills which stress cooperative behavior and attitudes of social responsibility will be a priority. Children's activities will include group activity in solving of problems as well as conducting the affairs of life in general. The cooperative stance will require the

American educational classroom organization to undergo fundamental changes. Moreover, the development of cooperative behavior may result in the reorganization of housing patterns and the redefinition of concepts of privacy and property. Children will have to be socialized into this milieu with appropriate studies and experiences.

The degree of humane socialization desired for future living will not be attained by year 2000. However, the trend toward this goal will be underway and will be evidenced in the emphasis of educational policy. For teachers this goal will mean the structuring of classroom activity to include more participants from the greater community and perhaps having students directly participate in the affairs of their neighborhood. The activities of children will include the assistance of various resource agencies and personnel. For example, very young children may develop a picture story of houses they now live in and another in which the students are asked to project what they consider to be desirable residences for the future.

Among the activities of the future will be more extensive travel to study firsthand how people live. More opportunities for exchange type educational experiences will be available to students. Housing and its problems will become a part of the education of every child. Trips to places such as Disneyland, in particular Tomorrowland, will contribute to broadening the perspectives of children. Fieldtrips to localities such as building sites, renovation areas, renewal projects, and housing developments should make a child more knowledgeable. Firsthand experiences on the part of children will provide them with data from which to pose more penetrating questions.

Besides extensive travel to future-oriented communities, children will be afforded opportunity to visit with others living under conditions different from theirs. Such future programs should provide valuable learning experiences whereby apartment dwellers can share ideas with those living in rural settings. There is need to broaden the views of children that will result in appreciation of the idea that housing comes in many forms. It is through personal experiences that children may gain insight as to some of the problems related to housing.

It is suggested that situations be developed in which children plan and execute a four- to five-day simulated space or undersea mission. Such a unit of study can be both a learning experience as well as a motivating device to get students interested in the future. The class can be assigned responsibilities to sustain the "space" or "undersea" travelers during the period of the mission through various activities. Report writing as well as reading would become an integral part of the structure of the unit of study. Equipment such as walkie-talkies, dry foods, electrical gear, and portable toilets can be used to simulate the crowded conditions of initial space travel and habitation. Students outside the capsule or diving vehicle can be organized to relay messages to those inside. Through this type of simulation the students can gain a better insight into the need for planning and coordination that may face them in seeking other viable housing alternatives.

For youth at the middle grades the question of housing should be broached to enable them to see the magnitude of the problem. Questions focusing on society's responsibilities for housing should be introduced and examined. Students need the opportunity to advance solutions regarding problems of displacement and the consequences of policies that are operative in the housing industry. Every effort should be made to take advantage of the idealism of youth to impress upon them the seriousness of housing as a problem of society.

Among the activities can be a local study of housing and the projections made by local government with regard to the future. Students can study the situation by visiting local governmental agencies and using their data to develop a picture of the future. Too, students ought to be provided opportunities to study the position of various community groups as to the future role of housing. Concepts such as decay and rehabilitation can be considered as provocative topics from which to initiate class study. All activities should require students to suggest solutions to problems they feel are in need of consideration.

In the industrial arts classes there should be both a core of technical knowledge as well as consideration of social concerns with regard to questions of housing. Activities in the middle grades will become more meaningful when reasons for the study of housing are identified and discussed. The goal of the middle grades ought to be the further development of an attitude of concern with regard to pressing problems facing society. Activities should be selected to foster greater exploration by students in facing problems of society. Therefore, activities should include a detailed study of the issues at hand as well as the utilization of materials and processes in production of units of housing.

For students in this age level the program can be built around themes such as the environment and the home, or perhaps energy and living. The theme will allow teachers to focus attention to specific problem areas in housing with some parameters. The treatment of a theme as related to housing can be expanded to coincide with declared interest weeks such as solar-heat week and the like. Lessons and study can be directed to result in the presentation of educational exhibits as well as demonstrations by students during such times to further share information with fellow classmates. Another example might be the design of a future school for National Education Week. Students would be responsible for making a statement about a school of the future with drawings, models, reports, and other student work.

An activity for children living under less than desirable conditions might include an analysis of their plight. They might be asked to suggest ways to improve their condition of housing and to identify skills needed to survive more effectively. It may be necessary for a number of such students to be provided additional attention to enable them to rise above their condition. Activities for such students may be learning to repair windows and doors or utilizing available resources more effectively to make homes more livable.

Programs in the industrial arts in the housing area can be expanded to include summer study. For a program of this sort the reclaiming of an abandoned home may be the subject from which students may learn about the intricacies of building and remodeling. Urban homesteading may lead to the development of skills on the part of the students during the hot summer months as well as putting a unit of housing back into the available inventory. Summer work/study would enable some students to earn as well as learn by being a participant in a reclamation project. Future oriented ideas such as solar heaters and other new products can be incorporated into the rehabilitation program by either applying for federal funding through the energy-related agencies or by soliciting local businesses.

Children need to be provided activities of a meaningful nature. Writing and reading skills may be improved through activities such as the composing of reports and writing of letters. Letters to the editor of a newspaper will accomplish the mission of development of basic skills. The study of building codes, ordinances, planning reports, and technical papers should provide students with situations requiring the use of reading skills.

Other activities for middle school children may include the building of future model cities, the designing of apparatus for the home of year 2000, and making of a video tape recording on the future of housing. Class projects involving all students can contribute to their understanding that the housing problem in the future will require cooperative efforts of many people.

Older youth studying housing may devote time to planning and constructing models of housing based on ideas generated by practicing futurists. Housing alternatives founded on theory such as agritecture may not only be informative but may be a viable alternative in some climates. The consideration of theories which at present are not popular should not deter teachers from including such subjects to be examined. The attempt to actualize theory may be a motivating factor for some student to extend study in a detailed manner. For other students the study may be directed to a timeframe which is closer to the present. Their efforts may be that of making the transition into the future with less dislocation. It is the teacher's responsibility to assist the student by providing support in form of availing resource material and advice. Teachers will be expected to know the sources of materials and reading material. Journals, writing in other forms, films, and personnel with deep commitment to the future can serve as the basis from which to draw ideas. Laboratory work may consist of engaging in study of growing plants into shapes which hold some promise as possible building blocks, or the study may entail the collecting of residues from seawater to build/grow bricks for construction purposes.

Industrial arts classes may examine paper as a potential source of material for building purposes or students may experiment with various foaming plastics to ascertain feasibility as possible new coverings for buildings. Too, classes may engage in detailed study of ice as a possible material for construction. Within this classroom study of housing the students may organize expositions to exchange ideas and skills with fellow students from other schools and classes. Fairs in which students from many localities participate in learning plus the opportunity to teach others should lead to making the study of housing more intense.

Future students will be encouraged to utilize outside sources more than is now practiced. What are now considered alternative modes of education will be a part of the normal delivery system, a greater number of children will be studying with members of the community. The future form of apprenticeship will enable students to learn and study directly with persons expert in their fields of endeavor. In the field of housing related occupations, there are a number of situations where students can gain valuable experiences by direct contact. By associating with architects, urban planners, real estate managers, construction personnel, building supply distributors, and mortgage specialists, students may gain insights which may be valuable in sustaining the housing industry.

Urban Peace Corps-type programs may allow some students to put into practice lessons learned in the classroom. Through on-site programs students may apply the procedures as well as sharpen skills that are necessary in the construction industry. Such programs will allow students to realize the extent of effort needed to gain clearances for renovation and building. Community organized projects for youngsters may lead to the establishment of a manpower pool necessary to maintain a steady workforce in the construction trades.

Activities which require students to study and develop solutions to specific topics within the domain of housing may include work in providing housing for the aged or a problem of raising necessary housing for an over-populated country. Student teams can be asked to submit solutions and recommendations to members of a class or other body of interested citizens. Experiences can be organized to maximize student participation in collecting, analyzing, and interpretation of data as well as to provide them with opportunity to interview individuals with expertise on various subjects.

Other activities may include testing of new materials applicable in the housing industry. For example, materials may be tested for heat retaining characteristics. Materials such as sand and concrete may be experimented with to give students insight as to the state of the art as well as the possible design and forming capabilities of materials. From available data students may be asked to summarize in a report the status of resources available for building in the year 2000. Other projects may focus on the economic aspects of housing as related to the consumer.

In the industrial arts the study of housing should extend beyond the learning of building techniques or drafting skills. To be sure, these skills are valuable for some; but is should be recognized that for many other students the skills of recognition of the problems inherent in the transaction of business of the housing industry are of equal priority. Therefore, the thrust of programming should be that of developing skills among students to become better consumers of housing by being able to recognize various options open to them. Activities in this context may be those of comparative shopping through use of newspaper ads, consumer study of prices in various hardware stores, or the study of use of bids in the process of purchasing services.

Shorter activities for students may include the development of new products to replace present items used in the housing industry. For example, students may be asked to replace the kitchen counter by some other device, or they may be asked to find a replacement product for the door handle. Students should be provided opportunities to explore and design homes for different environments such as mile-high cities or colonies in space. In short, students ought to be given more alternatives to explain their desires as well as learn new skills applicable for their future.

LEARNING ACTIVITIES FOR ADULTS

In 1955 Ernst (5,305) projected the future of 1976. In his text, it was claimed that by 1976 American houses would be designed so that the inducements of the marketplace would be turned away by built-in mechanisms. Ernst believed that intelligence and reason would prevail over the pressure of advertising and that some of the apparent ills of his day would be rectified by 1976. While some of his projections have come to pass, the element of innovation has drastically changed the production/consumption patterns he envisioned would be common by

1976. His forecasting missed the dependency of American marketing on imported goods from then developing nations. This discrepancy between the present and the future must be expected in any speculation of the future.

Yet, for adults, the study of the future is more important today than it was a few decades ago. The concept of lifelong learning is in fact compatible with a rapidly changing society. Therefore, effort in the industrial arts should be devoted to teaching adults and allowing them to learn new skills. Both men and women should be informed about the pressing issues that underlie the responses to the problems of housing. Industrial educators should look hard at the problems faced by retired persons who as a group may have great difficulty in making the adjustments to the emerging changes in lifestyles.

Learning activities may be as specialized as that of workshops on insulation for those in the occupation or may be as broad as that of relating to the study of solutions for proving the community information as to how to apply for federal assistance funds. Activities may be organized in a number of ways. The forum from which ideas may be communicated can range from the local newspaper, the radio, the television or it may be accomplished by utilization of organized seminars and classes sponsored by schools and other allied institutions. If it is the intent of society to base governance of the future in more direct citizen participation, then means must be provided which will result in more direct citizen action with regard to the activities selected. In conjunction with the study of future housing, problems and issues, such topics as energy, mass transportation, pollution, taxation, and other problems can be coupled with the housing issue to make for more potent public information sessions.

Activities which will assist the individual homeowner or tenant to enhance a residence will continue to be a major factor in school sponsored programs. Courses such as drapery development, home decorating, painting and house trimming, appliance repair, basic carpentry, fireplace and patio design, and other similar courses will add to the skills of adults. Activities in courses designed to yield immediate results may include the fabrication of a movable wall, the raising of a fence, the building of an addition to a house, or the designing of a room. Group activities may entail the rebuilding of a future-oriented model home, a stylized bus stop, or a public cabin in a park. However, such courses may not result in dividends in solving the housing problem as related to the increasing of available units to the stock of houses to be marketed.

Programs which will challenge the more pervasive problems of housing may be defaulted to other sources if schools find it impossible to deliver such services. On the other hand, if the schools see fit to meet this challenge a systematic plan must be put into action to bring to the attention of the public the magnitude of the housing problem as a social issue. Adults must ultimately act on problems pertaining to open occupancy, ghettoization, and financing of large scale public projects. The agenda for the years preceding year 2000 requires that some significant steps be taken to rectify situations that have bordered on the crisis stage for the past few decades. Industrial educators ought not to sit silently on the sidelines; instead, adults should seek their advice and views with regard to both the technical and social ramifications of practices that sustain the housing industry.

Communitywide activities may be one alternative method in both providing an avenue for learning as well as an organization for immediate local action. It has been doubted that PTA-type groups are the ultimate in local participation and change. (2,164) Community action-type activities and organizations are probably more effective in bringing about change. Adult educational programs should focus on social problems in housing and should strive to result in political and/or social action. Adults engaged in the study of housing issues and problems should be taught how change can be effected by group processes. Such topics as those pertaining to the law, rights, and codes can provide the stimulus for concerted action to change the status in which community members find themselves.

New technical information as related to housing should be made known to adults. Activities can be organized both in schools and in the greater community. For example, senior citizens may be better served by providing services through their public service agencies. For others adult classes in the public schools may suffice. For those desiring specific technical information for specialized use there should be facilities available for quick retrieval at minimal cost. Activities in the technical areas can vary from industry sponsored product information workshops to those that are organized on a statewide basis around designated days for particular purposes such as Home Beautification Week. Subjects for dissemination of technical information should not be relegated to those with immediate application but to information which may provide the impetus for further study. New tunneling devices, undersea mining machinery, and materials for geothermal conversion units may provide the adult with encouragement and result in unexpected breakthroughs.

In the organization of educational efforts it may be prudent to consider the utilization of adults to work closely with communitywide projects. The process of planning and producing units of housing or other public buildings should result in experiences to both youths and adults which can be of value to themselves and society. The year 2000 will require its citizenry to continue seeking solutions in the area of housing.

Industrial educators must continue to expand the vision of students whereby as future residents they will meet the challenges of the housing problem.

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Chapter 7

The Industrial Work Environment

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The objective for the industrial work environment is productivity. Productivity can be defined as creating durable and nondurable goods and servicing those goods. Increasing productivity implies improving the decision-making capabilities of management, and the cooperation of personnel to produce goods and services to meet peoples' needs and wants. The incentive for personnel to perform more effectively and efficiently is the quest for a higher standard of living. This chapter deals with an analysis of selected work-place conditions that have helped this nation's economy reach its present status and some projections for the future.

BACKGROUND

The colonization of America created demands for labor. The affluent settlers had established themselves as the ruling class of people. Many had either purchased land in the colonies from England or been deeded the property by the Queen. These individuals did not feel that they were of the laboring class so they made pleas for laborers from England. England was enjoying industrial growth during the 17th century and was not interested in advancing the level of technology in the colonies. However, two types of people were recruited heavily: those who were seeking religious and social freedom, and those who were in prison and decided that going to America was better than remaining behind bars.

Therefore, most of the working class of people who started our industrial growth were industrial servants. Some had a voluntary status which meant that their employer paid for their transportation to this country and provided housing for a specified length of time or until the cost of relocation was paid back to their benefactor. Others arrived as involuntary indentured servants who were working as an alternative to imprisonment. Children, from 10-15 years in age, who may have been runaways or orphans, were among the voluntary group and usually served until they were 21 years of age.

As time passed, England began to fear that productivity in the mother country would be reduced if there was too much of an exodus of labor. Therefore, the colonists had to seek other labor resources. Cahn (1972, p. 16) points out that Massachusetts was forced to enact a compulsory labor law. The act stated that women, girls, and boys were to spin when not otherwise occupied.

Southern colonies sought other labor sources. People had been sold as slaves or indentured servants or kidnapped from Europe or Africa and sent to America.

Obviously, not all workers in this nation were unskilled. Since people needed to be housed for living as well as working in home-factories, skilled carpenters found employment rather easily. These people were itinerants who carried their own tools from one community to another and constructed buildings from lumber usually provided by the customer. As the population increased, these skilled individuals were able to settle in a community and find enough work to remain employed all year.

Industrialization brought about many changes in productivity. Some priorites began to become evident. During the Revolutionary War, papermakers, ironmakers, blacksmiths, and carpenters were exempt from military service. After the war, people began to separate the home and workplace. There was a trend to develop the factory system.

Among the first industries to develop factories were the textile manufacturers. One example was the cotton spinning mill. Samuel Slater had memorized the drawings in England, came to America, and built the first machine. He hired 7 boys and 2 girls, all under 12 years old, to spin cotton (Cahn, 1972, p. 41). Later he employed families and had all members over 9 years of age engaged in making cotton.

As the textile industry developed, problems arose. For all practical purposes, women were "owned" by the company. The girls were told when to (1) get up in the morning, (2) eat, (3) start work, (4) quit work, and (5) what recreation they could participate in as well as (6) where to go to church. For this they earned $2 to $3 per week plus board (Cahn, 1972, p. 50). Children who also had company housing earned only $1 per week for their seven-day work week. In Massachusetts, women tried to organize against this form of persecution. They created the Lowell Female Reform Association. The group was ineffective and, in reality, led to the blacklisting of the people who were members of the Association.

Further efforts to increase productivity led to the premium system. Workers were required to tend a greater number of looms. The scheme provided bonuses for overseers or managers if they were successful in increasing output. This created problems in the relationship between employees and supervisors. Machines replaced craftsmen which resulted in a loss of human value in the workplace.

There were other efforts to organize workers. Employees resolved themselves to many atrocities but sought health and accident insurance through societies which later became trade unions. Strikes occurred as workers tried to force improvements in the conditions under which they worked and to improve their standards of living.

Apparently the first permanent labor organization was in 1792 consisting of a group of shoemakers in Philadelphia. Another organization, the Mechanics Union of Trade Association was established as the result of a strike for a 10-hour day by building trade workers (Cahn, 1972, p. 62). The Workingman's Party was the first labor party and the New England Association of Farmers, Mechanics, and Other Workmen was the first industrial union. Women formed the Female Society of Lynn and Vicinity for the Protection and Promotion of Female Industry.

Many issues confronted these and other groups of workers. Reducing work to 10 hours per day, increasing wages, ending child labor, and voting rights were but a few of the problems of the times. The social and religious rights of women were discussed. In fact, the first conference on women's rights was held in Seneca Falls, New York, in 1847 where a declaration of principles was signed to start the women's rights movement in America (Cahn, 1972, p. 76). Safety was another issue. Mines and railroads had extremely high fatal accident rates. Fatigue from long hours was one of the contributing causes.

These issues were the concern of William H. Sylvis who founded the National Labor Union in 1866. The group sought the 8-hour day, equality of all people with full rights, equal pay for men and women, equality for blacks, and other reform issues (Pelling, 1960, p. 56). Unfortunately this organization was short lived. There was too much reformism and too little economic interest. The Sovereigns of Industry was another unsuccessful labor organization. Still another organization, the Order of Knights of Labor, was established for all men, women, creeds, colors, crafts, skill levels, and who were citizens or noncitizens. This group met secretly for fear of reprisal. The organization flourished for awhile, but friction with the skilled craft unions and the loose nature of the organization contributed to its disintegration.

These organizational failures represented the inability of the working class to cope with the industrial leaders in improving working conditions. If a group struck, the mine operators recruited labor from overseas and brought them to the mines, often in freight trains (Cahn, 1972, p. 120). Illiterate blacks from the south added to the work force. Chinese were literally shipped cross country by boxcar to build railroads. Much prejudice existed against foreigners.

The accident rate among these workers was extremely high. Probably the greatest contributing factor was they they could not read, write, nor speak English. Imagine not being able to read safety signs. This might be the genesis of the degrading ethnic humor directed toward minority groups that exists in many geographic areas of our nation.

Boys and girls who were part of the labor force tried to organize unions. Children in the glass factories sought protection from cuts and burns. Girls in the garment industries fought the poor working conditions. Boys, ages 8, 9, and 10 worked in coal mine breaker rooms separating coal from slate in 12 hour shifts at $1-$3 per week (Cahn, 1972, p. 194). These youth formed junior local unions and held secret meetings in a vain effort to improve their working conditions.

The next major thrust in an effort to improve the conditions under which Americans worked was the creation of the American Federation of Labor (AFL). The organizers of this union tried to prevent making the same errors that had caused the Knights of Labor to lose its effectiveness. This union was directed by business-like people, young and energetic, who were considered aggressive or militant. The organization was oriented toward the craft trades. It supported the needs for compulsory education, prohibition of child labor, improved safety and sanitation laws for industry, and protection against cheap foreign labor.

Even with the effort of unions to develop clout in dealing with worker's problems, they were relatively ineffective and in some cases, merely tolerated by factory operators. The factory operators continued to take advantage of employees. The so-called "sweat shops" in the garment industry were stiffling hot in the summer and cold in the winter. Many were fire traps where scraps of cloth were left on the floors. Cahn (1972, p. 189) reports one case where a fire started on the 8th floor in a down-town New York garment company. Fire equipment was inadequate. As a result 146 workers were killed and hundreds were injured. Many of the deaths resulted from doors being locked to control the temperature in the factory and to keep workers from leaving their jobs. Needless to say, this caused the state to strengthen safety requirements in the factories.

An early account of the problem of using drugs is noted by Cahn (1972, p. 202). He states that there was a "deliberate cultivation" of narcotic drug use in lumber camps "at every company store, cocaine, morphine, and heroin were sold." Because it was readily available, it kept people who had a drug habit from leaving the camp.

Education in the late 1800's did not really help the workers improve their life-styles. For instance, the Land Grant Act of 1864 was passed to establish agricultural and mechanical colleges. These institutions provided engineers who worked very hard and were successful in making technological improvements that increased production. However, industries implemented improvements by shortening the hours of work per day as the production rate was increased. The hourly wages of the worker did not change and as a result they were maintaining management's production schedule in fewer hours of work for less pay.

The early assembly lines also victimized the worker. The concept of piecework had made the production worker a victim of the machine being operated. The automotive industry created additional problems for the organized labor movement. The production workers performed functions that were not compatible with the trade union concept. The person on the assembly line was unskilled or semi-skilled by the trade definition. Many of the workers were foreign born with language handicaps and unfamiliar with customs. The AFL was not interested in these people.

As time passed, it became more evident that the AFL concept of organized labor was not appropriate for people in many areas of industry. Companies attempted to organize their own unions. The AFL had voted against changing their structure from craft unionism. Some of the AFL unions that favored changing the structure to include industrial rather than craft organizations formed the Committee for Industrial Organization. The Committee refused to disband at the request of the AFL and was expelled from the AFL. The Committee pursued organizational activities and changed its name to Congress of Industrial Organization (CIO). When the name was changed most of the member groups were former AFL affiliates. As organizational efforts were expanded industries that were formerly open shops began to join the CIO.

The two unions operated independently through World War II. After the war, they both realized that they were spending time and money competing with each other for membership and control. Negotiations began for a merger. In 1955, agreement was reached, a constitution was written, and the result was the AFL-CIO as it is known today.

Leiter (1952, p. 134) notes that American labor made substantial gains between 1914 and 1920. There was a drain on the labor force to recruit military personnel for World War I as well as a demand for higher productivity to provide military goods. Even the employers became more willing to share profits with production workers since they had "cost-plus" contracts.

Much of the interest in sharing profits occurred as a result of the implementation of the concept of "scientific management," designed by Frederick W. Taylor. He established that efficiency would be increased by time-study and a carefully planned system of wage incentives to encourage the cooperation of production workers.

There was a great demand for productive labor. The government began to become more interested in labor problems. Woodrow Wilson was the first president to pay serious attention to the advice of the leaders of organized labor (Player, 1976, 118). Company unions were encouraged in order to maintain the production of military goods. Labor was represented on most important federal agencies during World War I, especially those dealing with industrial relations.

Immediately after the war there was a period of stagnation for labor. The lucrative contracts had ended. Employers began to revert to the open shop especially as they related to craft trades. However there was still some encouragement for management to form company unions (Leiter, 1952, p. 136).

After the stock market crash in 1929 the federal government began to get more involved in the problems of the labor force. President Franklin D. Roosevelt seemed supportive of the labor movement. He was a humanitarian who supported the need for a living wage so no one would starve. Unions that had been tolerated previously were now being encouraged.

Governmental programs to keep people working during the depression that followed the crash of the market were implemented. The Work Project Administration (WPA) and the Civilian Conservation Corps (CCC) were two such programs. Many projects were in the field of construction. Public buildings, roads, bridges, and utility systems were among the types of construction that took place during the 1930's.

During this same period of time, the legislature enacted other forms of pro-labor bills. Collective bargaining was the major issue. The National Industrial Recovery Act (NIRA) of 1933 prohibited employers "from coercion and restraint of labor unions" (Leiter, 1952, p. 223). For various reasons this Act was found unconstitutional but it did provide guidelines for future labor legislation. The first really significant legislation was the National Labor Relations Act, also known as the Wagner Act, passed in 1935 (Leiter, 1952, p. 225). It established the National Labor Relations Board (NLRB) to investigate questions affecting interstate and foreign commerce. It provided employees with the right to form unions and bargain collectively on matters of mutual concern. It determined how the employees would be represented: by employer unit, craft unit, plant unit, or subdivision. The NLRB would conduct elections and certify the results in all matters of bargaining. A procedure to enforce the NLRA by the NLRB was also included.

The Social Security Act of 1935 was another pro-labor piece of legislation. It was enacted to provide insurance against loss of a job. Since passage of the original act, amendments have been made. They include federal grants to states for old age assistance, aid to dependent children, and aid to the blind and otherwise temporarily or permanently disabled people. Additional federal grants are available to states for maternal and child welfare, vocational rehabilitation, and public health work.

In 1936, the Public Contracts Act (Walsh-Healy Act) was passed. It prohibited boys under 16, and girls under 18, from working on a government contract in excess of $10,000 (Leiter, 1952, p. 103).

In addition to protecting workers on the job there was also governmental interest in providing personnel for the job market. This was supported by the National Apprenticeship Law of 1937. It established a combination of training and classroom activities for two years or more for people to learn a craft, trade or job.

The next year, the Fair Labor Standards Act of 1938 was legislated. It provided numerous benefits for employees who were engaged in interstate commerce. There was a ceiling on hours and a floor under wages (Cahn, 1972, p. 255). The work-day was established at 8 hours and 40 hours for the work week. Beyond these limits the employees were to receive time-and-a-half for overtime. The original minimum wage was $.25 per hour with a graduated scale to raise the minimum periodically. (By 1950 the minimum wage was $.75 per hour, in 1961 it became $1.25, and in 1980 it went to $3.10.) The Act prohibited employment of children by employers engaged in interstate commerce. The National Association of Manufacturers (NAM) called this Act "a step in the direction of Communism" (Cahn, 1972, p. 255).

Throughout the depression and during World War II, efforts were made to reduce discrimination. Women had found broader opportunities in many areas of manufacturing and business than those in the "sweat shops" in the garment industry. The most flagrant incidents of discrimination were against blacks.

During World War II an executive order by the President ordered the Fair Employment Practice Committee (FEPC) to eliminate discrimination because of race, creed, color, or national origin in all governmental agencies and contracts. The Committee handled many complaints but "had no power to compel obedience" (Leiter, 1952, p. 100). Congress defeated efforts to make the FEPC a permanent agency and it went out of existence after the war.

Since the FEPC was terminated and a large number of strikes occurred in 1946, there was great resentment and public apathy toward organized labor (Leiter, 1952, p. 232). In response, Congress passed the Labor Management Relations Act (LMRA) of 1947, commonly called the Taft-Hartley Act. This Act amended the NLRA. It modified the NLRB by providing a council with authority over the investigation of unfair labor practices. It protected the rights of the workers. Rights also were given to management personnel. Unions were forbidden from forcing employee membership or refusing to bargain collectively. Certain kinds of strikes and boycotts were outlawed. Unions could not charge excessive initiation fees. Employers were protected against featherbedding. Open shops were permitted and a union could be established only by the vote of the workers. Workers could also vote to disband a union. Unions were prevented from contributing to federal elections. Employees were provided certain safeguards from the union. The public also was protected by allowing the NLRB to issue an injunction that would prevent a strike or lockout and require a "cooling-off" period in an effort to settle a problem.

The LMRA seems to have been the legislation that removed much of the clout of union control. Based on the protections, provisions, preventions, and other terms used in the Act, there are sections applicable to the individual worker, the organized union, the employer, and the public.

From the turn of the century the government has become much more involved with interstate commerce and regulating the buying of goods and services. Pressures have been applied for congress to show more concern for the people providing the commodities needed by the government. This type of legislation has become more prevalent since World War II. For example, the FLSA was amended in 1949. Where the original Act prevented interstate commerce by employers of children, the amendment made employment illegal (Leiter, 1952, p. 104). It also prevented child labor in many specific occupations, especially those which were deemed hazardous, and it limited the amount of time that a child could work. There also were some exceptions. For example, if children were employed by parents, as actors, in agriculture, or to deliver newspapers, there was no provision for their well-being.

The Equal Pay Act of 1963 also was an amendment, or updating, of the FLSA. It was an effort to eliminate wage difference based on sex for many production workers. Another amendment in 1974, states that most state, local, and federal agencies are to refrain from discrimination based on sex (Player, 1976, p. 38). It added professional people to the coverage. Pay is to be commensurate for equal skill, effort, and responsibility when the working conditions are the same. Differences are justified by (1) seniority, (2) merit, and (3) quantity or quality of production (Player, 1976, p. 39).

In 1965, Executive Order 11246 created the Office of Federal Contract Compliance (OFCC), an agency of the Department of Labor. This

Order further deals with reducing discrimination in employment. When a governmental contract in excess of $10,000 is to be let, the bidders must: (1) explain how the bidder's work force is divided relative to minorities (must be more than tokenism) in a pre-award conference (a requirement for contracts over $1,000,000); (2) submit an affirmative action plan when contracts exceed $50,000 and 50 or more employees work for the bidder; and (3) be open to compliance review while the contract is in force. The OFCC has the authority to terminate or suspend any existing contract. This could happen after a review that would be requested by an individual or organization who complained about a violation.

Age has been added to the anti-discriminatory acts relative to race, creed, color, religion or national origin. The Age Discrimination in Employment Act of 1967 protects individuals between 40 and 65 years of age from discrimination by (1) employers of 25 or more persons engaged in interstate commerce, (2) employment agencies servicing such employers, and (3) labor organization of 25 or more members whose duties affect interstate commerce. This Act is not totally inclusive and therefore, has some exceptions. The Act prohibits age discrimination unless (1) bona fide occupational qualifications are reasonably necessary, (2) factors other than age are pertinent, (3) where a seniority system or existing employee benefit plan would prevent employment, and (4) discharge or discipline of an individual is for a good cause other than age. This Act was actually an amendment to the Civil Rights Act of 1964.

These various acts and executive orders are quite specific concerning civil rights. Civil rights legislation is not totally new. The first expression of concern for people was expressed in the Civil Rights Act of 1866. This Act stated that *all* citizens shall have the same right (1) as enjoyed by white citizens in their rights to inherit, purchase, hold, and convey property, and (2) to make and enforce contracts (Player, 1976, p. 96).

Several of the previously mentioned references to civil rights are based on the Civil Rights Act of 1964. As noted it has been amended several times. One of the major contributions of this Act was the Economic Employment Opportunity Commission (EEOC). This commission is a conciliatory agency responsible for investigating employee complaints about an employer's or union's violation of the individual's civil rights. After the EEOC investigation the court may enjoin the respondent from unlawful behavior or whatever action would be appropriate.

Still another form of discrimination is the thrust of the Rehabilitation Act of 1973. This law concerns people with physical and mental handicaps. The Act states that the handicap cannot be the sole reason to exclude the person from "participation in, being denied the benefits of, or be subjected to discrimination under any program or activity receiving federal financial assistance" (Player, 1976, p. 268).

Productivity has increased at a rapid rate through the history of our industrial economic system. The industrial system has developed from a group of indentured servants, slaves, and apprentices under the control of a small group of affluent masters and employers. These employers very often had no consideration for the individuals and subjected them to long hours of work in an extremely poor environment. The workers were exploited and threatened. Often their total lives were controlled by the employer or the landowner.

The factory work force consisted principally of women, children, and minorities. The rewards for their efforts were meager pay with few or no benefits. They were almost certain to lose their employment by complaining and not maintaining the production schedule.

At the outset of the industrial revolution work was accomplished by primitive methods. As machines were invented and energy was harnessed, managers of production were able to increase their output. The assembly line became the way to do business. Great problems of resentment developed among workers as they were manipulated by mechanization.

The long hours took their toll in illness, accidents, and death. Workers began to rebel and try to band together in an effort to make their feelings known. Unions were formed by trades, industries, and groups of women and children. They tried collective bargaining and striking as means of being heard by management. These efforts often were unsuccessful.

Foreigners were often brought in by employers to operate the factory or mines when strikes occurred. This caused rioting and bloodshed as the union members tried to protect the integrity of their strikes.

Health of the workers was at stake. Filthy working environments, disease, fire, and dangerous equipment created untold social problems.

Wars caused some changes in the industrial workplace. Employers learned that they were faced with restrictions which had existed previously but were flagrantly violated.

During the great depression the government provided work. The conditions of employment were often better than those experienced by the workers before layoffs from private industry. This was due primarily to the New Deal efforts initiated by President Roosevelt.

As a result of this humanitarian effort many acts have been legislated that have affected the conditions under which people work. This has resulted in a definite improvement of the standard of living for the American people. Labor relations and civil rights have been the major thrust.

The next section of this chapter deals with the industrial work environment relative to the present conditions under which people work.

PRESENT STATUS

As indicated in the introduction of this chapter the principal objective for the industrial environment is productivity. Evolution of products and processes creates a problem for distinguishing past, present, and future as these terms would normally be used. Therefore, the present status is not something exclusive of the past and future.

This nation has commonly been described as a society based on the "work ethic." This is the situation where employees feel that the primary purpose for their work is to produce the products and perform the services of our industrial economy. In the past, factories encouraged and rewarded individuals who suggested innovations to improve productivity. Scientific management has brought about somewhat of a diminishing effort in this respect. In fact, there is even resistance to change.

Scientific management and technological advancements have contributed to this resistance to change in modern times just as the reference made in the background section to mass production in the automobile industry. Scientific management in manufacturing has reduced the actual percentage of employees engaged in production. A similar situation has occurred affecting agricultural workers. The total number of people engaged in tilling the soil or handling the product in the factory is diminishing. This does not necessarily reduce the total work force but it does change job classifications. This means that computers and technological advancements in the field of automation are taking employees off the factory floor and placing them at stations where they command or control a phase of a process and monitor the results through electronic computation.

Many of the products and services that we enjoy at the present time are the outputs of our mass production system. It seems that the human aspect is completely ignored in the elements of mass production identified by Kranzberg and Gies (1975, p. 106):

1. Standardization of parts
2. Interchangeability of parts
3. Precision tooling
4. Process mechanization
5. Synchronization of material flow
6. Continuity for eliminating waste and maintaining a smooth flow of material

In years past, the work force of industry has been dedicated to the work ethic. Pride was measured by the quantity and quality of the goods produced. Division of labor has changed this attitude. When referring to the worker of today, Dunnette observes, "He is simply a payroll number, a cost, a kind of liability. It is the job or the performance of the job duties – that is, the work – that counts" (1973, p. 3). This suggests that today's production worker is functioning mechanically with indifference to the quality of the product manufactured. Such an attitude is in support of McGregor's classic Theory X for having to depend on coercion, compensation, and external control for work to be accomplished (Reber & Terry, 1975, p. 47).

This problem is not really new. Deans (1973, p. 3) indicates that the indifference of workers and the slowing down of productivity began in the 1960's. His reasons for the decline in industrial output were the:

1. Business cycle
2. Youthful workforce
3. Increase in women workers
4. Shift to a service economy
5. Arms race and technology
6. Emphasis on environmental improvement
7. Organized labor practices (Deans, 1973, pp. 6-7)

Deans (1975, p. 18) further states that many efforts have been made in the area of motivation through:

1. Reduced work hours
2. Increased benefits
3. Off-hours recreational activities
4. Sponsored vacation trips
5. Prizes
6. Bonuses
7. Other inducements

In spite of all this, there is still absenteeism, tardiness, defective workmanship, and high rates of personnel turnover.

Apparently, standard company benefits are not adequate to alleviate the above-mentioned problems. The solution may involve worker participation in making decisions for the company.

McGregor's Theory Y suggests much greater involvement by the workers in the functions of the organizations where they are employed. If committed to the objectives of the organization, the worker will exercise self-discipline and self-control and be internally motivated (Reber & Terry, 1975, p. 49). This attitude exemplifies the *Work in America* (1972, p. 13) list of the most important aspects of work:

1. Interesting work
2. Enough help and equipment to get the job done
3. Enough information to get the job done
4. Enough authority to get the job done
5. Good pay
6. Opportunity to develop special abilities
7. Job security
8. Seeing the results of one's work

These aspects support the notion that workers have placed social and psychological goals ahead of pay and job security in order to be satisfied with their employment. This is in contrast to the traditional approach to job design where:

1. Skills should be specialized
2. Skill requirements should be minimized
3. Training time should be minimized
4. The number and variety of tasks in a job should be limited
5. The job should be made as repetitive as possible (Reber & Terry, 1975, p. 69).

To evolve away from the traditional approach to job design will require the application of several factors such as motivation, aptitude, educational opportunities, training, and emotional stability (Bass & Barrett, 1972, p. 40). The transition would suggest that the workers will become involved in participative management and help make decisions about:

1. Their own production methods
2. Internal distribution of tasks
3. Questions of recruitment
4. Questions regarding internal leadership
5. What additional tasks to take on
6. When they will work (*Work in America,* 1972, p. 103).

Most changes are the result of evolution rather than revolution. Several of the more current humanistic problems of personnel that are undergoing change are: discrimination, minority groups, and women's employment. All of these are sociological in nature. Social concern for communications, attitude changes, group structures, group processes, interpersonal relations, social roles, and leadership also would give direction to the improvement of working conditions.

Another pressing issue is the current problem of maintaining necessary employment levels. The Bureau of Labor Statistics (August, 1974, p. 5) reports that there are 58 million people unemployed. Many reasons were given, such as: attending school, illness, disabled, discouraged, keeping house, retired, et cetera. Most of these are individual problems which can possibly be alleviated by a combination of psychological and educational factors, many of which can be overcome by proper self-analysis, guidance, and training.

There are many indications that industry should become more humanistic in its attitude about people. Ways suggests:

> As we gain confidence in the ability to rise far above the level of material substance, we become more interested in the human side of enterprise. We become more intent on judging the economic system in psychological, aesthetic, and moral terms (1972, p. 197).

Ways (1972, p. 199) characterizes today's society with four words: change, knowledge, individuality, and interdependence. These words suggest adaptability for everyone. Workers must overcome their resistance to change. They need knowledge rather than muscle to prevent obsolescence. Some automomy is important for personal satisfaction, even though interdependence is needed for the enterprise to function efficiently.

Managers and executives also have some problems with their work situations. Their decisions result in company success or failure. Correct decisions may lead to promotions. Incorrect decisions may result in dismissal. In either situation, the psychological effect on managers can be overwhelming and contribute to physiological problems such as ulcers and heart attacks. Gerber (1973, p. 65) points out that people in middle management "pass up promotion for the sake of staying where they like or doing what they want." He notes what he calls causes for the "erosion of the company man":

1. He places his own interests and those of his family ahead of the corporation.
2. There are problems of wive's roles in the corporate image.
3. Mores in personal grooming (Gerber, 1973, p. 68).

Dishonesty is a problem in the industrial environment. White collar crimes have risen greatly in recent years. Theft, fraud, embezzlement and arson are having a financial and social impact on persons with management responsibilities in industry. Blue collar workers also are involved in theft, extortion, and other crimes.

There are other significant factors about manpower which affect the worker:

1. Technology – automation redistributes the work force rather than reducing it.
2. Rise of service industries – as an alternative to manufacturing.
3. Trade unions – organizing other than blue collar workers.
4. Blue collar is fading – retraining is needed for dead-end jobs.
5. The geography of employment – means worker mobility.
6. Educational changes – those which are vocationally oriented are considered beneficial (Fleming, 1972, pp. 205-206).

These are problems that have apparently not been conquered in our industrial society. One comment about the last item, educational change, is that according to various reports as high as 25% of the jobs people will be performing in the next 10 to 20 years have not even been identified yet. As a result, many current job titles will probably become obsolete.

There are many physical, psychological, and fiscal concerns for industrial personnel. There have been suggestions that the work week should be shortened to 38, 35 or even 32 hours to provide more free time. Workers are rejecting good-paying, boring jobs in favor of lesser-paying jobs which offer interesting activities and opportunities to make decisions.

Since the beginning of the Industrial Revolution, wages and materials have had varying impacts on the cost of goods and services. Priorities have changed from time to time. The immediate goals of the American enterprise system, according to Hoadley, are:

1. To improve the quality of life amidst probably slower economic growth.
2. To better balance population, jobs, and the labor force.
3. To control inflation.
4. To achieve less congested urban living (here is where our system will meet some of its most severe tests).
5. To increase creative productivity (Hoadley, 1972, p. 266).

These represent internal concerns which must be resolved.

However, there are much broader goals to be considered. Some are "how the increasing velocity of social change might affect the size, form, structure, and internal and external relationships of the corporation" (Amara, 1972, p. 77). Amara writes that the social changes can be aggregated into four environmental trends:

1. Economic toward Social
2. Industrial toward Postindustrial
3. Technological toward Posttechnological
4. National toward International (1972, p. 77).

The first three situations suggest forms of internal or national structures. The last is leaning toward Kahn's aspects of the world context that the international or the multinational corporation (MNC), as he perceives it, would have much to offer:

1. Continuation of world peace, relative political stability, and worldwide economic growth.
2. Dispersion of resources and markets – disparities in labor costs.
3. New or emerging technologies, sources of resources, markets, and methods of rationalizing the economics of various industries.
4. Increasing "similarity" or standardization of markets.
5. In some cases continued protectionist policies, but in others decreasing protectionism.

6. Increasing importance of economics of scale – requirements for large amounts of capital, competent management, and advanced or new technology to accomplish desired or required tasks.
7. Proportionate decrease in transportation and communication costs.
8. Pressures to maintain a competitive market share.
9. "Momentum" from current investment and experience.
10. No pervasive and/or effective interferences from political authorities (Kahn, 1972, p. 20).

The structures of the industry workplace, whether local, national, or international, should be understood by all who enter the labor market and become involved in the problems of industry.

In addition to the aspects of the organizational structure under which the industrial workplace functions, there are other pressing issues of a personal nature. These have to do with the individual's health. Many solids, liquids and gases present in factories have jeopardized workers' lives, created disabilities, and on occasions been lethal. Cravener refers to these matters as part of "contamination control" and provides the following observations:

> To be completely general we would have to say that nearly everyone is concerned with contamination – the doctor, the radiation physicist, the engineer, the housewife. In industry, each individual from the product designer to the assembly technician is concerned (1968, p. 10).

In addition to the gaseous and solid particles contaminating the atmosphere, another source of air pollution has to be controlled – noise. Without concern for noise levels (measured in decibels – "dB"), an individual's hearing can be permanently impaired. Injury occurs progressively over a period of time when people are exposed to more than 90 dB during an 8-hour period. For example, a power mower produces approximately 100 dB and should not be operated for more than two hours per day (Priest, 1973, p. 271). Not only is there physical damage, but increased blood pressure and heartbeat have been caused by noise pollution and could lead to a variety of psychological effects. As a result, the worker in a manufacturing plant could experience interference with work performance, efficiency, and sound communication, as well as outright annoyance (Priest, 1973, p. 266).

The government now is legislating against problems in the work place. Patton indicates that the thrust of the legislation has to do primarily with standards for noise, air contamination, and heat. He states that these problems should be solved by (1) substitution, (2) isolation, and/or (3) control. The returns for compliance will be (1) lower maintenance costs, (2) improved quality of products, (3) reduced accidents and absenteeism, (4) improved employee morale, and (5) greater efficiency and profitability (Patton, 1973, p. 8-9).

Specifications for how to reduce these problems have been prepared and distributed by the government. This regulative legislation is P. L. 91-596, entitled "Occupational Safety and Health Act of 1970" (OSHA). This Act is, by far, the most progressive effort to protect the physical well-being of industrial employees at all levels, both management and production. Various resources, including hospital and insurance claim records, were used to write guidelines for industrial safety. State efforts to protect workers have failed because they lacked clout. The federal legislation has been copied from many of the states' enactments with the stipulation that the industry will have fines levied against it if compliance is not achieved within a reasonable amount of time. The following is a list of the general areas for which comprehensive health and safety standards have been developed as a result of OSHA:

1. Workplace Standards
   A. Electrical wiring, fixtures and controls
   B. Exits and access
   C. Fire protection
   D. Housekeeping and general work environment
   E. Illumination
   F. Sanitation and health
   G. Signs, labels, markings and tags
   H. Ventilation
   I. Walking and working surfaces
2. Machines and Equipment Standards
   A. Appliances, electrical utilization
   B. Compressed gas and compressed air equipment
   C. Conveyors
   D. Cranes – crawler, locomotive and truck
   E. Cranes – overhead and gantry
   F. Derricks
   G. Hand and portable powered tools
   H. Machinery and machine guarding
   I. Miscellaneous equipment used in general industry
   J. Miscellaneous equipment used in special industries
   K. Trucks
3. Materials Standards
   A. Hazardous materials
   B. Hazardous locations due to materials
   C. Materials handling and storage
   D. Materials handling machines and equipment
4. Employee Standards
   A. Ionizing radiation protection
   B. Medical and first aid
   C. Personnel protection in tanks and confined spaces
   D. Personal protective equipment
   E. Skills and knowledge

5. Power Source Standards
   A. Electrical power
   B. Explosive actuated power
   C. Hydraulic power
   D. Pneumatic power
   E. Steam power
   F. Miscellaneous power sources used in special industries
6. Process Standards
   A. Abrasive blasting
   B. Dry grinding, polishing and buffing, exhaust systems
   C. Process, dip and open surface tanks
   D. Processing plants and operations
   E. Special industries and related processes
   F. Spray finishing
   G. Welding, cutting and brazing
7. Administrative Regulations
   A. Advisory committees on standards
   B. Inspections, citations and proposed penalties
   C. Promulgating, modifying or revoking occupational safety and health standards
   D. Recording and reporting occupational injuries and illnesses
   E. Records – employee exposure to hazardous substances or conditions
   F. Variances, limitations, variations, tolerances and exemptions (U.S. Department of Labor, 1972)

The Act was passed December 29, 1970. The various elements of the standards were first published in the *Federal Record* on October 18, 1972.

There was a great wave of opposition to many of the standards. Compliance has been expensive. Some industries have been forced out of business by the stringent regulations. The result has been that it was found necessary to revoke some of the elements. The proposed revocations appeared in the *Federal Record* on December 13, 1977. More changes may be forthcoming as new materials and processes are used in the workplace.

Another factor that has had an impact on the workforce and the workplace is the computer. Computers are management tools used to make decisions concerning planning, organizing, and controlling the many functions of modern industry. They become an integral component essential to the larger systems of production in that they perform many operations previously done by workers at various skill levels. Computers are being adapted where they can provide economic advantages by decreasing operating costs and increasing productivity. However, a disadvantage of the computer is the high initial investment, but time-sharing plans are being used to benefit small companies through centralized installations.

The development of the computer and its extensive utilization within the manufacturing industry does not necessarily suggest a decrease in the number of employed workers. It does, however, indicate that job descriptions are changing. Many who were formerly skilled have found it essential to seek additional education to become technicians who program computers, process data, and maintain these electronic devices.

More and more electronic devices are entering the work place to compete with humans. This reference is to the invention of an electronically controlled robot with a capacity comparable to mental and motor systems of a human (Foster, 1968, p. 6). As a result, the robot assumes many of the physical activities formerly accomplished by a person. Solving the problems of man-machine communications (cybernetics) will permit the robot to assume more duties in manufacturing. In the plant, this device is used to handle materials and operate automated warehousing activities. Other applications for basic robots are:

> . . . forging, upsetting, plastic molding, machine loading, flame cutting, spot welding, punch press operation, furnace loading, assembly, glass tube handling, glass plate handling, paint spraying, conveyor loading, and other minor applications (Cakebread, 1973, p. 46-74).

Their implementation will be determined by the amount one can afford to spend on an industrial robot installation based on:

1. The cost of labor
2. The amount of human involvement required
3. The cost of a standard developed Robot System
4. The cost of adapting to a particular job
5. Interest rate on capital
6. Amortization period
7. Running cost (Heginbotham, 1973, pp. R1-6).

Still other generations of robots, the second and third, are in the planning stage and at the most sophisticated level will have "eyesight, hand/eye coordination, adaptive learning, and be capable of exercising judgments" (Cakebread, 1973, pp. R6-100).

Information about specific uses of robots often is highly proprietary. However, the Society of Manufacturing Engineers has organized a component of its services as the Robot Institute of America. This organizes and disseminates information about the adaptability of robots through symposiums and published papers. Robot applications have been reported for processing, manipulating, and moving materials. They relate to separating, forming, and combining practices for the scope of activities from component making to packaging.

Jack Thornton, reporter for the *American Metal Market/Metalworking News* (AMM/MN), has described several uses for robots. He states that robots are being adopted to sheet metal processes for the United States Air Force (AMM/MN, June 26, 1978, p. 14). Plans are underway for robot-operated fabricating cells for the F-16 aircraft production. Another procedure being developed is to combine a video robot that directs a second robot in sheet metal fastening operations.

Mr. Thornton reported later (AMM/MN, Supplement, August 28, 1978, pp. 89A-90A) on the state of the art in robot technology. He states that robots are being used most often for welding, investment casting, spray painting, and pick-and-place operations. He notes that the payoff for investments in robots is when the work is too hard, too noisy, too dirty, or too arduous for humans.

Management is finding that robots and other numerically controlled equipment are becoming more and more reliable through technological advancement. Part of the attractiveness is that they can function in environments detrimental to the health of a person. They do not take vacations or coffee breaks. They can function around the clock. Many workers' fringe benefits may someday be diverted to electronic maintenance equipment.

The discussion to this point about the present conditions in the industrial workplace has been generic to all workers with special implications for people employed in factories. Many of these general problems and some unique concerns exist for people who build factories as well as other structures. They are the employees of the construction industry.

First, there is the problem of seasonal employment. Since the workplace is generally without shelter from the weather, the worker has little control over the work schedule. But as Wittrock (1967, p. 225) suggests "the seasonal character of the construction industries is to a considerable extent a matter of custom and habit, not of climatic necessity." If seasonal employment could be reduced (1) there might be greater stability in the work force, (2) the contractor would not have to close down a project and idle much expensive equipment, and (3) owners could have projects started any time during the year. Wittrock (1967, p. 233) states that certain technological advancements have extended the number of days per year that construction projects can be in progress:

1. Rust resistant steel
2. Concrete additives
3. Enclosures
4. Space heaters
5. More powerful equipment to work frozen soil
6. Improved low temperature lubricants
7. Use of drywall

8. Use of curtain walls
9. "Lift up" construction
10. Use of prestressed and precast concrete structural elements

There are some factors, according to Wittrock (1967, p. 233-34), that may be implemented to contribute to further progress in helping to reduce seasonality:

1. Attitudes of employees and trade unions
2. Unemployment insurance schemes
3. Organization of the building industry

Lefkoe (1970) reports that the causes of seasonality are:

1. Added cost of materials, equipment and protection
2. The reluctance among small contractors to share in the added cost
3. Building codes
4. The unions' restrictions on the use of prefabricated units
5. Habits and customs
6. The government's lack of interest in winter contracting

One of the solutions to the problems of seasonality in the construction industry is to require less on-site activity. Housing units and modules are being manufactured in factories. Units such as motel and dormitory rooms have been manufactured and transported to the site and stacked as though they were boxes. They have even arrived with furniture in them. When complete units are not preassembled, partially assembled modules or components may come from a factory. Roof trusses, prestressed concrete beams, and wall sections containing plumbing are examples of this practice. These technological advancements reduce the seasonality problem but they also reduce the on-site work of the labor force in construction.

In addition to seasonality there is a problem of rivalry between union and non-union workers. The union workers have traditionally been aligned with a craft or trade as purported by the AFL organizational structure. Non-union workers seem to be more flexible in their employment classification and perform tasks that would require several people in a union shop according to Northrup and Foster (1975). Non-union workers traditionally have received lower pay but with the EEOC regulations the difference between union and non-union pay scales is reducing. There are also "double breasted" operations that have a common ownership for open and closed shops (Northrup & Foster, 1975, p. 187).

The combination of factors such as seasonality, in-factory manufacturing for construction, the flexibility of the non-union worker, and the rigid jurisdictional boundaries of union employees is quite a contrast. The result is that large conglomerates are employing personnel permanently to construct large development projects. Many times an industrial union is organized that does not require negotiating with several highly specialized craft or trade unions.

This section of the chapter has presented some of the problems and solutions related to the industrial environment as it is at the present time. Union control has diminished somewhat. The government's intervention into industry as a client or customer with numerous anti-discrimination and safety restrictions has improved the life-style of many industrial workers. Technological advancements have altered many industrial organizations and the production processes they use to remain competitive. Practices that implement automation through the use of such hardware as computers and robots will more than likely lead our nation into a post-industrial society. The life-style of the industrial employee has improved greatly and since technology continues to evolve, the human factor to maintain this evolution must also change.

PROJECTIONS FOR THE FUTURE

In less than two hundred years, industrial technology (knowledge or theory of industrial practice) has been the primary catalyst in molding the United States into the greatest goods-producing nation in the world. Once electricity was harnessed and applied, the industrial revolution led to drastic changes and improvements in the American way of life. For example, many time- and labor-saving inventions have evolved into products which have removed much of the need for physical strength in factories and on work-sites. These devices have been the results of an efficiently operating free enterprise system. Modern industry has been very successful in designing the production hardware (machines and equipment) to maintain the system. What is needed is the production software (knowledge of how to optimize machines and equipment utilization) to improve productivity.

The challenge lies in the future:

> The Nation now stands at a critical crossroad – possibly on the threshold of a new era. New discoveries and inventions have mushroomed; knowledge has been increasing exponentially; communications have become practically instantaneous; and efficiency in many sectors has risen beyond the wildest expectations. An assiduous application of new knowledge and technological advances to pressing issues could enable us to become more effective architects of our destiny, and timely adaptation to change would enhance our capacity to realize a grand future never before possible (Miller, 1972, p. IX).

This challenge of technological change is directed not only toward the United States, but to the entire world. Any nation that can emerge from this era with "man controlling technology" rather than "technology controlling man" will have a significant influence on the emerging human element in the industrial world of the future.

Our nation is currently confronted with some very serious problems relating to our man-made world. Many expressions of grave uncertainty are being heard concerning the future:

1. About our ability to live peacefully in a changing world.
2. About our ability to remain productive without ravaging our natural resources.
3. About our ability to manufacture products that are safe.
4. About our ability to educate our children.
5. About our ability to compete effectively in a dynamic world economy.
6. About our ability to enable all our citizens to live without poverty and with human dignity.
7. About our ability to govern ourselves (Connally, 1972, p. 11).

These are broadly stated concerns and could all develop into technologies of a national or international scope. For this discussion they will be delimited by their application to specific industrial practices.

The employee who has the opportunity to make decisions is most apt to be satisfied. Dunnette (1973, pp. 127-130) projects that there are nine new reward systems in which the worker in the future may participate: (1) opportunity to schedule own hours of work; (2) redistribution of job duties; (3) opportunity to create new jobs; (4) opportunity to participate in bonus drawing; (5) opportunity to choose any area of the organization in which to work for a limited period of time; (6) on-the-job non-work activities; (7) new organizational ventures; (8) accrual of time off, including educational and/or civic activity leaves; and (9) intercompany exchange of employees. Implementation of a new reward system requires the following:

1. Specification of performance objectives
2. Specification of methods of measurement of performance
3. Methods to insure an opportunity for receipt of reward (Dunnette, 1973, p. 130).

Management has invested much capital in the establishment of current practices. Changes will occur as new production procedures can be researched and developed to increase productivity.

One of the most recent technological advancements has been Group Technology (Mehlhope, 1975). This system has been devised by management to improve the operation and control of their organizations. Mehlhope (1975) indicates that this is necessary because of the following basic needs of manufacturing:

1. *Increased productivity* — The alternative is galloping inflation which we are experiencing today.

2. *Increased versatility* — The world-wide trend toward a greater variety of products is leading toward smaller lot sizes and to a greater complexity of products.
3. *Increased precision* — A growing emphasis on product performance and reliability requires parts of closer tolerance.
4. *Reduction of Job Monotony* — The declining interest in the factory can be reversed by automating dull, repetitive operation, thereby creating a more interesting and challenging atmosphere in which to work.

These needs are being applied most effectively in the factories utilizing batch production practices. "Its objective is to break the conglomerate problems of batch manufacturing into small manageable units which can then serve as targets for automation technology as economics dictate" (Mehlhope, 1975, p. 2).

As an example of the economics of group technology, the Haliburton Services Company has two cells in operation (Thornton, AMM/MN, August 28, 1978, p. 11). In one cell are four automatic turret lathes, an N/C drill, and a vertical mill. Since production began in February, 1978, set-up time has been reduced 531 hours or 23% and parts production time reduced 7000 hours or 61% compared to previous production data. The second cell consists of five turret lathes and one chucker. This cell saved 217 hours, or 59%, in set-up time and 1500 hours, or 31% in production run time. Together, the cells cost $500,000. The Haliburton Company plans to break even in November, 1978.

High volume production utilizes fixed automation and zero flexibility whereas batch production is highly flexible with little automation. Group Technology, as indicated, is a compromise with "flexible automation and constrained flexibility of product" (Mehlhope, 1975, p. 2).

The process involves part-family manufacturing (similar components processed on a small "cell" or group of machines). Parts are assigned according to shapes such as the cube, wedge, tetrahedron, cylinder, segment, and fillet. A group of employees operating the cell makes all the decisions about production and then proceeds to create the batch-produced component.

Another example of group technology is the Volvo automobile assembly system. A small group of workers assembles the entire vehicle. These assemblers need broader knowledges and more experience than specialists on an American automobile assembly line.

Merchant (May, 1975, p. 14) states that group technology is one of five programs receiving world-wide attention for increasing productivity through computer-aided manufacturing. The others are: (1) integrated manufacturing software systems; (2) computer control; (3) multi-station manufacturing systems; and (4) the computer-integrated automatic factory. He notes that Japan is well underway in planning the automated factory which they call Methodology of Unmanned Manufacturing (MUM). This is a prototype "Unmanned" machine building plant scheduled to be operating by 1980. "Processes carried out automatically would include forging, heat treatment, presswork, machining, inspection, assembly, and painting" (Merchant, January, 1975). The plant is to be a 200,000 to 800,000 square foot factory operated by a "control crew" of about 10 people compared to a normal complement of 700 to 800 worker.

Best (1973, p. 64) notes:

> "Today we are finding it humanly desirable and also more efficient to use machines rather than people to perform routine and predictable tasks."

New technologies need to be developed to systematize the collection and recycling of discarded industrial products. The goal of this endeavor should be to reclaim raw material at a cost comparable to producing new materials. Organizations engaged in recycling are often called "Secondary Industries." The automobile salvage industry represents an isolated effort at material recovery. Entire automobiles are compacted and shredded to reclaim raw materials.

Control of this system is the responsibility of producers, consumers, and the government. Material recovery must become an important consideration of that nation's industrial and educational systems, especially within the context of industrial technology. The effect will be a greater utilization of material and a more pollution-free environment. Presently the average citizen disregards the need to conserve industrial material due to failure to separate disposable waste and recoverable material. Secondary industries will provide employment to maintain the products that support our life-styles.

Daniel Bell (1973) has written in *The Coming of Post-Industrial Society* that the number of people directly involved with manufacturing production is on the decline, much the same as with agricultural production, where, by 1980, the number of on-the-farm workers is forecast to be only 2.7% of the total labor force. He suggests that manufacturing, with 69% blue-collar workers in 1970 and 65.5% in 1975, will continue to have an increased percentage of white-collar workers. Regardless of this increase in white-collar personnel in manufacturing, the *total* work force will be reduced by only a few percentage points within the overall labor force by 1980.

Other white-collar workers will be performing "services" within the economy, which according to Bell's forecast, will be the principal form of employment in the post-industrial society. Bell (1973, p. 15) identifies what he feels will be the nature of "services":

1. personal (retail stores, laundries, garages, beauty shops)
2. business (banking and finance, real estate, insurance)
3. transportation, communication, and utilities
4. health, education, research, and government.

Some of the personal service industries will be created to satisfy the worker during leisure time.

It is the growth of the fourth category which is decisive for post-industrial society. "And this is the category that represents the expansion of a new intelligentsia – in the university, research organizations, professions, and government" (Bell, 1973, p. 15). Total growth is based on the data that today (1973) about 60% of the labor force is already engaged in services and that by 1980, that will increase to 70%. As this occurs, increased productivity, the goal of our industrialized society, will undergo some reevaluation. In the past, workers have been displaced by machines for the sake of goods production. Bell (1975, p. 155) comments about judging productivity in service occupations:

> "Productivity in services, because it is a relation between persons, rather than between man and machine, will inevitably be lower than it is in industry" (Bell, 1975, p. 155).

Soutar forecasts business problems and prospects concerning industrial personnel:

1. Necessity for a favorable business environment
2. Present union attitudes must change
3. More goods at less cost
4. More codetermination between employer and employee
5. More constraints on wages
6. More emphasis on nonwage benefits
7. Medical services broader, less personal
8. Worker job-satisfaction more important
9. Industry-subsidized education
10. Earlier retirement
11. Work distinctions diminish (Soutar, 1972, pp. 228-231).

Although other rewards are expressed as being more important to job satisfaction, money must influence employment. Future income distribution will affect the wage earner as indicated in Table 7-1.

The organization from which employees will receive the increased income will be changed if it satisfies the forecast made by Soutar. Best (1973, p. 75) suggests that "The old loyalty felt by the organization man appears to be going up to smoke." He further notes that "Today we are observing the professionalizing of industry." Today's modern organizations are based on job description, job analysis, job evaluation, career ladders, and on-the-job training (Dunnette, 1973, p. 2). He further states that the trouble with this approach to modern organizations

Table 7-1
Changing Income Distribution

Family Income	1970	1980	1990
$25,000 and Over	5%	13%	27%
$15,000 - $25,000	19%	33%	33%
$10,000 - $15,000	28%	23%	17%
$ 7,000 - $10,000	19%	12%	10%
$ 5,000 - $ 7,000	11%	8%	5%
$ 3,000 - $ 5,000	10%	6%	5%
Under $3,000	8%	5%	3%

(Conference Board, 1972, p. 55)

is that the work is done independent of the workers who do it. People in these types of organizations often take secondary jobs. Workers often engage in "moonlighting" in lesser paying jobs that are personally satisfying as a diversion from their regular employment.

Breaking from a routine job will apparently become the type of employment that people will perform in the future. Best (1973, p. 71) projects that "non-routine" jobs will "employ 65% of the total United States work force by the year 2001." He further indicates that the managers controlling this type of non-routine job organization will work temporarily on "projects." When the project is finished, the manager will be reassigned like the worker (Best, 1973, p. 70).

In addition to the types of work and organizations projected in the future the employee may have the option of making decisions about when and how long to work per day or week. Fleuter (1975, p. 7) projects that the "shorter work week is an inevitable sociological change." In opposition to the traditional work ethic, employees will seek employment that supports their self-interests.

Fleuter (1975) identifies some of the work schedule options. They are:

1. The four-day work week with a three-day weekend which reduces travel and non-productive time as well as allowing time for personal matters. A temporary employee could be hired for the fifth day.
2. The five-day/four-day week where the employee works a 32-hour work schedule every other week.
3. The five-day 35-hour week which seems to be the most popular option but increases the per hour cost of products and decreases productivity.
4. The three-day 36-hour week would be compatible with special circumstances such as operating computer equipment. The employee schedules two work days in a row with a four-day break.

5. The four and one-half day week which shortens the week by one-half day.

There are some disadvantages as well as those features that would attract employment (Fleuter, 1975). For the worker they include:
1. The assumption that people would trade short days for long weekends (e.g., campers and sports enthusiasts).
2. The idea that people would travel on their day off.

Disadvantages for the business include:
1. The feeling that there is little to offer the company.
2. The fact that production diminishes after eight hours.
3. The observation that there would be less utilization of facilities and equipment.
4. The assumption that normal service scheduling may suffer.

A schedule that may be more attractive to industry would be the continuous work week. One option would be a 10 hour day for three and one-half days or a 35-hour week. Another option would be three days one week and four days the next. In either situation productivity is increased. Fleuter (1975, p. 27) indicates that:

1. This is a true workweek reduction.
2. There would be an increase in the volume of items moved.
3. Two work groups could be employed and provide seven days of service.
4. Facilities and equipment can receive greater utilization.
5. Overtime is eliminated.
6. There is no need for the current number of holidays.
7. Absenteeism is reduced.

Dunnette (1973, p. 6) refers to the daily schedule of the 35-hour work week as the "cubic day." He describes the concept as having two people perform the same job seven days each week. The two workers involved could alternate (1) mornings and afternoons, (2) days, or (3) weeks.

There are many options for altering the employees' work schedules. A number of experimental efforts have been tried with both private and public employees using a concept of scheduling called "flextime" (Fleuter, 1975, p. 74). Under this plan the employees have a base period of time when everyone must work. There are variations at the beginning and ending of the day. For example, some workers may work a morning flextime from 7 a.m. to 9 a.m. The base time, or required work period, is from 9 a.m. to 4 p.m. A second group of workers may arrive at 9 a.m. and make use of the afternoon flextime from 4 p.m. to 6 p.m. The business day is from 7 a.m. to 6 p.m. Using the concept of flexibility, an employee may work six hours one day and 10 hours the next. Based on the employee's responsibilities the flextime cycle could be weekly or monthly.

According to Fleuter (1975), the flextime concept has been enthusiastically accepted. There has been an improvement in morale and productivity where the experiment has been conducted. For the employee the advantages are that the individual (1) and set his or her own schedule, (2) is under less stress, (3) enjoys less commuting time, (4) has more time to attend to personal matters, and (5) experiences job enrichment. From the standpoint of management, there also are advantages. These have been that it (1) reduced absenteeism, (2) fluctuated the work load, (3) provided quiet time, (4) offered better communications, (5) allowed for backup training, (6) attracted applicants, (7) improved morale, (8) made no reduction in total hours, and (9) had less employee resistance (Fleuter, 1975, pp. 79-81).

There are some disadvantages to flextime. They are few but it does (1) increase utility costs, (2) develop problems of people not being available at a given time, (3) create time recording problems, (4) draw adverse reactions from unions, and (5) causes conflicts with some wage-and-hour laws.

The past and the present provide the basis for projecting the future. This nation has become the greatest goods-producing country in the world. We are confronted with the proposition of whether we will control technology or whether technology will control us. The achievements of automation and cybernetics through creative applications of computers have made many changes in the industrial environment. People have been relieved from many repetitive, boring operations. The challenge of technology in the future will be the reduction of job monotony and increased productivity, versatility, and precision. These goals likely will be achieved with the aid of computers.

The industries that must become a concern of every one are the commonly called secondary industries. They try to reduce the waste of materials by recycling them to become useful products again.

As time passes we will continue the evolution from a goods-producing to a goods-servicing economy. Services have been identified as personal, business, transportation, communication, utilities, health, education, research, and government. Satisfied employees in these and other industries will need to find work challenging, non-routine, and rewarding. The worker will want to become more involved in decision making especially if the decisions affect the individual. An example of such a decision would be the area of work scheduling. Shortening the work week seems to be inevitable in many industries. Opportunities from concepts like flextime and cubic day may provide the industrial employer and employee some benefits that are not known at this time. The employer may find the increased productivity necessary to maintain our economy in a post-industrial society. The employee may realize greater rewards of employment. Among them may be the satisfaction from many leisure-time industries that meet the individual's needs during free time.

The servitude of early primitive industries has passed. The atrocities experienced by workers during the industrial revolution have disappeared through legislation to protect the rights and health of the employee. The work ethic has given way to the productive worker interested in the wage and benefit rewards of labor. The worker of the future likely will be engaged in more service endeavors. There will be more opportunities to participate in making decisions. Some of these decisions will relate to the group of people as well as when the work will be scheduled. Having the right people in the right place at the right time is essential to an effective and efficient productive industrial environment.

INDUSTRIAL ARTS ACTIVITIES RELEVANT TO THE INDUSTRIAL WORK ENVIRONMENT

The activities listed below are designed to provide students with opportunities to study industrial problems related to the work environment. Many are interdisciplinary. They could involve economics, social studies, science, and other areas of education. For these activities, use the following glossary:

worker (student)
manager (instructor)
industry (the laboratory or shop)
productive (enroll and participate in activities)
fired (removed from class)
employment (class assignments)

1. What makes work boring? What industrial activities are boring to you? Assuming that the operation is essential, design a mechanical system to replace you.
2. In this industry are there any management decisions in which the worker could participate to a greater extent?
3. Discuss the differences in working conditions that could exist in a factory that (a) is strictly a local operation and one that (b) deals in interstate commerce or provides goods under a government contract.
4. Perform a study of industry to determine whether workers in wheelchairs could be productive and identify limitations of their job assignments. Design changes in the facility that could make these workers more productive (use more tools and equipment).

5. Research information about affirmative action plans in your community.
6. Discuss management's use of McGregor's Theories X and Y in industry.
7. With a sound-level meter measure the noise level when machines are operating.
8. Obtain an OSHA color chart from a local paint store and conduct an inspection for color coding.
9. Role-play the following grievances:
   a. A worker is fired for violation of safety regulations.
   b. A worker is fired for theft, vandalism, sabotage, or other white or blue collar crimes.
   c. Management's failure to provide, or the workers resistance to use, various kinds of safety equipment.
10. Discuss various applications of the concept of "group technology" or job enrichment.
11. What limitations would there be on productivity without railroads or trucklines to transport raw materials and finished products? What about productivity if there was no electricity? Try operating the industry without electrical power for machines for a day.
12. Discuss some of the MUM (Methodology for Unmanned Manufacturing) advantages and disadvantages for our society.
13. Set up an automated assembly line using people as robots.
14. Make a list of some businesses and factories in the community where flextime would be appropriate. Identify specific advantages and disadvantages.
15. After graduation what kind of "service" career do you think you might want to seek? If this career becomes obsolete, what will you do then?

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Chapter 8

Pollution

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> The time has come for humanity to unite against the common enemy in itself. The great irony of our time is that humanity may be destroyed, not by its madness, but by its carelessness – by its wanton disregard for its special relationships to the planet Earth.
>
> Arthur Toynbee

Pollution, like disaster preparedness and safety, is not an exciting topic. It is often "left to others" by those who should be most accountable – industrialists, public officials, and teachers. Each has a level of responsibility:

- Industrialists – for they manufacture the products which produce pollution (automobiles, etc.) as well as produce vast quantities of pollutants in the process.
- Public officials – for they study and regulate society *for the benefit of all* through laws and regulations.
- Teachers – for they help pass on to coming generations the values, needs, and problems of society.

Pollution of the air we breathe, the water we drink, and the soil on which we live is the heavy price paid for our standard of living. The sources of this pollution are all around us and often include our finest technological accomplishments.

Our efforts to help feed the growing world population have increased our use of fertilizers and pesticides. The same pesticide which saves a crop by destroying insects may be washed into a river and enter the food chain via the fish living in the river. The result can be dead or contaminated fish, or even worse, people unknowingly eating the fish and becoming seriously ill.

Major sources of pollution include automobiles, airplanes, power plants, home heating, industry, agriculture, hospitals, and all the waste produced daily by man. Virtually every action of man produces waste or helps pollute our environment. Pollution has become and remains one of society's major problems and concerns.

NATURE OF POLLUTION

The Environmental Pollution Panel of the Presidential Science Advisory Committee has defined pollution as:

> Environmental pollution is the unfavorable alteration of our surroundings, wholly or largely as a by-product of man's actions, through direct or indirect effects of changes in energy patterns, radiation levels, chemical and physical constitution and abundances of organisms. These changes may affect man directly, or through his supplies of water and of agricultural and other biological products, his physical objects or possessions, or his opportunities for recreation and appreciation of nature. (Monitor, p. 73)

The key phrase is "unfavorable alteration." This alteration may reduce opportunities for recreation, threaten our food supply, cause sickness or death, or simply make life less enjoyable. Since the "alteration" is unfavorable, every effort should be made to control and minimize the unfavorable effects of pollution. This can be accomplished by controlling the source or by removing, modifying, or recycling the pollutant.

Pollution has been traditionally divided into four categories or types: air pollution, water pollution, soil (land) pollution, and thermal pollution. These four categories are important for study purposes. They permit division of the problem and provide the opportunity to work towards solution on a problem-by-problem basis. However, the categories are not mutually exclusive; rather they are interrelated. For example, a waste disposal area is a form of *soil (land pollution)*. At the same time, water running through the disposal area can be polluted, producing *water pollution.* A by-product of decomposing food waste is methane, producing *air pollution.* In the final analysis, pollution has to be considered in terms of its effects on the total environment.

History of Pollution

Problems of pollution are not new – they have plagued man throughout all of recorded history. Ancient history makes numerous references to pollution. Some of the early sources were smoke and fumes from forest fires and volcanoes, by-products of domestic heating and cooking, and odors of decaying animals and waste products.

Excavations at the ancient city of Troy showed that inhabitants dropped their refuse on the floor and let it accumulate until the level rose so high that doors would not open. Ancient Athenians corrected this problem by establishing dumps on the outskirts of cities. Similar dumps caused many problems for the Romans. Their mass of refuse, garbage, and even human corpses contributed to the outbreaks of typhoid, typhus, cholera, and malaria.

Medieval cities passed many ordinances against refuse dumping in streets and canals, often without much effect – much like many modern ordinances. The first smoke abatement law was passed in 1273 A.D. in England.

By the beginning of the 19th century, the smoke problem in London and other English cities was of sufficient public concern to appoint a select committee (1819 A.D.) of the British Parliament to study and report on smoke abatement. Numerous laws and regulations were passed, all designed to decrease the buildup of smoke within the city. The laws varied from the practical to the impractical. On the impractical side, Parliament during the 19th century passed a law requiring locomotives to consume their own smoke. The British may have been the first to use the word "*smog*." In 1905 A.D., H. A. Des Voeux, a London physician, used "smog" to describe the frequent condition of the atmosphere which enveloped many British towns.

In the United States, federal laws regarding pollution date back to the turn of the century. The Refuse Act of 1899 prohibited the discharge of waste material into navigable waters. The Oil Pollution Act of 1924 forbade the discharge of oil into coastal waters.

Pollution became a major problem following World War II and has grown into a major concern of the nation and the world. Numerous pollution laws have been passed during the past 30 years, all designed to control and restrict pollution. Unfortunately, the problem has grown more rather than less severe. Some of the major pieces of legislation affecting pollution are:

- The Water Pollution Act of 1948 authorized the public health service to coordinate research and provide technical information and assistance to reduce water pollution. Federal involvement in water pollution and enforcement of regulations was expanded by the Water Pollution Control Act of 1956, with amendments in 1961, 1965, 1966, and 1970.
- Air Pollution Control Districts (APCD) were created in 1955. The Clean Air Act of 1963 provided grants to states and localities for establishing air control and improvement programs. Pollution devices have been required on some motor vehicles since 1961. National standards for motor vehicle emissions were established in 1968 and significantly strengthened in the late 70's.
- The National Environmental Policy Act of 1970 created a permanent council on environmental quality.

Most legislation and fiscal support has been directed towards air and water pollution. Since thermal pollution involves both air and water, it has been included. Land pollution has received less attention and usually comes into prominence when air or water pollution is produced by polluted land. For example, a heavy rain can wash dangerous pesticides into river beds polluting city water supplies. The more recent efforts to study the total problems of pollution, the interactions between different forms of pollution, and the effects of pollution on the environment and quality of life should bring a more generic focus to the problem.

Technology and Pollution

All life produces waste. The leaves from trees can kill small plants on the ground. Elephants kill many trees while feeding. Archaeologists have learned much about ancient man from studying rubbish piles.

Nature also produces pollution. Volcanoes discharge particulates and a variety of gases, many of them harmful to man, animals, and plants. Marshes generate natural gas which is discharged into the atmosphere. The list of natural sources is long and for much of the life of man accounted for most of the earth's pollution.

That situation has changed and natural forms of pollution are minor concerns when weighed against the problems created by man. As man learned how to use energy to work for him, to free minerals from ores, to improve crops through fertilization and pest control, the by-product of polluting air, land, and water has grown at an alarming rate. *The more man consumes, the more waste and pollution man produces.* Since consumption is still increasing, waste and pollution are also increasing.

Two additional factors must be considered. First, the population of the earth is increasing, thereby increasing the pollution problem even if consumption per person remained constant. Second, the less affluent countries of the world are trying to match the affluency of the United States. A few already have. The thought of every person on earth consuming goods at the rate of the average citizen of the United States is frightening. The increase in pollution could well tip the balance between the earth's ability to restore itself and the rate of pollutants being produced. The most sensitive aspect, our atmosphere, could well become polluted to the extent that both the quality and longevity of life could be markedly decreased. Current problems are of such magnitude that both life expectancy and quality of life are already adversely affected in some urban areas.

The primary villain is "man's use of technology." Man has used the abilities gained through increased technology to produce more goods and create a life-style that thrives on consumption. Even national economics are based on increased production and consumption. If man is to reverse this trend and gain control of pollution problems, technology must contribute. Essentially, most of our technology now stops with the production and utilization of goods. The "new technology" must consider the total process — *the use of raw materials to produce* *goods, the distribution and use of the goods, and* **the disposal and recycling of the waste products back into raw materials to repeat the cycle.** While this total cycle will vary for different products, it must be considered for all aspects of technology.

This concept of technology being responsible for the disposal, and preferably, reuse of waste is the theme of this chapter. Past practices must give way to new practices, and new practices must consider the control of waste and the reuse of the by-products of man and technology.

Interactions

The next four sections of this chapter will study the four types of pollution: air, water, land, and thermal. These forms of pollution have a variety of interactions which must be considered.

The solution of one problem may create a new and different problem. Some air pollution problems can be corrected by transferring the pollutant from air to water, causing water pollution problems. Ground water can leach through polluted soil or waste disposal areas, polluting water. Improper incineration of solid and liquid waste can produce air pollution. As a result, pollution cannot be categorized and analyzed without consideration of total environmental effects.

Another area of interaction is the cause or source of pollution. A nuclear power plant can produce thermal pollution (heated water), air pollution (water vapor from cooling towers and small amounts of radioactive particles) and land pollution (the disposal of waste nuclear materials). In some cases, one form can be decreased at the expense of another. Water vapor into the atmosphere can be decreased or eliminated by placing all waste heat into a river or other body of water.

Keep this concept of interaction in mind as the four areas of pollution are analyzed in greater detail.

AIR POLLUTION

Air pollution is the presence in the atmosphere of an adverse substance resulting from either direct or indirect acts of man. For air pollution to be a concern, the substance (or substances) must be in such quantities as to adversely affect humans, animals, vegetation, or materials. There are two major elements of this definition of air pollution:

- Substance or substances produced by man – this excludes natural substances such as the products of weather or volcanoes.
- Quantities harmful to man or the environment – the level identified as harmful often changes as new information about a pollutant is found.

This definition leads to a subtle difference between the terms *contaminants* and *pollutants*. Contaminants are generated by natural means, such as volcanic eruption. Dust and pollen are generally considered contaminants. Pollutants are introduced by man's activities. Carbon monoxide and particulates from power plants are pollutants.

On the basis of origin, air pollutants are classified according to two categories: (1) primary pollutants, and (2) secondary pollutants.

- Primary pollutants exist in the air in the same form in which they were discharged. Examples of primary pollutants are particulate matter, sulfur dioxide, carbon monoxide, hydrocarbons, and nitrogen oxides.
- Secondary pollutants are the result of primary pollutants undergoing chemical reactions within the atmosphere and producing new substances (secondary pollutants). These reactions usually require special conditions, such as sunlight. Perhaps the best known secondary pollutant is ozone, a principal ingredient of smog. Others are nitrogen dioxide, peroxyacl, aldehydes, and aesolein – all products of nitrogen oxides and hydrocarbons and all contributors to the complex condition known as "smog."

The Different Pollutants

The major source of air pollution is the combustion of coal, oil, gasoline, and natural gas, with natural gas producing the least. The burning of these fuels to provide energy in the form of heat produces carbon dioxide (CO_2) and water (H_2O). The substances are generally not considered pollutants, even though the increasing percentage of CO_2 in the atmosphere may produce climatic changes in the future.

The chief pollutants produced from the burning of fossil fuels are sulfur dioxide (SO_2), carbon monoxide (CO), oxides of nitrogen (NO and NO_2), and unburned hydrocarbons. Secondary reactions of these gases within the atmosphere produce a variety of secondary pollutants which can be harmful to man.

In addition to these pollutants, the air is polluted by fluorides, particulates, and small quantities of a variety of gases and solids.

Sulfur Dioxide. Some scientists believe sulfur dioxide is the most dangerous and harmful of the gaseous pollutants. Most sulfur dioxide comes from the combustion of coal. Sulfur (S), in the form of a compound (FeS_2), is present as an impurity in coal. When coal burns, oxygen (O_2) combines with the compound forming a new compound and sulfur dioxide (SO_2):

$$FeS_2 + 3O_2 \longrightarrow FeSO_4 + SO_2$$

Sulfur dioxide is soluble in water and readily reacts with water forming an unstable sulfurous acid (H_2SO_3) which can be easily converted back to water and sulfur dioxide. Sulfur dioxide, in the presence of other substances and the sun's energy, can form sulfuric acid (H_2SO_4). It may also form various other sulfur compounds such as ammonium sulfate [$(NH_4)_2SO_4$].

Sulfuric acid, sulfur dioxide, and other compounds are corrosive agents and are suspected of causing damage to humans and other living organisms. Sulfuric acid is also present in the atmosphere in the form of acid droplets, an aerosol (a suspension of minute particles in a gas or mixture of gases).

Visibility in the atmosphere is reduced by the presence of an aerosol. The sun's rays are scattered and absorbed producing haze. The reduction of brightness reduces contrast between objects thereby making it more difficult for people to see clearly.

A more dramatic effect of SO_2 in the atmosphere is the potential for "acid rainstorms." The formation of sulfuric and sulfurous acids in the atmosphere can produce rains that contain these acids. Such rains are reasonably common in Northeastern United States, Canada, and Scandinavia. These areas are the victims of global air currents which carry pollutants from heavy industrial and polluted regions of the United States.

In studying the effect of "acid rainstorms," researchers have found that:

- Rainwater and snow have become increasingly acidic in the Northeast and parts of Canada in the past 15 years.
- Fish life has been eliminated in more than 85 high altitude lakes in Adirondack Park in upstate New York because of acid rains (Carl L. Schofield, Cornell University biologist). In Scandinavia, lakes have become sterile bodies of water and salmon runs have been wiped out in rivers and streams, especially in Norway and Sweden (Norman Glass, Environmental Protection Agency research scientist).
- Studies show deterioriation of buildings and statuary is being accelerated by acid rain, which slowly dissolves cement and stone.
- Increased soil acidity from acid rains can retard the growth of forests and reduce crop yields (Ellis Cowling, North Carolina State University forest expert). This phenomenon has not yet been found in nature but has been indicated as a possibility in laboratory and greenhouse experiments (Associated Press, Washington).

The effects of SO_2 on humans is much more difficult to determine. The presence of other pollutants in the air and the difficulty of studying people in their normal environment and determining damage contribute to this difficulty. The information available is based on studies in areas having high concentration of SO_2 and H_2SO_4, and on studies of animals and plants. Based on this level of information, SO_2 is identified as being harmful to the respiratory system. There is evidence to show that SO_2 contributes to infections in both the upper and lower respiratory tracts and may contribute to decreasing the size of the air passages in the lungs (bronchoconstriction). SO_2 in the atmosphere also causes eye irritation.

Carbon Monoxide. Carbon monoxide (CO) is an odorless, tasteless, colorless, and poisonous gas. As a pollutant, it is produced as a by-product of the combustion of fuel in automobiles, and from other forms of incomplete burning of hydrocarbons. As much as 90% of all CO is produced by natural processes, such as decaying organisms (oxidation of methane) (Monitor, p. 114). Fortunately, nature has devised a method of removing CO from the atmosphere, and there has been no apparent increase in the percentage of CO in the air.

The problem with CO exists in large cities where the large number of automobiles can increase the amount of CO to a concentration 100 times greater than exists worldwide. As a result, some of the first concerns with control of automobile emissions centered on the control of CO.

Carbon monoxide is formed when fuel burns in an atmosphere which has insufficient oxygen to burn the carbon completely. A number of factors in automobile engine design contributed to this incomplete burning and production of carbon monoxide. These include the corrosive effects of too much oxygen in the engine, fuel enrichment during acceleration, and the rate at which fuel is burned in the engine.

Carbon monoxide is a dangerous gas. When inhaled, it reacts with the hemoglobin present in the lungs. The hemoglobin normally combines with oxygen in the lungs and carries the oxygen to the tissues where it is used to produce the energy which keeps us alive. When the hemoglobin combines with CO, it cannot carry oxygen thereby starving the body of needed oxygen. When too much CO is present, death from carbon monoxide poisoning will occur.

Concentration of 0-10 ppm (parts per million)[1] is considered acceptable. Concentrations about 15 ppm are unsatisfactory and injurious. Figure 8-1 shows human symptoms resulting from CO concentrations of 15 ppm and above.

The role of carbon monoxide as a pollutant is being decreased by the emission control standards being placed in operation. However, control is only partial and CO remains a dangerous pollutant even though decreasing in severity.

Nitrogen Oxides. Oxides of nitrogen are produced by both natural and industrial processes. Natural sources include lightning and forest fires. The main source of nitrogen oxides is the combustion of fossil fuels at high temperatures. The two most important nitrogen oxides

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[1]ppm refers to the volume of pollutant per million volumes of air.

Concentration Of CO in Air	Symptoms
Up to 300-400 parts per million (ppm)	Severe headache, dim vision, nausea, collapse.
100 ppm	Headache. Impaired performance on simple psychological tests and arithmetic.
50 ppm and below	Ability to detect a flashing light against dim background worsens with increasing amounts of CO. CO from a single cigarette could be shown to cause rise in visual threshold. It is, therefore, obvious that smoking and exposure to CO from auto exhaust interact.
	Subjects presented with two tones and asked to judge which is longer. Judgment impaired at this level of CO in the air. Results interpreted as impairment of ability to judge time.
15 ppm	New York's air quality goal. Even this amount of CO could cause some of the effects on vision and loss of judgment of time that are mentioned above.

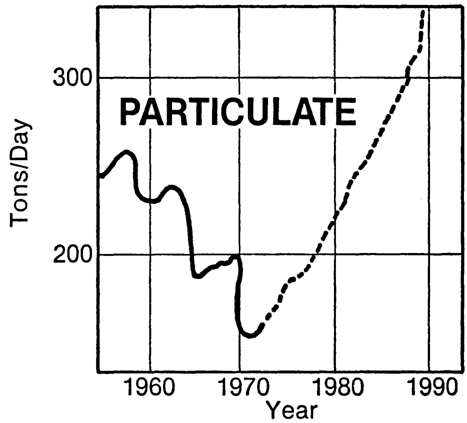
Fig. 8-1.
Health Effects of Carbon Monoxide *(Man's Control of the Environment,* p. 91.)

cause problems. Its main contribution as a pollutant is in the production of smog and secondary pollutants, as presented in a later section. Reducing the amount of NO and NO_2 produced by combustion could significantly reduce the amount of smog produced.

Nitrogen accounts for 78% of the gas mixture making up our atmosphere. Oxygen provides 21%, and the remaining percent is divided among argon and other gases. The presence of large quantities of nitrogen during the combustion process makes the production of nitrogen oxides possible.

Trends In Air Pollutant Emissions

The graphs below show for each of the five main air contaminants the variation in Tons/Day emissions through the years. Solid portions of the curves represent historical emissions which have been adjusted so as to be consistent with the 1973 Source Inventory and the latest computation techniques. Dotted portions of the curves indicate estimated emissions for the future.



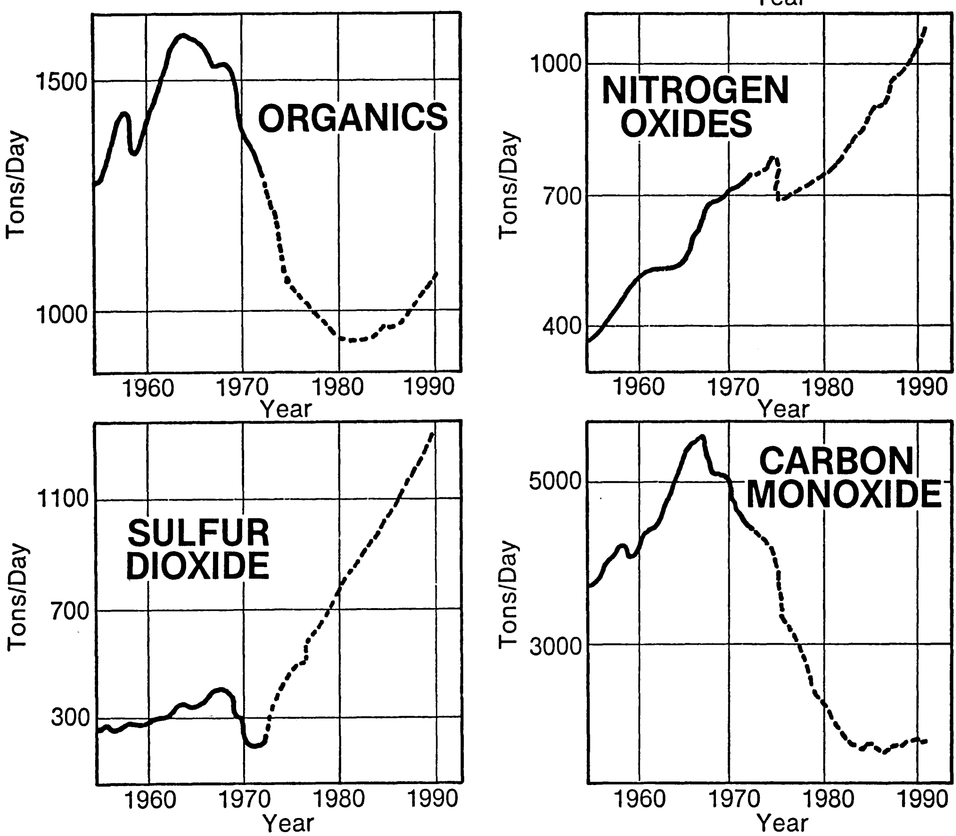


Fig. 8-2.
Trends in Air Pollutant Emissions.

The amount of NO and NO_2 produced in an automobile engine increases in high temperature and in the presence of excess oxygen. This amount can be lowered if the fuel is enriched (more fuel, less oxygen) and if burning occurs at a lower temperature. Unfortunately, the conditions which *decrease* the amount of NO and NO_2 are the same conditions which *increase* the formation of carbon monoxide. As a result, control of both nitrogen oxides and carbon monoxide by regulating engine temperature and fuel mixture is impossible. Recent efforts in automobile engine design have produced good results with a dual-chambered cylinder design, the first producing a fuel-rich mixture, producing minimum NO and NO_2 but considerable CO. The mixture then flows to a second chamber (a different portion of the total chamber) where additional oxygen is introduced to burn the CO to CO_2. The result is a decrease in the production of both pollutants.

Hydrocarbons. Hydrocarbons are compounds consisting of hydrogen and carbon. All fossil fuels are hydrocarbons and one of the principal sources of hydrocarbons in the atmosphere is evaporation of fuel from gasoline tanks, fuel storage units, and during the refining of gasoline. Additional sources are from the use of solvents in paints, cleaning fluids, etc. The major source, however, is the automobile which accounts for one-half or more of the hydrocarbons in the atmosphere.

Hydrocarbons are potentially harmful to man, but probably not in the concentrations which currently exist in the atmosphere. As with nitrogen oxides, hydrocarbons are of concern because of their ability to produce further reactions in the atmosphere, thereby contributing to the build-up of smog.

Smog. The word "smog" was first coined to mean a mixture of smoke and fog. This initial concept was an oversimplification of what is now known to be a very complex photochemical process. While man has accumulated considerable knowledge about the formation and effects of smog, much more knowledge is necessary before a full understanding can be reached.

Smog is a secondary rather than primary pollutant. It apparently is the product of nitrogen oxides, unburned hydrocarbons, oxygen in the atmosphere, and sunlight (primarily ultraviolet radiation). The result of these reactions is a build-up of ozone (O_3), a powerful and harmful form of oxygen.

Scientists believe the formation of ozone results from the following reactions:

- Oxides of nitrogen from automobiles and other burning of fossil fuels absorb ultraviolet radiation at the beginning of the day. This absorption breaks the bond between N and O in NO_2 molecules:

  NO + Energy (ultraviolet light) $\longrightarrow$ NO + O (free radicals)

- The resulting free molecular oxygen (O) reacts with oxygen O_2 forming ozone (O_3):
  $O + O_2 \longrightarrow O_3$
- The O_3 rapidly reacts with available NO (the more prevalent oxide of nitrogen):
  $O_3 + NO \longrightarrow NO_2 + O_2$
- The NO_2 in this reaction can be divided by the absorption of ultraviolet light, repeating the cycle.

Based on this cycle, the buildup of O_3 *cannot occur*. Unfortunately, that is not the case. As the day progresses, the concentration of O_3 increases while the concentration of NO declines. There are, therefore, intervening reactions which must be occurring. The most likely reactive agents are hydrocarbons.

- Hydrocarbons are susceptible to free radicals, such as molecular oxygen (O). The resulting reaction will produce various compounds as well as free organic radicals.
- The free organic radicals can, in turn, react with free NO to produce NO_2, thereby using the NO radical which could have been used to neutralize the ozone. Or the free radical can react with O_2 to produce more ozone.

These reactions continue throughout the day. The result is an increase in O_3 and NO_2 and a decrease in NO. As the sun goes down, the levels of O_3 and NO_2 drop, decreasing the level of smog. However, the primary pollutants remain in the atmosphere and will repeat the cycle the next day unless blown away. Through a temperature inversion, pollutants can be trapped over a city for a number of days. Each day more pollutants are added to the atmosphere and the potential build-up of smog becomes greater.

In addition to ozone, the hydrocarbon reactions produce other gases contributing to the irritating and detrimental effects of smog.

Ozone and nitrogen dioxide (smog ingredients) are officially classified as *oxidants*. Oxidants are chemical compounds which can oxidize compounds not usually oxidized by regular oxygen. Essentially, they are chemically active and have available oxygen to enter into chemical reactions.

Oxidants are harmful to plants, often damaging the leaves through shrinkage and discoloration. The result is limited plant growth and general plant damage. Oxidants also attack materials, such as rubber, fabric, and cellulose materials. The result is fading and weakening of the materials, thereby requiring early replacement.

The effects of oxidants on animals and humans is less known due to the difficulty of study and the complex composition of the atmosphere. Studies indicate that oxidants have effects similar to those of sulfur dioxide. They attack the respiratory system and seem more harmful to people who are weak, old, or ill. Long-term effects are still unknown even though being studied intensely.

Particulates. During the study of SO_2, we noted that SO_2 can react in the atmosphere producing an aerosol, or tiny droplets capable of diffusing light. This particular aerosol is one of a group of minute particles in the atmosphere. These small particles are called particulates and consist of dust, smoke, fumes, flying ash, pollen, spores, metal oxides, pesticides, and any other particles that are released into the atmosphere by either natural or human causes.

Some particulate concentration in the atmosphere is necessary and beneficial. Rain is formed by water vapor collecting around a particulate, usually dust, and forming a rain drop.

Particulates can also be harmful. Metallic substances, such as lead, can be harmful to humans. The increase in lead aerosols to over 7% of all particulate matter resulted in the federal standards requiring the reduction and eventual elimination of lead as a fuel additive.

The danger of particulates to the health of humans is considered less severe than the danger from sulfur dioxide, smog, and other gaseous pollutants. There are, however, regional exceptions. Particulate discharge due to improper smoke control can damage plants and injure humans.

A long range concern of particulate build-up comes from meteorologists. Added diffusion and reflection of radiant energy can cause a loss of heat to the earth. This loss coupled with unknown forces which have produced ice ages in the past could influence the earth's climate.

Fluorides. One of the major pollutants in the air is a variety of chemical groups called fluorides. Fluorides have received considerable publicity in recent years due to their use as gaseous propellants for a variety of household goods, varying from food products to insecticides. Fluorides are also produced as by-products of industrial processes at steel mills, phosphate fertilizer plants, aluminum reduction plants, etc. Fluorides are also used in refrigeration and air conditioning. When these units leak, the refrigerant (fluoride) is released into the atmosphere.

Fluorides may be harmful to plants and indirectly to humans. The greatest concern, however, centers on the chemical reactions which might occur as the lighter fluorides travel into the ionosphere (30 miles from the earth's surface). Ozone, in the ionosphere, is a primary absorber of X-ray radiation. The reduction in X-rays helps keep the natural radiation level on the earth low. Many scientists now fear that the fluorides are reacting with the ozone in the ionosphere thereby decreasing the ability of the ionosphere to reduce radiation reaching the earth.

Radioactivity. Up to 1934 only natural radioactivity existed on the earth. Since that time, man has developed the ability to use and produce radioactive materials. The result has been a gradual increase in radioactivity within the atmosphere. The existing level is very low, and most concern centers on the questionable ability of man to maintain this low level.

Radioactivity is the discharge of minute energy particles from the nucleus of the atom. There are only a few elements in nature that are radioactive – most are not. Most of the radioactive elements are very heavy materials, such as thorium, radium, and uranium. However, nuclear reactions produce waste products, most of which are radioactive. These products may be lighter elements and be identical to existing harmless elements in all properties except radioactivity. Thus, we have a large variety of radioactive materials available for use, or as waste which needs to be discarded.

Radioactivity in the atmosphere is the result of X-ray radiation from the sun, background radiation from the earth, and radiation from radioactive particulates or gases released by industrial and chemical processes. This latter form of radiation, that produced by man, can occur from a number of sources, including:

- Mining and enriching of uranium
- Nuclear power plants
- Combustion of fossil fuels
- Processing of radioactive waste
- Nuclear explosions

The greatest potential source for atmospheric pollution is nuclear explosions. The termination of testing nuclear weapons in the atmosphere has greatly reduced this source of pollution. It should be noted that *not* all of the sources of pollution listed above involve nuclear reactions. The burning of fossil fuels, especially coal, produces radioactive particulates in the atmosphere. These radioactive particulates are present as impurities and enter the atmosphere as ash or waste products.

Radioactive materials are harmful to plants, animals, and men. In man, radioactivity can produce physical changes varying from mild illness to cancer to death. Scientists do not, at present, know the levels of radioactivity which are safe for man. We know, for example, that radioactivity varies more by altitude than by any man-made causes. Higher altitudes are closer to the sun and more natural radiation reaches these locations than lower altitudes. However, we do not know whether the variation of radioactivity due to altitude is acceptable or unhealthy for man. Radioactivity is probably similar to all other forms of pollution – the less we have, the healthier we will remain. And, it may be no worse than other forms of pollution.

Noise pollution. Sounds are transmitted through the air. When an object vibrates, the surrounding air is placed in motion. The air vibrations travel much like an ocean wave. When they reach our ears, the motion causes the eardrum to vibrate creating the sensation of sound.

Much of the sound we hear is pleasant and desirable. Often, the context in which we receive sound determines whether it is welcome or not. Falling rain after a long drought may be a welcome sound. When it rains during an outing, it may be unwelcome.

Noise pollution usually refers to unwanted sound, and sound which may damage the ears. The measurement of sound is the decibel (dB). The decibel scale is a logarithmic scale with zero representing the threshold of human hearing. Sounds of less than 85 dB may be annoying, but not harmful. Sounds over 150 dB are usually painful and can cause permanent hearing loss. Between 85 dB and 150 dB exposure, time becomes a factor. Long-term exposure at or over 90 dB may cause temporary or permanent hearing loss.

The noise level in the United States is increasing each year, possibly by as much as 1 dB per year. This increase is of considerable concern, both from the potential for injury to the more subtle effects of increased noise in the environment. Some scientists believe that long-term exposure to even modest noise levels can produce physiological changes in man and animals. There is general agreement that high noise levels cause irritability, loss of sleep, increased nervousness, and a general disruption of personality traits.

Sources of Air Pollution

Air pollution is the by-product of our technology. The single greatest source of air pollution is the burning of fossil fuels to obtain heat energy. The derived heat is used to propel vehicles, generate electricity, power industry, and heat buildings. The by-product is an ever increasing amount of air pollution in the form of sulfur dioxide, nitrogen oxide, carbon monoxide, free hydrocarbons, lead particles, radioactivity, smog, and a variety of other gases and particulates. All other sources of air pollution are secondary to that produced by the burning of fossil fuels.

Other sources of pollution include:

- Manufacturing and agriculture – in addition to using fossil fuels, manufacturing and agriculture are responsible for numerous particulates. These include pesticides from agriculture; metallic particles, poisonous gases, and organic materials from industry; and radioactivity from nuclear power plants and related industries.
- Aerosol cans – release fluorides and other gases into the atmosphere.
- Cities and government – improper disposal of waste permits the formation of methane and other gases. Also, governments are often

engaged in manufacturing and agriculture. On occasions, governments will exempt themselves from regulations designed to control air pollution. Government acts can be among the most harmful, such as conducting tests involving nuclear explosion.
- People – the source of all pollution. Other than natural contaminants, humans are responsible for the burning of fossil fuels and the sources of pollution cited above.

Effects of Air Pollution

Our knowledge of the effects of air pollution on living organisms is based on laboratory tests on plants and animals, and observations in nature. From these tests we know that pollutants are harmful to living organisms. Also, we know that many of the pollutants, such as carbon monoxide, are lethal in large doses. This does not mean that they are necessarily dangerous at lower doses but does mean that they deserve constant study and monitoring.

Smog, sulfur dioxide, and other pollutants all have harmful effects on plants. Cities, such as Los Angeles, have noted a significant destruction of plant life within the city.

Large cities have also shown higher rates of human respiratory disorders; and on days with heavy pollution, deaths due to respiratory failures increase. While scientific proof is often lacking, there is considerable evidence pointing towards serious health hazards due to rising levels of air pollution, especially in cities.

Also, the overall quality of life has decreased due to air pollution. The Los Angeles Basin, once renowned for its natural beauty, is often filled with eye-irritating smog which decreases visibility, thereby hiding the scenic mountains surrounding the Basin. The same can be said for hundreds of major cities throughout the world.

Control of Air Pollution

Air pollution is a by-product of a combination of increased affluence and world population. The uncontrolled growth of these two factors will continue to reduce the quality of life. Many scientists already believe world population has exceeded the number the earth is able to sustain with an adequate standard of living. As people consume more resources, all forms of pollution will continue to grow. Hence, *the first level of control* must address the social and humane problems related to limiting population and reducing the use of natural resources. Both have been proven to be almost impossible to consider in a rational manner. They immediately become involved in economics, religions, values, life-styles, and other volatile factors affecting our environment.

The *second level of control* considers the pollutants. Pollutants are best controlled at the source. Once released into the atmosphere, they remain until removed by natural processes. Fortunately, there are numerous natural controls in effect. Large particles settle to the ground in still air while small particles are washed from the air by rain. Many gases are rendered harmless through chemical reactions with other gases and the oceans. Others may remain in the atmosphere for a long period of time.

Most control of air pollution has taken place at the source. Coal can be filtered to remove particulates. Automobile emissions can be controlled to significantly reduce pollutants, thereby reducing smog. Each source of air pollution needs to be analyzed to determine the ways the source can be controlled to produce a minimum of air pollution.

Our knowledge of the effects of air pollution on all forms of life is small compared to our knowledge in other areas of technology. Research must continue and increase if we are to establish a balance between the amount of air pollution we produce with the amount we can sustain without serious reduction in the quality of life.

The combination of planned control of air pollutants and increased use of fossil fuels and other sources of pollution provide some data regarding future level of air pollution. The graphs shown on Fig. 8-2 show both past and anticipated levels of air pollution.

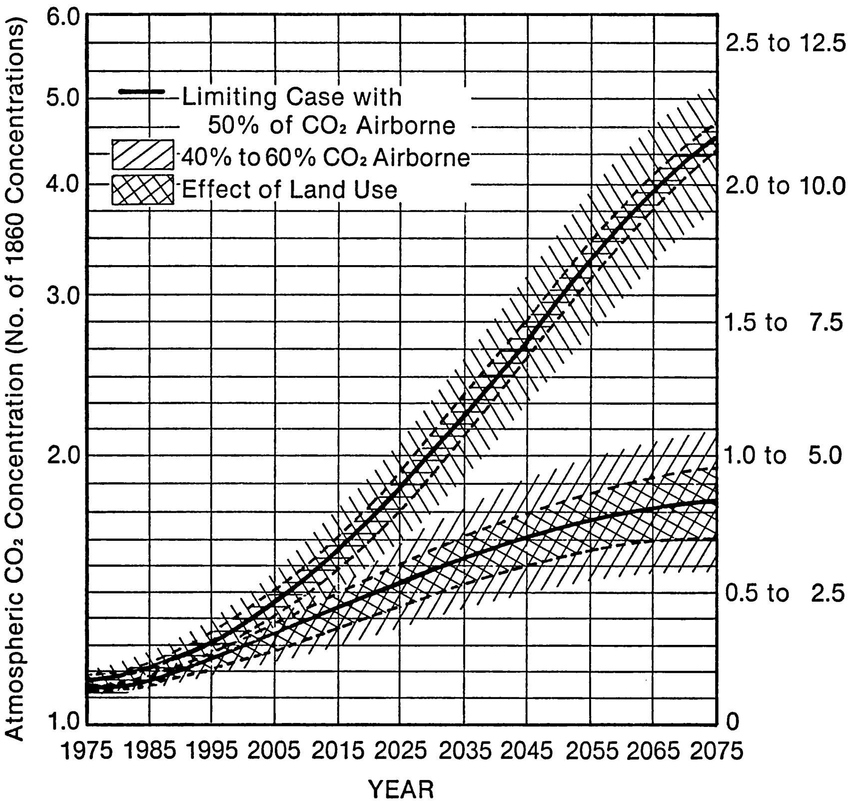
Carbon Dioxide — The Greenhouse Effect

Up to this point, the discharge of carbon dioxide (CO_2) into the atmosphere from burning fossil fuels has been considered harmless. In fact, plants need CO_2 and man exhales CO_2 as the waste product of breathing. Unfortunately, CO_2 in large quantities may not be as harmless as supposed. Most scientists viewing the accelerated burning of fossil fuels now agree that *excess CO_2 will probably warm the earth's temperature significantly* (Washington Post). Opposing factors, such as shielding due to particulate pollution in the atmosphere, will not offset this warming effect.

The problem lies with the increased use of fossil fuels. The principal by-product of burning any of the fossil fuels is CO_2. Some of the CO_2 released into the atmosphere is used by plants and converted back into oxygen. The oceans also absorb CO_2 through chemical reactions. However, the capacity is limited, resulting in a gradual, but steady increase in the amount of CO_2 in the atmosphere. Approximately 50% of the CO_2 being released remains in the atmosphere and is producing the steady increase of CO_2.

Carbon dioxide affects the earth's temperature by the "greenhouse effect," the same principle that traps heat inside a greenhouse. Carbon dioxide can absorb infrared radiation and blankets the escape of infrared radiation from the earth's surface to outer space. The result is trapping heat on the earth which would normally have escaped into

Fig. 8-3.
Projected Atmospheric CO_2 Concentrations and Possible Changes in the Average Surface Temperature.
(C. F. Baes, Jr., et al, p. 40)



space. The result is a gradual warming of the earth, thereby raising the average temperature of the earth in order to reestablish a balance between heat received from the sun and heat radiated into space.

The production of CO_2 from fossil fuels has been increasing at an annual rate of 4.3% (Baes, Jr., et. al., p. 4). Figure 8-3 shows two scenarios. The first, the worst condition, is continuation of the 4.3% annual growth rate, reduced in proportion to the recoverable fuel supply. The second scenario assumes a 2% growth in fossil fuel burning until 2025 and a symmetrical decrease (phasing out) thereafter, as renewable energy sources become more readily available and use of fossil fuels is discouraged. The following information will help explain the complexity of Fig. 8-3.

- The upper curve is the effect of the 4.3% rate of increase; the lower curve is the 2.0% rate. The graph line assumes a 50% retention of CO_2 in the atmosphere. This is the present rate. The remaining 50% is removed by plants (land use) and by the oceans. Since all of the chemical reactions removing CO_2 are not known, nor is the satura-

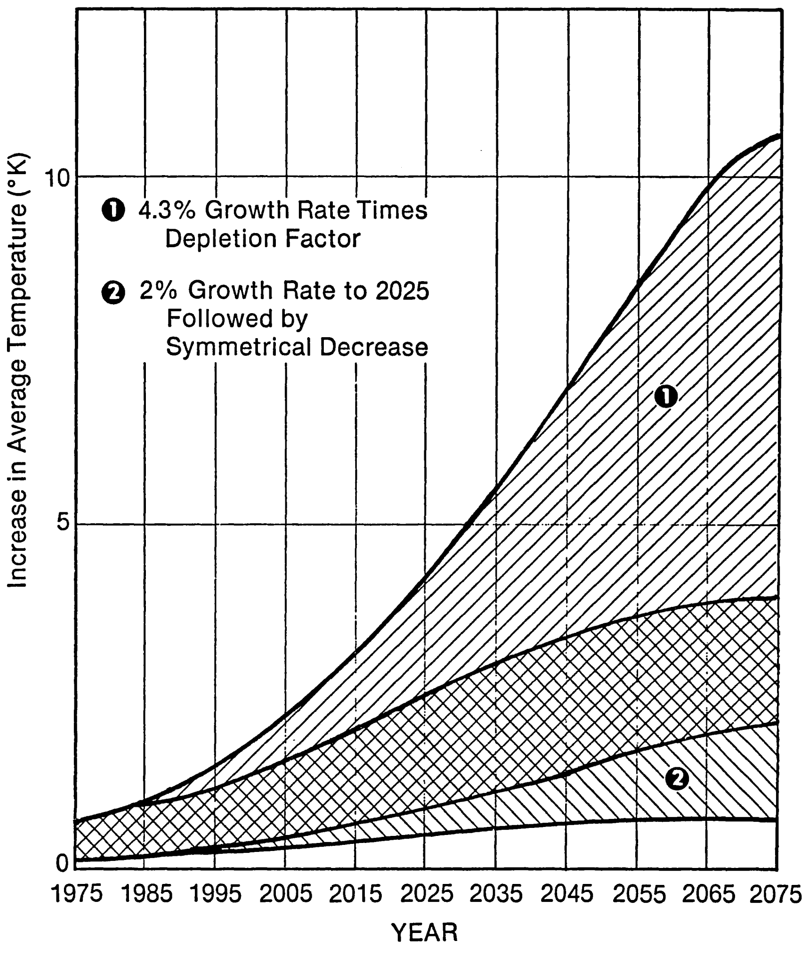


Fig. 8-4.
Projected Range of Increase in Average Surface Temperature for the Limiting Cases of Fossil Fuel Use. Δ T – 1 to 5 °K per Doubling of CO_2 Concentration.
(C. F. Baes, Jr., et al, page 44)

tion level of the ocean known, a range of 40%-60% of CO_2 remaining is shown.

- Note that the graph is logarithmic – the curve is much steeper on a normal projection.
- The level of CO_2 is based on the mid-nineteenth century as 1.0. The increase to 2.0 around 2025 (on the 4.3% graph) represents a doubling in the amount of CO_2 in the atmosphere.
- The projected temperature increase gives a wide range. This wide range takes into account numerous factors which are either unpredictable with present knowledge, or not clearly understood.

The effects of temperature are shown on Fig. 8-4. Keep in mind that temperature change has been only ½°K over the past 200 years, 3.0°K in 20,000 years, and 8.0°K in 100,000 years. The difference in the average surface temperature between a glacial and an interglacial period is about 5.0°K. Thus, temperature changes near the upper limits of the projection of Fig. 8-4 could be catastrophic.

We are presently in a very warm period, about 10,000 years since the end of the last glacial. The effects of the increased production of CO_2 remain speculative. However, *the potential for major climatic changes is great, and the potential for some level of change almost certain.*

WATER POLLUTION

Water pollution is "the presence of any foreign substance (organic, inorganic, radiological or biological) in water which tends to degrade the quality so as to constitute a hazard or impair the usefulness of the water." (U.S. Public Health Service, p. 1)

Water is vital to life, and water pollution like air pollution can threaten life. The following are some of the basic consequences of water pollution and poor water management:

- Disease transmission through infection
- Poisoning of man and animals
- Detrimental effects on aquatic life
- Objectionable odors and unsightliness
- Unsatisfactory quality of treated water
- Impairment of shellfish culture
- Excess mineralization
- Destruction of aesthetic values (AMA Proceedings, p. 3)

Classifications

Water pollutants occur in both solid and liquid forms. Solid pollutants include soil, ashes, cinders, sludge and sewer waste, vegetable matter and garbage, animal waste, rubber, wood, and paper. Liquid pollutants occur from the discharge of municipal, industrial, and agricultural waste.

Water pollutants are classified into three general categories: chemical, physical, and biological.

- Chemical pollution is either organic or inorganic. Organic chemical pollution consists of municipal, industrial, and agricultural wastes and includes resins, coal, oil, tars, dyes, synthetic detergents, and toxic chemicals such as DDT. Organic pollutants reduce the oxygen available in water. Oxygen is needed by fish and other aquatic life.

  Inorganic chemicals have the same sources as organic chemicals and consist of acids, alkalies, toxic compounds, chlorine, hydrogen sulfide, and soluble salts. Inorganic chemicals can be poisonous and kill fish, damage plants, and endanger man.
- Physical pollutants are primarily from land erosion and can affect the color, temperature, and life in water. Suspended particles filter out forming a sludge in quiet water areas. The result is destruction and damage of spawning beds, smothering organisms, and increasing the need for dredging ship channels.
- Biological pollutants include disease producing bacteria and can be the cause of water-borne diseases such as typhoid, dysentery, and cholera.

In addition to the classifications of chemical, physical, and biological, water pollutants are also classified as degradable or nondegradable. Degradable pollutants are those which are broken down or decomposed by natural processes in water. The term bio-degradable is used to identify those products decomposed by biological processes.

Nondegradable pollutants are those not altered by processes which occur by nature. Some pollutants are "somewhat" degradable, but because of the length of time to decompose are classified as nondegradable. For example, the decay of some radioactive dust is extremely slow.

Pollutants which are degradable include most organic matter, soft detergents, organic nitrogen, nitrides, and ammonia. Nondegradable pollutants are of greatest concern since their effects are persistent and difficult to control. Some of our most persistent pollution problems relate to nondegradable pesticides and chemicals remaining in rivers and the oceans, thereby threatening all forms of life.

Forms of Water Pollution

The U.S. Government has divided water pollutants into eight categories (FWPCA, p. 24). This categorization permits study, analysis, and determination of control technique. The following sections briefly describe these categories. As the list is reviewed, remember that most of our wastes are a mixture of many of these forms of pollution, thereby creating a complex control problem.

Sewage and Other Oxygen Demanding Wastes. These are the traditional organic wastes contributed by domestic sewage and industrial wastes of plant and animal origin. Besides human sewage such wastes result from food processing, paper-mill production, tanning and other manufacturing processes. These wastes are usually destroyed by bacteria if there is sufficient oxygen present in water. Since fish and other aquatic life depend on oxygen for life, the oxygen demanding wastes must be controlled or the fish will die.

Infectious and Disease Causing Agents. This category includes infectious organisms which are carried into surface and ground water by sewage from cities and institutions. A secondary source is industrial wastes such as tanning and meat packing plants. Man or animals come in contact with these microbes either by drinking the water or through swimming, fishing or other activities.

Plant Nutrients. These are substances in the food chain of aquatic life such as algae and water weeds which support and stimulate their growth. Nitrogen and phosphorous are the two chief nutrients present in small amounts in natural waters. Much larger amounts are contributed by sewage, certain industrial wastes and drainage from fertilized lands. Biological waste treatment processes do not remove the nutrients – rather they convert the organic forms of these substances into mineral forms making them more usable by plant life. The problem starts when an excess of these nutrients overstimulates the growth of water plants which causes unsightly conditions, interferes with treatment processes and creates odors in the water.

Synthetic Organic Chemicals. Included in this category are detergents and other household aids, pesticides, industrial chemicals, and the wastes from their manufacture. Many of these substances are toxic to fish and aquatic life and possibly harmful to humans. They cause taste and odor problems and resist conventional waste treatment.

Inorganic Chemicals and Mineral Substances. A vast array of metal salts, acids, solid matter and many other chemical compounds are included in this group. They reach waters from mining and manufacturing processes, oil field operations, agricultural practices, and natural sources. Water used in irrigation picks up large amounts of minerals as it filters down through the soil on its way to the nearest stream. A wide variety of acids are discharged as wastes by industry. The largest single source of acids is from mining operations.

Sediments. These are the particles of soils, sands, and minerals washed from the land and paved areas of communities. Construction projects are often large sediment producers. Sediments fill stream channels and harbors, requiring expensive dredging. They fill reservoirs, reducing their capacities and useful life. They erode power turbines and pumping equipment, and reduce fish and shellfish populations by blanketing fish nests and food supplies. More importantly, sediments reduce the amount of sunlight penetrating the water. The sunlight is required by green aquatic plants which produce the oxygen necessary for normal stream balance.

Radioactive Substances. Radioactive wastes are solid, liquid, or gaseous waste produced during the manufacture or use of radioactive substances. They result from the mining and processing of radioactive ores; from the use of radioactive materials in power reactors and for industrial, medical, and research purposes; and from fallout following nuclear weapons testing. Since radiation may accumulate in humans through the accumulation of radioactive substances in the body, control of this type of pollution must take into consideration all aspects of our environment, including air, water, and food.

Heat. Heat reduces the capacity of water to absorb oxygen. An increase in water temperature, known as thermal pollution, reduces oxygen holding capacity and fosters algae growth. Power generating plants are the primary sources of heat.

Detecting and Combating Water Pollution

While many pollutants are visible (sediment) or easily detected (odor), most are more subtle and require careful testing. If chemical pollution is suspected, the water must be subjected to chemical analysis. Chemical tests include processes to detect the presence of specific chemicals and the quantity and intensity of the pollutant. Other tests include testing for the oxygen demand; that is, the amount of oxygen necessary to stabilize or oxidize a waste product. This test will determine the amount of organic pollutant present.

Filtration testing removes sediment and analyzes the sediments to determine their composition and source. Biological testing determines whether water is fit for human consumption. Water found to have animal or human waste is considered unfit for human consumption until properly treated.

Water treatment for human consumption consists of two basic methods: primary treatment and secondary treatment. In primary treatment, solids are allowed to settle and are removed from the water. The water is then chlorinated which kills disease causing bacteria and removes any remaining odors.

Where water contains increased amounts of waste products, especially those more difficult to remove, the water is given a secondary treatment. Secondary treatment depends on the nature of the pollutants and may involve added chlorination, other chemical treatments, filtration, and distillation.

The only water treatment of any magnitude exists to treat water for human consumption. Water for agricultural and industrial purposes normally receives no treatment.

As with air pollution, the most effective method of eliminating pollution is through control of the source. Efforts must be made to reduce or eliminate the use of nondegradable pollutants. Other pollutants should be controlled at the source rather than dumped into natural waterways where nature may or may not be able to maintain clean water.

Lake Pollution

The relatively still waters of lakes provide a habitat for microscopic, free flowing algae which cannot thrive in rapidly flowing waters. Since algae are the ultimate source of food for fish and other aquatic organisms, it is essential that some algae be present. However, a problem arises when large influxes of nutrients such as nitrogen and phosphorous stimulate algae growth. With rapid enrichment of lakes by nutrients, large quantities of organic matter are produced and rapid decaying can cause noxious odors and deplete the water's oxygen supply. These enriched lakes are less desirable for recreational activities and hasten the aging process of the lake.

The normal aging process for lakes follows the pattern described above, but may take thousands of years. Man can increase the rate of aging to the extent that visible and disturbing changes may occur in less than a decade. A spectacular example of this process is Lake Erie which went from a beautiful clear lake to one filled with algae and possessing all the characteristics of an old and dying lake – all in less than a generation.

Ocean Pollution

Ocean pollution is usually the result of wastes dumped either directly into the ocean or from streams and rivers emptying into the ocean. The pollutants are the same, but the ocean must dispose of them. The problem is made complex by the fact that most ocean life important to man exists relatively close to shore, thereby close to the pollutants. The result has been major damage to near-shore fisheries, especially the shellfish industry.

A relatively recent new source of ocean pollution is oil spills, both from damaged tankers and off-shore drilling. Oil can kill fish and birds, as well as destroy recreational lands and damage shore facilities when the oil washes to shore.

SOIL (LAND) POLLUTION

A soil pollutant is any substance which when added to the soil impairs the yield or quality of farm products, affects the health of animals or humans or which may contribute to subsequent air or water pollution.

Air and water pollution have received the greatest public attention because they are fluid and carry pollutants with them. When burning coal in the U.S. produces an acid rainstorm in Sweden, many people from different nations become concerned. However, when a mining operation destroys future plant growth through poor soil management, public concern is minimal. Soil pollution is often local and has, as a result, gained less attention.

Soil pollution should, however, be a grave concern. It is often linked with air and water to form a pollution cycle. Particulate matter from the air can be deposited on soil, washed into streams and rivers, and eventually reach the ocean. The sulfur from burning coal represents a cycle of this type. The sulfur forms sulfur dioxide during burning which, via chemical reaction in the atmosphere, forms an acid. The acid is a particulate which reaches the soil with rain. The acid makes the soil more acidic, affecting plant life. The acid can wash into rivers and lakes destroying fish.

Soil must be valued for its ability to grow food and sustain life. Soil destroyed through mismanagement may take many generations to return to productivity. The world already faces a food crisis. Reduction of the amount of land available for food production must cease if the people of the world are to be fed adequately.

Solid Waste

Solid waste is the largest pollutant of the land. Every substance that is obtained from the earth is accompanied by large amounts of waste. The smelting of one ton of copper, for example, results in the formation of 500 tons of waste rock and earth. Figure 8-5 shows a typical classification of solid waste.

Solid wastes must be disposed of in a manner which will reduce the waste into forms that are least harmful to the environment. The main processes for disposal of solid waste are through the use of mechanical, thermal, biological, or chemical reduction.

- Mechanical reduction reduces the volume of the waste by grinding, crushing, and compacting. The reduced volume makes disposal easier and often permits use of the reduced waste. Mechanical reduction is common in mining.
- Thermal reduction is often used in the disposal of refuse and other combustible materials. Reduction is by incineration and an efficient-

Fig. 8-5.
Solid Waste.

Category	Description
Urban Wastes:	
Garbage	Animal and vegetable kitchen waste
Rubbish	Dry household, commercial and industrial waste
Ashes	Residue after burning
Demolition Waste	Construction and demolition debris
Sewage Residue	Sludge and other solid residues from sewage treatment plants
Metal Scrap	Automobiles, large appliances and machinery
Industrial and Agricultural Wastes:	
Industrial Wastes	Industrial processing, scrap and by-products
Mining Wastes	Mill tailings, washing plant rejects, and other mining wastes
Agricultural Wastes	Animal manure and carcasses, crop residues, logging debris

Bureau of Solid Waste Management

ly operated unit can reduce volume by 80 or 85:1. However, incineration can lead to air pollution through the production of waste gases and particulates.

- Biological reduction refers to the degradation of the organic portion of solid wastes by microorganisms. Generally the most useful process is composting. Composting is generally accomplished by heaping the refuse and moistening it, then letting it ferment for about six months (the decomposition is faster if the refuse is first ground up into smaller particles). The fermentation takes place at 50-80°C which is apparently too high for pathogens to survive so that disease is not of concern. Sewage sludge can also be added to the combustible material.
- Chemical reduction uses chemicals such as acid oxidizing agents and solvents to decompose and alter the waste material. The costs are very high because of the large quantities of chemicals that must be added. Thus, chemical reduction is least used.

Solid Waste Disposal. Disposing of solid wastes in *open dumps* is the most common method used in the U.S. In open dumping, wastes are picked up at various locations and brought to an isolated site where they are deposited on the land surface. Open dumps produce health and air pollution problems and are not acceptable as a method of disposal. They can cause public health problems by encouraging the growth of population of flies (which can transmit typhoid fever, cholera, dysentery, tuberculosis, anthrax, and other diseases), rats (which can transmit plague, murine typhus fever, leptospirosis, rabies, rickettsialpox and other diseases), cockroaches, mosquitoes (which can transmit malaria, yellow fever, dengue and filaxiasis) and other pests.

Besides open dumping, mechanical methods include:

- Controlled burning of dumped wastes (a combination of mechanical and thermal reduction)
- Refuse filling
- Sanitary landfill

In controlled burning, refuse is unloaded onto a prepared dirt bank. The refuse is evenly distributed on the bank and then each load on the downward edge is set on fire. In refuse fills, the solid waste is compacted and periodically covered with some material.

Sanitary landfill is superior to all other mechanical means. It does not create a nuisance or a safety or health hazard. In this method of waste disposal, the solid waste is confined to as small an area as possible and the volume is continuously reduced. The sanitary landfill consists of four basic operations.

1. The solid wastes are deposited in a portion of the dump area.
2. The wastes are spread and compacted into layers 2-15 feet deep.
3. The wastes are covered daily (or more frequently) with a layer of earth of 6 or more inches. The covering material is often obtained by excavating the site.
4. The covered material is compacted daily.

Radioactive materials pose special problems due to the danger to man and the long life of the materials. Much of the current controversy regarding nuclear power centers on the disposition of radioactive byproducts. Plans vary from surface storage to burying deep in the earth.

Utilization of Solid Waste. Reclaiming of solid wastes represents a partial solution to the disposal of solid wastes, as well as preserving our dwindling supply of raw materials. Reclaiming of selected refuse (aluminum, paper, glass, etc.) is already in limited practice. Expansion through publicly supported incentives or laws can be beneficial to all of society.

Solid wastes are also receiving increased attention from business and industry. Crushed rock from mining operations can be used for road beds. Almost every part of a tree is now used as either lumber, bark chips, pressed board, pulp, or manufactured fireplace logs.

Reduction of Waste Production. A careful evaluation should be made of the American life-style to determine ways to stop the growth of the "throw-away society." Business and industry continue to manufacture new throw-aways, and Americans continue to use them. We now have throw-away bottles, cans, boxes, diapers, medical supplies, and dishes. Many cafeterias, *notably campus food services,* have shifted to throw-away dishes and silverware. Throw-aways are often plastics or materials which require high energy input for production. The waste, therefore, is not only a disposal problem. Of greater concern is the waste of natural resources and energy.

Land Management. Destruction of valuable land for food production can be reduced or eliminated through appropriate land management. A high priority must be given to maintaining high quality agricultural and forest lands, and restoring land which has been destroyed through misuse.

Strip mining is a good example of what can be accomplished through appropriate land management. Many thousands of acres of good land have been unnecessarily made useless through strip mining. Recent laws have forced procedural changes which require the restoration of land to its original use. A next step might be to go beyond restoring the land and determining how the land might be improved for agricultural and forest use.

Pesticides and Fertilizers

Pesticides have been mentioned in past sections since they, like fertilizers and other toxic materials, can be washed from the soil and become a serious water pollutant. Some scientists have become very alarmed at the long-term effects of using nondegradable toxic materials to control insects and other destructive pests. The concern includes pollution of water, killing of fish, destroying shellfish industries, killing of birds and animals, and causing health problems and death for humans.

The concern started with pesticides but now has grown to include fertilizers, especially those which have nondegradable compounds.

The problem is complex — the growing demand for food throughout the world can be met by increased productivity. Pesticides and fertilizers contribute to this productivity. However, we must be careful that the meeting of immediate needs does not generate greater problems than currently exist. The uncontrolled use of pesticides and fertilizers could produce a chain reaction of serious consequence to all. The episodes of kepone in Chesapeake Bay seafood and the PBB in Michigan dairy cattle are examples of the potential damage which can occur.

THERMAL POLLUTION

Thermal pollution has been separated from air and water due to its growing importance. Thermal pollution is the impairment of the quality of environmental air or water by raising its temperature.

Since temperature is relative, we must consider heat in terms of the environment. A water temperature of 32°C (90°F) is normal for the tropics but would be deadly to trout in a northern stream.

The primary source of thermal pollution is electrical power plants fueled by either nuclear or fossil fuels. More than 50% of the heat produced by the burning fuel is waste and must be discarded. The volume of heat produced is so great that direct transfer to the air, such as from a car radiator, is impractical. As a result, water is used to remove the waste heat.

The most common method is to build the power plant near the ocean, a river, or one of the Great Lakes. Water is pumped from the source, through the plant, and discarded back into the source at a higher temperature.

The result can be detrimental to fish. There are no common species of fish in the United States that can survive in waters warmer than 34°C (93°F). While temperature may be this high near the discharge, they quickly disperse to a lower level. However, the heat produced changes the water temperatures of the river for many miles. The result is a change in the river environment with less desirable warm water fish becoming common. If the power plant shuts down, even temporarily, the effect on the fish life depending on the warmer water can be devastating.

Heated water also contributes to the algae growth and, especially in lakes, increases the rate of aging, making the water less desirable.

An alternative method of disposing of the waste heat is to use a cooling tower and/or pond. This combination is the most practical. A pond, constructed with the power plant, is used to remove the waste heat. The circulation of the water includes passing it over a cooling tower where the water is cooled by evaporation. This closed system is more costly but eliminates the pollution of rivers, oceans, and lakes. This system is effective in dry climates. Effectiveness decreases as humidity increases and becomes unusable in areas of high humidity.

Unfortunately, the solution produces a different form of pollution. The evaporation process raises the humidity of the surrounding area. The increased humidity can reduce the quality of life, especially in summer, and modify the regional climate.

Several suggestions have been made for the beneficial uses of thermal pollution. Some of them are heating of buildings, heating of swimming pools, warm water irrigation. The production of fish or shellfish that thrive in warm water could also benefit from heated waste water.

THE FUTURE

The problems of pollution will continue to grow until people learn to view our use of energy and natural resources as a closed cycle. The use of energy and natural resources should be done under careful control so that the energy serves us appropriately, and the resources provide the automobile or product that we wish. The same care and control must be carried through the disposal of the waste, or preferably, the recycling of the waste back into usable products. Essentially, this means placing similar levels of time and effort (cost) on both development and disposal, whether the product be food, an electrical appliance, transportation, or a service.

It is highly unlikely that this level of time and effort will be placed on the control of pollution. The result will be a growing concern and a reduction in the quality of life for everyone.

Most current predictions show the use of fossil fuels increasing until we are well into the twenty-first century. The more optimistic predictions indicate *a growth rate of 2%,* while less optimistic ones place the rate at 4% or more. The result will be increased air and thermal pollution, with some level of climatic change brought about by the CO_2 build-up in the atmosphere.

The need in this area is obvious. *Every effort must be made to identify alternative sources of energy to the use of fossil fuels.* This need plus the need to control world population must be met if we are to improve the quality of life rather than continue to reduce it.

The consumption of energy and natural resources is many times greater in the United States than in the rest of the world. Europe, Japan, and Australia have similar though lower rates of consumption than the United States. Low energy consumption and low use of natural resources are the norm for most of Asia and Africa. However, these continents have the majority of people and all would like to improve their standard of living.

If the underdeveloped countries throughout the world make gains in their standard of living, their consumption of energy and natural resources will increase, producing a major increase in world pollution problems. Most predictions and statistical analyses assume a rate of growth equal or slightly higher than the past. However, acceleration is possible and the pollution problems could become far more severe.

The cost of pollution control, even at its present inadequate level, is very high. As requirements become more strict, costs will increase further. Many economists, for example, believe that the best method of reducing fossil fuel consumption is to increase the cost of fuel.

Another factor affecting future pollution is the world economy. If the economy continues to grow, pollution problems will increase as people become more affluent. If, however, the economy goes down, the use of fossil fuels and natural resources will either level off or decrease.

The outlook for the future is for increased problems with air, water, land, and thermal pollution. The result will be reduced quality of life and the potential of increased health problems for most forms of life, including humans. An immediate reversal isn't possible – but future improvements are possible if people unite behind elimination and control efforts and adjust life-styles to be more compatible with the environment.

INDUSTRIAL ARTS ACTIVITIES

Industrial arts must make a strong effort to acquaint students with the problems of pollution, and the potential solutions to these problems. Since pollution is not limited to a single area of industrial arts, it should be a concern of all teachers.

The backlog of activities in the area of pollution is minimal. As a result, the following should be viewed as "untried efforts" and strong attempts made to identify and develop interesting activities which will help industrial arts students gain the knowledge they need about pollution. There are two approaches which can be used to plan and develop student activities – problem solving activities or pre-planned projects.

The problem solving activity is built upon the concept of having an individual or small group of students identify a problem related to pollution. The problem could be regional or national. The solution to the problem should have three distinct phases:

- Identification of Problem – this should precede work and clearly define the problem. For example, the local solid waste disposal area may be nearly full and a new site is needed. This section could identify the problem the community is encountering in determining a new site. All of the arguments and related problems could be cited.
- Solution or Alternatives – the solution to the problem might be a set of drawings, a model, a report, a combination, or some other type of solution. In some cases, a clear-cut solution is impossible. The identification of a set of alternatives with strengths and weaknesses might be the best approach. The individual or group could rank the alternatives or provide a recommendation for one of the alternatives.

  Using the example of a waste disposal site, alternatives might include a survey of possible sites, consideration of a reclaiming pro-

cedure which would salvage glass and metals and burn refuse for production of heat and electricity, etc. Drawings showing possible sites could be prepared. A model of a salvage plant and operation could also be built. Additional activities include a model showing a sanitary cut and fill, and a cost comparison of the different solutions.
- Presentation – the problem and possible solution should be presented by the individual or group as an oral report to the class. An integral part of the solution could be a plan, drawing, mock-up or working model. The report might include a question and answer period and defense of the recommended solution.

The list of pollution problems in most communities is almost endless. Among the more common problems are:
- Waste disposal sites
- Polluted lakes, rivers, or streams resulting in
  - loss of recreation
  - odors
  - loss of fish
  - loss of business (fishing, recreation, etc.)
- Air pollution from
  - automobiles
  - industry
  - agricultural burning
- Culmination of rubbish in towns and cities producing
  - disease
  - flies, rats, etc.
  - unsightly neighborhoods
  - reduced property value
- Increased noise pollution from
  - airports
  - industry
  - urbanization

Pre-planned projects represent a second approach to student activities in this area. Activities may include drawings, models, experiments, library research, interviews, and oral and written reports. Emphasis may be placed on the problems within the local community, or the problems of the state or nation. The following examples are based on gaining a better understanding of the community in which the students live.

- Develop Transportation Plan Designed to Reduce Air Pollution and Conserve Energy – study mass transit systems, community transportation needs, and regional problems. Develop a local transportation plan which will reduce air pollution and conserve energy. The solution could include:

- Consideration of mass transit system
- Drawing or model describing the system
- Car pooling plans
- Modified traffic patterns
- Combination driving-parking-and mass transit plans.

- Local Status of Air Pollution – meet with local officials to determine what measures and records of air pollution are maintained for the local area. The meeting should reveal the following:
  - Specific air pollution problems of the community and geographic area
  - System for monitoring air pollution, including past records
  - Regional tendencies for inversions and other climatic factors affecting air pollution
  - Future plans to monitor and control air quality
- Visibility Test for Particulates – conduct daily visibility tests to determine the extent the particulate level of the air varies. Remember that visibility can be affected by clouds and fog as well as particulates.

  The study should consist of daily records and graphs, using landmarks of known distance. Part of the activities is the identification of distance to local landmarks.

  Compare the class visibility study results with those of the local airport, or appropriate community office.
- Automobile Smog Devices – Power and automotive classes should study automobile smog devices in terms of their effects on air quality. The pollution reduction characteristic of each device should be understood and their use encouraged.

  A study of the transition of the automobile from heavy smog and air pollution device to its present and future level would help students understand the importance of smog devices.
- Aerosols – list the potential health/safety hazards of various aerosol products. Include aerosols harmful to the atmosphere. For each one listed, provide an estimate of the extent of the hazard.

  Conduct a survey to determine what, if any, health/safety problems people feel they have encountered in using aerosol products.

  Check the labels on a wide variety of aerosol products, and list any toxic/hazardous ingredients noted. How do manufacturers suggest that users contend with these substances.

  Find out all you can about the governmental agencies and laws which regulate the production and sale of aerosol products. What, if any, guarantees of safety do these agencies/laws provide to potential consumers (Posthuma, p. 26).
- Local Status of Water Pollution – Repeat the local status study, but for water pollution. The meeting should reveal the following:

- Specific water pollution problems
- Source and quality of local drinking water
- Methods of drinking water purification, including a tour of the facilities
- Future plans to monitor and control water pollution

• Water Sediment Analysis – Obtain samples of water from a number of different sources including drinking water, water from local streams and/or lakes, and well water if available. Place like quantities of water in containers and place in a quiet place so the sediment can settle. Compare the quantities of sediment in the different water samples. Keep in mind, most water companies permit sediment to settle as part of their processing of water.

If the school has a chemistry laboratory, conduct chemical analysis of water, as appropriate. This would include PH factor (acid) and other tests depending on laboratory equipment available.

• Water Temperature Outflow at Local Power Plant – If there is a power plant generating electricity through use of fossil fuels or nuclear energy nearby, analyze its means of waste heat disposal. This could include:

- Meeting with company officials to determine their control procedures
- Measuring water temperatures at different places and compare at different times
- If discharged into a lake or river, determining (through discussion or library research) what ecological changes have taken place due to the release of waste heat
- Preparing a model or plan of the power plant operation. Identify possible changes which could be beneficial to marine life.

• Local Status of Solid Waste – Repeat the local status study but for solid waste disposal. The meeting should reveal the following:

- Specific solid waste disposal problems
- Method used (sanitary land fill, etc.)
- Visit to local dump(s) to determine effectiveness of solid waste disposal

• Recycling – if the community has a recycling center, visit the center and plan a project which will help support the center's efforts. The outcome could include raising some money for a school activity.

If the community does not have a recycling center, determine whether one is possible. The class could undertake a recycling activity for the school, establishing either a temporary or permanent center. This effort should include a review of what other communities have done and the problems they encountered.

This activity could include the development of plans and a model of a recycling center.

- Industrial Efforts – Through visitations to local industries, public offices, and other local sources, study the problems and solutions being sought for industrial problems related to air, water, and land pollution.

  A project could be the study of a single local industry to determine progress in improving the quality of life for employees and the community.
- Past, Present, and Future – Study some area of pollution such as the pollution of a local river, to determine past history of the problem. The study could look at the river 50 years ago, 20 years ago, today, and possibilities for the future. The study may be revealing since some communities have made significant improvements and fish populations have increased. Other communities have made minimal progress, and the study could determine the nature of the problem and future action.

There are numerous other activities and studies individuals or groups can undertake. The above should help a class or group identify appropriate projects.

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Chapter 9

Transportation

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INTRODUCTION

The term "Transportation" is used variously to designate the process, the means, or the systems whereby socially meaningful objects are conveyed through space. The process involves the movement of goods and people, by a mechanism, through an environmental medium. The dictionary defines transportation as "an act, process, or instance of transporting or being transported," and the verb to transport means "to transfer or convey from one place to another" (Webster's New Collegiate Dictionary, 1977, 1242.).

This breadth of reference indicates that transportation is a concept that is not easily definable, for it does not refer to a clearly delimited aspect of social reality. When the objects being transported are human beings, or when humans move by self-locomotion, in conceptual terms, transportation merges with mobility. At another extreme, when objects are messages composed of meaningful symbols, then transportation blends with communication. Perhaps this definitional ambiguity reflects the fact that transportation is a basic process by which direct physical contact and exchange among social units is attained and maintained.

According to Lenski (1970), transportation is an integral element of any society and becomes a basic support system within a social organization regardless of how primitive or advanced the level of society may be. Because of the integration of transportation in almost all human activity, it is in principle difficult to differentiate completely between "cause-and-effect" it may have had on society. For instance, seldom is transportation desired or developed for its own sake but rather serves as a means to accomplish other human objectives which bring about change in the total societal structure. Some of the objectives are economic in nature: (1) to exploit natural resources; (2) to increase productivity; and (3) to enhance per capita consumption. Side by side with the economic objectives are non-economic objectives: (1) to promote political cohesion; (2) promote leisure and recreational activities; and (3) to bring about certain socially desirable locational patterns (Heymann, 1965).

Because transportation affects all fabrics of society, differentiation between the "cause and effect" relationships becomes very complex. Historically, humankind has not been able to predict long-term sequence of societal results that follow from the decisions made (intended or unintended) through the employment of transportation technology. Consequently, we proceed to pursue predictable short-term benefits that often lead to (unpredicted) long-term disappointments (Cannon, 1973).

Transportation technology, like all technologies, ought to be mankind's good servant in every way, but often and increasingly it is not. It is not because we simply haven't acquired the necessary level of technological literacy to properly analyze the "cause and effect" relation involved in the total role and function of transportation in society. Only when we learn to understand much better the dynamic interaction between transportation and the structure of social/economic organizations can we take full advantage of transportation's potential as an effective tool in mankind's quest for a finer quality of life.

MAJOR DEVELOPMENTS IN TRANSPORTATION AND THEIR IMPACT ON THE SOCIETAL STRUCTURE

Since mobility is essential to almost everything that countries and individuals are striving to accomplish, it follows that transportation is a factor in the success or failure of the entire development effort. Food, shelter, health, education, and useful jobs are the ultimate goals, but transport may be the catalyst essential to the realization of these objectives.This perspective causes us to view transportation as a "means-to-an-end rather than an-end-in-itself" (Crowther, 1975, 16).

Transportation seems to be one of the most basic human needs and affects the fabric of all human societies. It cannot be viewed solely as an activity isolated from the changing environment and the larger objectives it is expected to serve. Historically, humans have always wanted to move around, and yet life has been possible with very limited forms of transport. It might be said that humans create for themselves the need to move. As a nomad, they may want to move to new pastures. As explorers, they may want to do the same out of curiosity, or population pressure behind them, or greed for new trade or trade routes. As a warrior, they would want to be mobile enough to defend themselves or, more often, to attack others. When mankind settled down and started growing domestic crops, transport needs began to affect not only the style of living but also their goods. Food grown in one place might have to be taken to another for consumption and storage. Food might also be transported in order to be exchanged for money or other goods in trading systems. Various raw materials might have to be brought to one place so that out of their use together something new might emerge; then the finished product itself would have to be taken away and distributed.

Today, a major use of travel is for pleasure. The travel systems were not developed because there was a strong need for them but because technology was available; the opportunity created the need and humans traveled simply because it was possible (Fair and Williams, 1975). It is quite evident that once travel becomes a possibility it seems to become a necessity.

Stages of Transportation Development

The foundations of the world's present transportation system were laid down thousands of years ago. In fact, the movement of goods and people is as old as humanity itself (Morlok, 1978). Throughout the history of mankind, it has been a continuous struggle to overcome transport barriers to supply individuals and societies with the necessities of life. The evolutionary process of transport has been dictated by the rate of innovation and invention which determined the rate of advance technologically.

In Fig. 9-1, we go back rather far in history to trace the major inventions and innovations for each of the four common environmental transport divisions — terrestrial, marine, atmospheric, and space. A glance at this historical record reveals that progress in transportation technology had to wait for the ideas of mankind which led to numerous inventions and innovations. Wilfred Owen (1965) has referred to five stages of transport developments. These stages are overlapping, their time and duration are by no means definitive. However, they represent a general sequence of events in which advances in transportation and progress towards higher levels of living are clearly related.

Stage One — The first stage was the period of immobility and the traditional society. In this period it was extremely difficult and costly to develop trade and cultural relations on any large scale except where channels of communication were provided by rivers and other bodies of water. The pattern of living emerging from these conditions was predominantly one of localized agriculture and handicraft industries with a minimum of economic integrations.

Most of the people of the world still live in this initial stage of primitive transport, and their efforts to break out of a subsistence environment and to achieve a higher technological level are being thwarted by the same barriers to movement that plagued all generations before them. The transport symbols of the traditional society today are the bullock cart, the donkey, the camel, and the jugs and trays carried on human heads.

Stage Two — The second stage of transport development was the period of internal improvements and the growth of trade. Human and animal power were made more effective by the development of roads and canals which reduced the cost of transport by traditional methods of moving on land and water. The developments aided both an expansion of capacity and lengthened the radius of trade and travel.

Stage Three — The third stage in the transport evolutionary process led toward greater mobility and higher standards of living due to transport mechanization and industrialization. Mechanical transport is a relatively new development in the history of mankind. Humans struggled with animate and wind energy most of history to aid in transporting goods and people. Mechanical transportation has, in fact, existed for only a tiny part – about four percent – of the time in which the world has had some elements of civilization upon it. It was during the third stage when steam power introduced both the steamship and the first railways.

Stage Four — This period in history was marked with greater mobility and higher standards of living through the development of motorization. The era was identified by a growing dependence on trucks, buses, and automobiles, and by extensive efforts to provide all-weather roads. People and economic activities were freed from limited mileage of fixed routes provided by railways and waterways during the previous stage.

Stage Five — A fifth stage is the air and space age and the conquest of distance, time, and space. The conquest of these factors has been one of the underlying objects in the development of transportation. Through the centuries a sustained 10 miles an hour was considered fast on land or at sea. Speed suddenly blossomed during the past 150 years out of all the thousands in which mankind has been on the move. Currently, humans can travel on everyday services at speeds higher than 1,300 miles-per-hour with atmospheric transport modes with much faster speeds through the application of space travel technology.

From earliest times the conditions in which mankind lives have been powerfully influenced by the ease and speed with which they have been able to move themselves and their materials from point to point on the earth's surface. By harnessing nature directly and indirectly, they have been able to explore and exploit the earth's resources. The chief landmarks in the history of transportation – the wheel, the sail, the steam engine, the internal-combustion engine, the electric motor,

TIME PERIOD STAGE	TERRESTRIAL	MARINE	ATMOSPHERIC	SPACE
STAGE ONE: IMMOBILITY 10^6 B.C.	Human Locomotive			
	— People walking — Foot-gear Human — Beast of Burden — Single yoke — Double yoke — Baskets — Carrying poles	Logs Rafts Paddles Dugouts Bark canoes Waterproof baskets Inflated hides Early sails		
5000 B.C.	— Travois — Sledges and skis	Skin covered frameworks (Umiak)		
3000 B.C.	Animal — Beast of Burden — Pack animals — Yokes — Dragging (travois, poles, slide car, etc. — Harness Wheels Early roads Carts	Early compass Ribbed canoes Rowing boats Oars Merchant ships		
1000 B.C. STAGE TWO: INTERNAL IMPROVEMENTS 500 B.C.	Spoked wheels Roman road building system	Sails Galleys		
	Carriages (fixed axle) War chariot Improved harness	Canals		
0 A.D.	Pivoted front axle carriage Stage coach	Merchant ship rudder control Anchor Magnetic compass Three-masted sail ship		Chinese fire rockets
1500 A.D. STAGE THREE: MECHANIZATION & INDUSTRIALIZATION	Omnibus (first public transit system) Mail coach Coach spring suspension system James Watt steam engine	Chronometer Canal systems Canal locks John Fitch's paddle steamboat	Balloon (free) Parachute	Military rockets

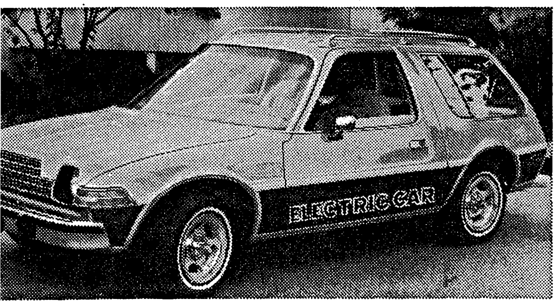
Fig. 9-1.
Five Stages in the Evolution of Transport Techniques.

TIME PERIOD STAGE	TERRESTRIAL	MARINE	ATMOSPHERIC	SPACE
1800 A.D. STAGE FOUR: MOTORIZATION	Trevithick's steam locomotive Steam powered coach Tram & trolley bus Bicycle Electric motor Railroad	Fulton's steamboat Erie Canal Screw propeller	Hot air balloon	
1850 A.D.	Pipelines Lenovi's gas engine Daimler's gas powered car Stanley steam car Daimler motorcycle Pneumatic tire Electric car Electric traction locomotive	Steam turbine propulsion Iron hulls Diesel engine propulsion Twin screw propeller Flat boats hauling oil barrels Suez canal	Airship Glider	Rocket-propelled torpedoes Jules Verne fictional space writings H.G. Wells science fictional writings
1900 A.D.	Traffic lights Trucks Buses Stirling engine Diesel/electric locomotive Parking meters Divided highways Elevators Pulley systems Belt conveyor	Hydrofoil Marine diesel engine Hydroplane Aircraft carriers Diesel/electric propulsion Radio direction finder	Airplane Dirigible (Zeppelin) Commercial aviation D.C. 3 Jet engine Aircraft radar Instrument landing system	Goddard solid fuel rockets Goddard liquid fuel rockets Guided missile (V-2)
1950 STAGE FIVE: AIR & SPACE AGE	Interstate highway system Hovercraft Subway	St. Lawrence Seaway Containerized freight Atomic powered submarine (Nautilus) Hovercraft Atomic powered merchant ship	Commercial jets Boeing 707 aircraft Hypersonic flight (X-15)	L.R. ballistic missile Inertial guidance systems Atlas ICBM Minuteman ICBM Titan I ICBM Sputnik (Satellite)
1960	Turbine powered auto High speed trains Automatic highway system Moving sidewalks Bus lanes	Super-tankers	Supersonic transport	First weather satellite Vostok I spacecraft (man in space) Apollo vehicles Man landed on the moon.
1970	Amtrak Personal Rapid Transit Tube Tube transportation Computer-controlled traffic Car radar & sonar	Waterjet propulsion Air propulsion	747 Jumbo jet VTOL STOL Satellite Control Air Traffic (aerostat)	Communication satellite Viking Skylab

and the great breakthrough of flight – promise, as the 21st century approaches, great advances in transport techniques capped by the rocket engine, which frees humans from dependence on earth's atmosphere and permits them to visualize traveling to other planets.

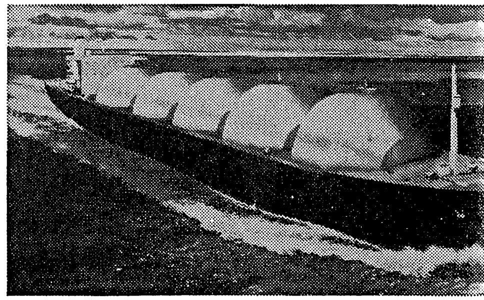
Fig. 9-2.
Various Terrestrial and Marine Vehicles.

Electric Vehicle Association, Inc.



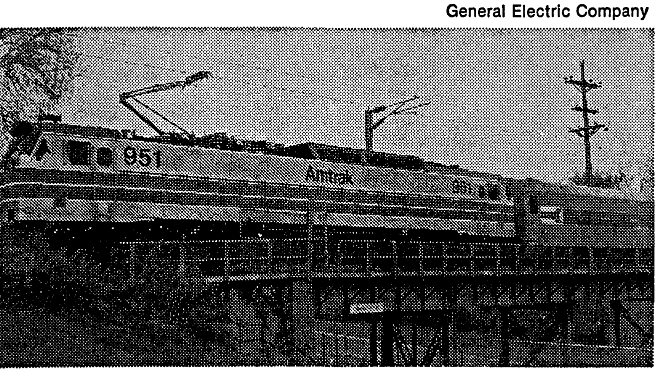
A. Wheeled electric road vehicle.

General Dynamics



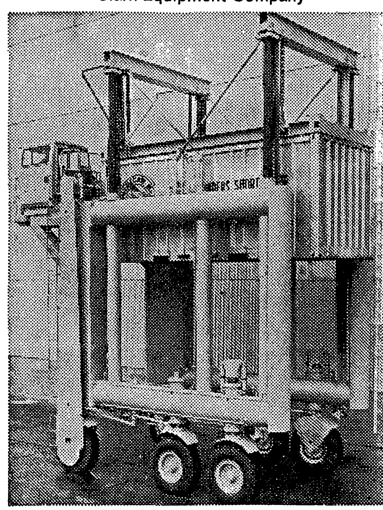
D. Natural gas tanker.

General Electric Company



B. All-electric railed locomotive.

Clark Equipment Company

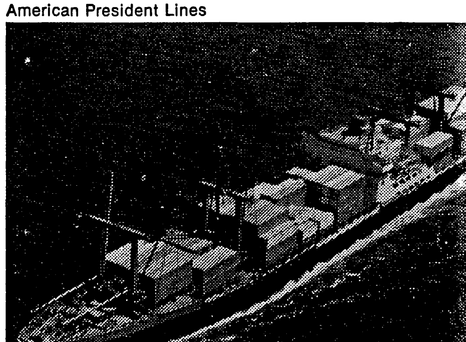


E. Off-the-road vehicle.

Rohr Industries, Inc.

C. Bus transportation.

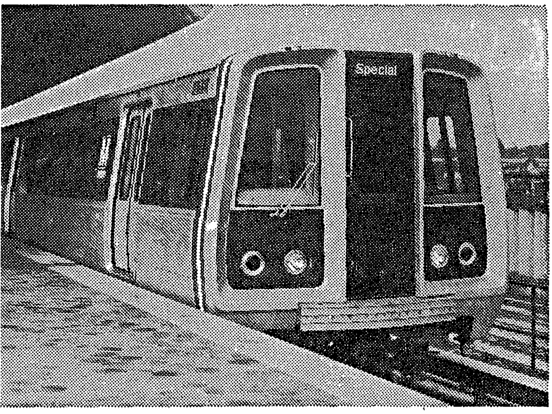
American President Lines



F. Containership.

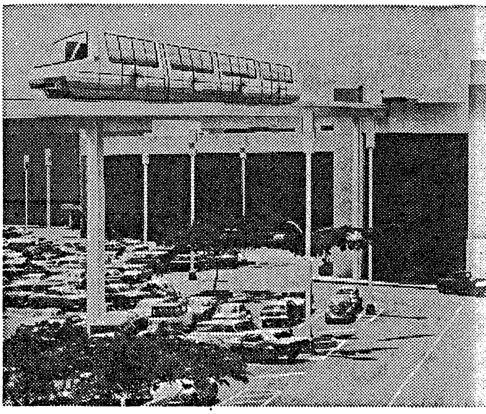
Fig. 9-3.
Terrestrial "Fixed" Guideway Vehicles.

Rockwell International



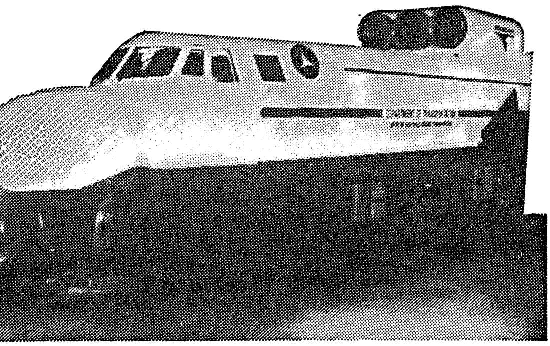
A. Electrically-Propelled Subway.

Rockwell International



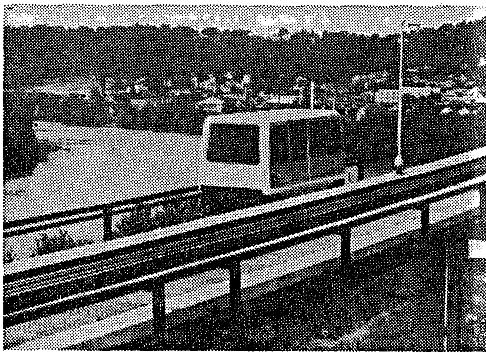
D. Elevated People-Mover.

Department of Transportation



B. Experimental Tracked Air Cushion Vehicle with LIM propulsion.

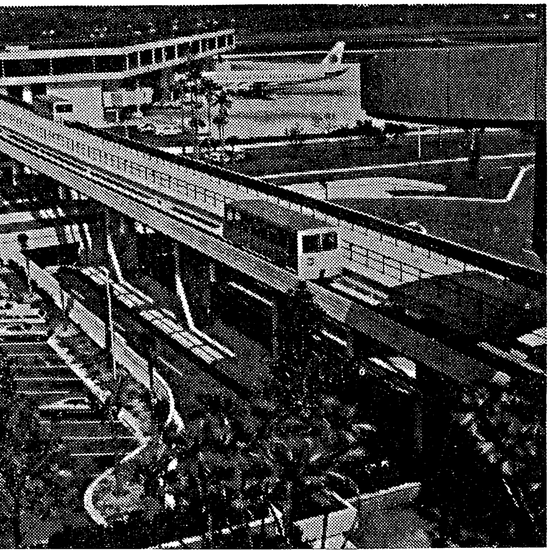
Boeing Aerospace Company



E. Morgantown Personal Rapid Transit.

C. Tampa Airport Transport Vehicles.

Westinghouse Corporation



F. Artist's Sketch of an Automated Transit System.

Otis Elevator Company

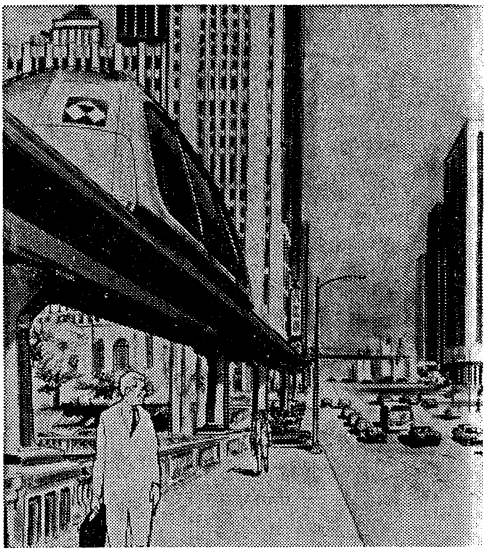
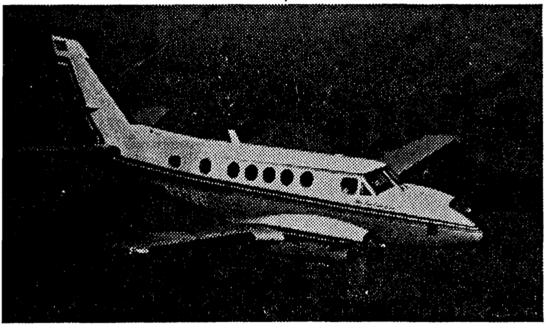


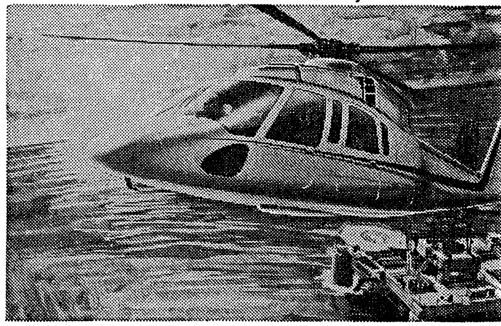
Fig. 9-4.
Atmospheric and Space Vehicles.

Beech Aircraft Corporation



A. Passenger Aircraft.

Sikorsky Aircraft



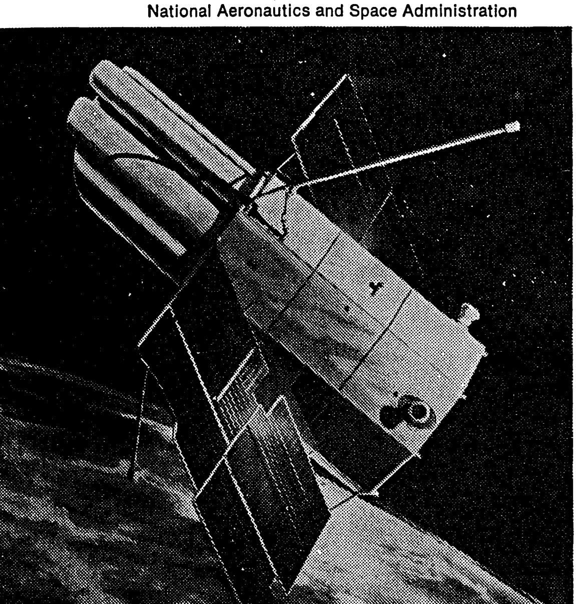
D. Helicopter.

The Goodyear Tire and Rubber Company

B. Airship.

C. Orbiting Astronomical Observatory Spacecraft.

Grumman Aerospace Corporation/
National Aeronautics and Space Administration



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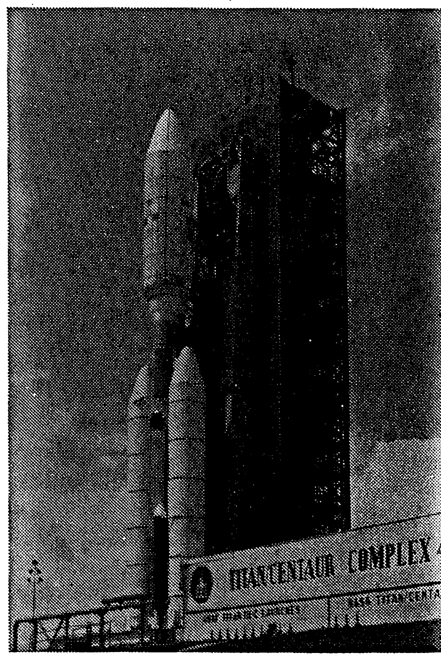
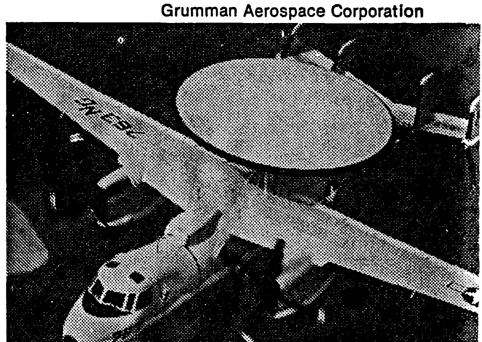


E. Viking-B at Launch Site.

F. All-weather Combat Intelligence Center Aircraft.

Grumman Aerospace Corporation



CURRENT AND FUTURE TECHNOLOGIES

Despite the great diversity of transportation modes, they can be categorized into four major environmental divisions: (1) terrestrial, (2) marine, (3) atmospheric, and (4) space. Each mode, within the environmental divisions, is unique but all possess common characteristics by nature of the mediums in which the vehicles operate. Various forms of transport technologies are illustrated in Figures 9-2, 9-3, and 9-4.

The most widespread form of modern transport is the use of a vehicle operating on the terrestrial medium. This form of vehicle generally has wheels, which give it mobility, and a body which is designed to contain and protect the load. To spread the weight of the vehicle and its load sufficiently to avoid sinking in the soil, guideways were constructed. There are substantial economics to be gained from providing a smooth, hard, prepared path for a vehicle, gains in the forms of higher potential speeds, reduced resistance to motion and hence reduced power requirements, capacity to carry heavier loads, and lessened difficulty in protecting the contents from damage. The most common form of propulsion of wheeled terrestrial vehicles is through the application of a force to rotate the wheels, with path-wheel friction providing the necessary reaction forces.

Rather recently other forms of vehicular terrestrial transport modes have been developed using forms of levitation other than the conventional wheel. These include the provision of mobility by means of an air cushion under the vehicle, with sufficient pressure to raise the vehicle above the pathway, and the use of magnet forces (in repulsion) to accomplish the same objective. Since there is no longer a physical contact between the vehicle and the guideway, some means other than mechanical friction is necessary to provide propulsion and guidance. This can be accomplished by propellers or jets acting against the air, or electromagnetic forces between the vehicle and the path, as in the case of a linear induction electric motor (Barrows, 1975).

Vehicle technology is not limited to movement on the terrestrial medium, but is also applicable to movement on the marine environmental medium and in the atmospheric/space environments. In either context, the vehicle may be maintained at the proper elevation by buoyancy in the medium (as a ship in water and an airship in air), by reaction forces from the medium (as in the case of helicopters), or by use of an airfoil to create uplift forces as a result of the relative motion of the vehicle and the medium (as in hydrofoil boats and aircraft). Vehicles are controlled by varying the forces against the medium.

There are other forms of transport technologies that are not as common but equally important in the transport of goods and people. Included in this area are sled and skid devices that are usually limited to special situations, such as over smooth paths in factories and over snow, ice or mud where appropriate. In addition, humans have also adapted the natural means of movement of liquids, solids and gases to their purposes. The technologies applied to utilize this form of transport have been the paths constructed to facilitate this movement where paths do not naturally exist. The path may be open channels or closed channels in the form of pipelines, which are useful only for gases or liquids. Gravity is usually used for propulsion in open channels, with mechanical devices used to stop the flow, while pumps of various sorts can be used with pipelines to force the gas or liquid to move the desired manner. Often solids can be carried in the fluid, although this is most often limited to solids which are buoyant in the fluid.

Between the discrete movement of objects on vehicles and the continuous movement of gases and liquids in pipelines or channels lies a hybrid form of transport. Here, mobility is provided by a device which rests upon the ground and has a moving surface. Conveyor belts represent one such type of system. Another is a roller line, in which the objects to be moved are transported along a path consisting of rollers placed sufficiently close together to provide a smooth path with almost continuous support. Yet another example is the cable line, or aerial tramway, in which the objects are suspended from a cable which is contrained to move along a predetermined path at speeds governed by rollers which propel it. This form of transport technology is best known for its application to ski lifts, although it is commonly used in factories and other locations for short-distance movements of objects which must follow one another in almost continuous succession.

There are undoubtedly many other forms of transport which have not been discussed in this chapter. Humans are always inventing new transport techniques, so in a sense any listing would be incomplete. It is more important to turn our attention to the system of transportation and its relationship to other sociotechnical systems in society.

INTERFACE OF TRANSPORTATION WITH OTHER SOCIOTECHNICAL SYSTEMS

Transportation is not a function that stands apart from other human functions as had been mentioned previously. Instead it is a connective among other sociotechnical systems that forms the physical bases of human societies. Innovations in sociotechnical systems have extended human capacities in all areas of human endeavor: (1) communication; (2) production; and (3) transportation. A sociotechnical system was defined by Kline (1977, 41) as "a system which includes interrelated social and technical components." According to Kline, the sociotechnical systems are generally goal-directed and typically

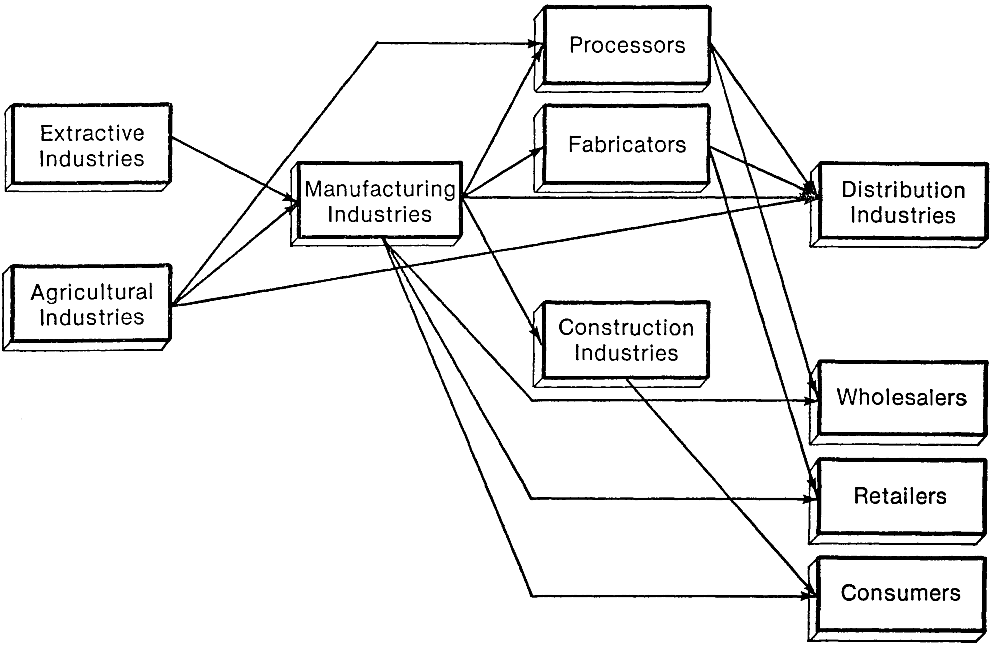


Fig. 9-5.
Three Common Sociotechnical Systems.

include the following elements – people, technics, social organizations, ideological bases, resources of materials, available energy, and information. These elements are integrated to form a sociotechnical system such as the system of transportation. Furthermore, each sociotechnical system is integrated with other systems to meet the needs and aspirations of human societies. See Fig. 9-5.

Interface Between Transportation and Production

Transportation is an integral part of the sociotechnical system of production and distribution. The relationship and importance of transportation to the industrial and distribution phases of economic activity are demonstrated by the role that transportation plays from the stages where raw materials are grown or extracted, through processing, fabrication, manufacturing, and construction until the finished products reach the consumers. Basically, transportation means changing the place or the location of raw materials or products to create utility. Sampson and Farris (1975) noted that value of materials or products could be created by the process of changing location, thus they called this "place utility," or the creation of value by changing position or location. For productive purposes, raw materials or parts for assembly have no value unless they can be transported to the place where they

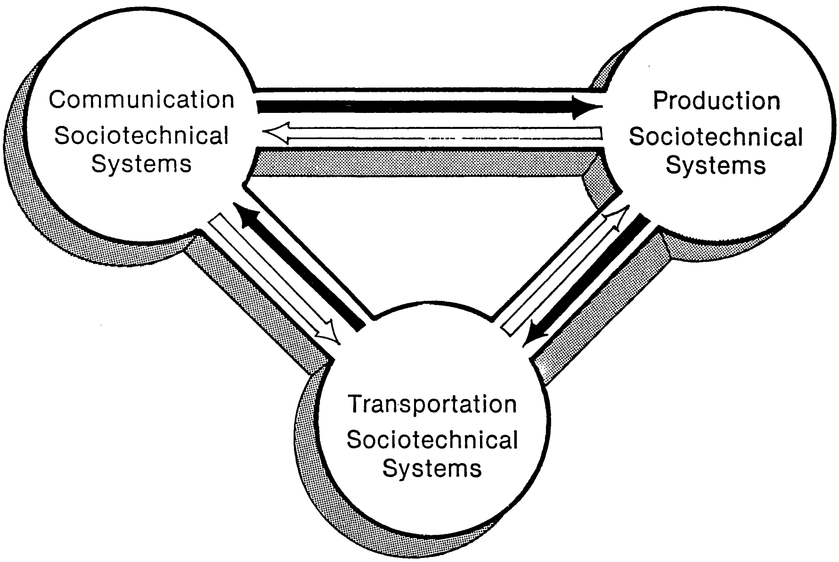


Fig. 9-6.
The Functional Interface of Transportation in Production.

are needed. The function of transportation in the many stages of production are illustrated in Fig. 9-6.

Adequate transportation is essential to improving the way of life for a growing population. It allows people to live where they are most comfortable and work where they feel most productive. This situation promotes economic development within a country or region. Specifically, transportation plays several roles in the area of production and economy according to a study conducted by the United States Department of Transportation (1977):

1. Good transportation spurs economic development by giving mobility to the factors of production permitting economies of scale and increased efficiency.
2. Good transportation enlarges the area consumers and industry may draw upon for resources and products.
3. Good transportation expands the area to which a given industrial manufacturing plant may distribute its products economically. The

resulting specializations and economies of scale provide a wider choice for consumers at lower cost.

4. New transportation investments constitute a substantial part of all new investments and help to sustain and induce economic growth.

Transportation and Communication Interface

There exists a direct relationship between the transportation and communication sociotechnical systems. Depending upon the application of communication, it may use transportation to accomplish a primary objective or communication may be used to facilitate transportation in the areas of vehicular guidance and control.

New methods of communication provide new approaches to transport problems. Historically, transportation has been the principal means of spreading ideas, of achieving political unity, and of making it possible for people to communicate over great distances. Until very recently the only method of communication over distance was physical travel. If a person did not travel himself, he would send a message, carried by someone else. In this perspective communication may be viewed as a user of transportation.

A century ago transportation and communication were closely allied activities because communications were possible only through the transporting of messages. This is the reason why the Post Office in the United States has always had a keen interest in all forms of transport, from the early development of roads for rural mail routes to the payment of subsidies to airlines (Owen, 1965). With the development of the telegraph and telephone services, however, the link between transportation and communication was broken. The gap was widened by radio and television. Consequently, the relationship between communication and transportation has changed considerably with the developments in modern electronic communication systems. Instead of communication being a "user" of transportation, it has become a "facilitator" or a "substitute."

Changes in information processing affect communication: new forms of communication provide alternatives for transportation; improved transportation networks allow more frequent face-to-face communication; faster information processing machines allow analysis for improving transportation; and so on. Today, all systems of transportation rely heavily on communication technology for control and guidance of individual vehicles and transport networks. There are numerous examples which illustrate communication as a facilitator of transportation. For instance, the "Dial-a-Bus" system uses a computerized system for dispatching small vehicles to provide shared door-to-door service.

New rapid-transit systems also make good use of communication technology with the application of physical automation to augment human operation. The communication and control system comprises: (1) Vehicle on-board operation control on the guideway and in the station; (2) Vehicle and system traffic control and monitoring; (3) passenger, in-car operational communications; and control system safety (Gravitz, 1972, 391). This is an example of "machine-to-machine" communication totally automated and controlled from a central computer.

Atmospheric transportation systems generally are controlled by electronic communications. Traditionally, navigational aids for trans-oceanic flying get an airplane to its destination. However, these aids are not good enough for precise traffic control with the ever-increasing number of flights. A new traffic control system using two satellites, called *Aerostal* has been developed which will double the traffic capacity of North Atlantic air lanes. In the Aerostal system, two satellites in synchronous orbits (orbits in which they remain fixed with respect to the earth's surface) will provide precise data on the positions of each aircraft. According to Rosen (1976, 184), this information, plus improved communication between aircraft and ground-based traffic control centers, will reduce reserved transoceanic air space into smaller blocks for more effective control. The system will be able to handle traffic at twice the present peak density. Satellites in the new "Aerostat" system will also provide high-capacity communication channels.

One of the great uncertainties which must be injected into a prognosis of transportation development is the extent to which communication will be substituted for transportation. In the past, advances in communications and transportation technology have tended to reinforce or facilitate each other, leading to greater demand for both. Major breakthroughs in communications technology might, however, change this relationship.

It is interesting to speculate on the future trends in travel and the demand for transportation. One factor which will undoubtedly become very important in influencing these trends in the future is the development of new methods of communication, involving the transmission of not only data (words, numbers, etc.) and voices, but also increasingly images (Lathy, 1975). It would be fatuous to argue that since all communications advances of the past have served to stimulate transportation, this will continue to be the case in the future. At some point, communication may serve equally as well as face-to-face confrontation in the transaction of human affairs. Already, there are experimental installations of videophones at different offices of the same firm, which enable conferences to be held regardless of the distance between participants, eliminating the need for travel to a single location.

ENVIRONMENTAL ASPECTS OF TRANSPORTATION

Although technological change during the past one hundred fifty years has been one of the most important forces in the formation of current society, understanding of the processes of technological innovation and change has not kept pace with the magnitude of that change. Only in recent years has it become increasingly apparent that many of mankind's productive activities have decided effects on both the social and natural environments. Transportation is among these changes that have taken place which cause detrimental effects on the environment. There are numerous categories into which these effects may be placed; a convenient categorization for purposes of this discussion consists of the following: (1) Pollution; (2) Consumption of energy; and (3) Social disruption.

Pollution From Transportation Systems

Transportation affects the environment in many ways. Vehicle exhaust emissions pollute the surrounding air; oil spills pollute waterways and noise becomes annoying. These detrimental effects on the environment are destructive to health and property.

Air pollution is perhaps the most serious pollution problem caused by the transportation systems employed in technologically advanced nations. The exhaust gases from internal combustion engines are carbon monoxide, oxides of nitrogen and hydrocarbons. Hydrocarbons can also be emitted as evaporative losses from carburetors, vehicle fuel tanks and fuel storage tanks. Nitrogen oxides and hydrocarbons are the main raw materials which when exposed to the ultraviolet light in sunlight combine in the photochemical reactions which produce smog.

There are both long-term and short-term air pollution problems involved with present modes of transportation. The long-term problem arises because, as some scientists hold, continued high rates of some pollutants may adversely affect the world's climate and all life. Responses to the short-term problems, such as the automobile emission standards already enacted into law, should decrease total nationwide pollutant emissions and, therefore the likelihood of the long-range problem according to the United States Department of Transportation (1977).

Noise pollution is usually defined as unwanted sound. Motor vehicles, trains and aircraft are important sources of the noise which plagues urban life. It is particularly a problem in the vicinity of roads, where vehicles operate at high speed or accelerate, and in the vicinity of airports. There is currently much research on reducing noise at its sources and in technological solutions that have the potential to alleviate much of this problem in the near future.

Water pollution related to transportation can arise from oil, garbage and sewage discharged by ferries and shipping during normal operation, and oil released by tanker vessels in accidents or when flushing their tanks. Another problem is the storm water runoff from roads carrying contaminating materials such as oil, rubber, grit and the products of oxidations and wear of the road surface.

Transportation/Energy Interface

Energy is the source and control of all things and actions of human beings including those involving the transporting of goods and people. According to Goodson (1974), mankind's activities in movement have only been limited by the available means of transport and energy supply during movements. Historically, there has been direct relationship between energy consumption patterns and the level of technological development attained by an individual or society. In fact, one measure of a nation's progression from low to high levels of technological development has been the transition from walking to horses to bicycles to buses to motor vehicles. The concern, however, is that each succeeding transport means requires more energy.

Presently, approximately twenty-five percent of the total energy consumed in the United States is used for transportation, including the automobile, trucks, buses, trains, pipelines, boats and airplanes. The percentage of energy used for transportation is divided up approximately as follows:

Mode	*Percentage of Total Transportation Energy*
Automobiles	52
Trucks	22
Aircraft	10
Military Operations	5
Railroads	4
Ships and barges	4
Others	2
Buses	1

Almost two-thirds of the transportation energy is used for passenger transportation, with most of the remainder being used for freight. Of the passenger modes of travel, the private automobile accounts for approximately ninety percent of the total passenger miles traveled while aircraft account for 8.60 percent, buses 1.1 percent and rail .3 percent.

There are significant variations in efficiency among the various transport modes. For instance, the relative energy usage of the various modes of personal transportation (to move one person 100 kilometers relative to the automobile) are as follows:

Automobile	1.00
Airplane	1.53
Train	0.63
Streetcar	0.50
Bus	0.26

These efficiency differences are due to the power-plant efficiencies for various automobiles and found variations from 7 to 17 percent with an average of 10 percent for 1973 automobiles. In the area of freight transport, it takes approximately four times the energy to move a ton-mile of freight by truck as compared to moving it by rail. This difference is due to larger drag forces on the truck, more efficient powerplants and better load factors for rail.

The least energy demanding form of freight transportation is the pipeline. The pipeline is excellent for bulk transportation of liquids and gases. By mixing crushed coal and water, a slurry can be formed which makes coal transportation by pipeline require less energy per ton mile than does rail transportation. However, in general these two modes of coal transportation require approximately the same amount of energy. Both rail and water modes require approximately fifty percent more energy per ton mile than does the pipeline. On the other hand, the airplane is by far the most energy demanding means of freight transportation. It requires fifty to sixty times as much energy per ton mile as is used in rail transportation. Its use can only be justified in terms of convenience and speed of service (Doolittle, 1977).

There is a wide range of energy consumption per "passenger-mile" or per "ton-mile" in freight for any given mode of transportation. This is particularly the case with passenger transportation. Energy requirements vary with many factors such as in the weight of the vehicle and the type of service (urban or intercity). Also entering into the energy required per passenger mile is the number of passengers conveyed by a given vehicle. In general, however, for intercity service, rail transport requires approximately seventy-five percent more energy than buses, private automobiles over twice as much as energy and aircraft over five times as much energy per passenger mile as is required by buses. For urban transportation, the automobile uses on the average over twice as much energy per passenger mile as is used by the average of the various mass transit systems. Thus it is evident that citizens, by their choice of the mode for their transportation, can have a significant influence on the conservation of our finite energy resources both now and in the future.

Energy conservation is one of the most crucial concerns to be dealt with in the future. It is anticipated that new technologies in transportation will reduce energy intensiveness substantially. New designs that will be incorporated into the active transportation fleets over a period of time should improve overall transportation energy efficiency through the end of the present century. For instance, the earlier energy intensiveness of the automobile was so high and the prospects for improvement are now so great that it is likely that its fuel consumption will decrease through 1990, according to the United States Department of Transportation (1977).

Transportation/Social Disruption

Transportation is a major determinant of the location and form of human settlement. Until now, the influence of transportation technology on human settlements has been largely beneficial. Only recently have we realized that what was once considered progress has numerous social costs. The sociological interactions of transportation activities are not as easily seen as are the environmental interactions. Yet they exist, and they affect individuals and society in such indirect ways that sometimes they go unnoticed but do have a bearing on the nature of spatial patterns of human settlement. One of the reasons "social costs" go unnoticed is that transportation aspects must be integrated with a whole series of other factors which interact to cause sociological effects. Rarely are transportation factors isolated; rarely can they be (Sampson and Farris, 1975).

Only recently have the possible detrimental effects of transportation systems become sufficiently great that they might threaten the viability of certain forms of settlements. Furthermore, transportation systems have grown so large and costly, and the time periods needed to amortize the necessary investment have become so long that these systems are among the most enduring features of urban landscapes. Thus, their detrimental effects on the urban environment are likely to be particularly long-lived.

Transportation affects the nature, intensity and the spatial pattern of human activities, which in turn results in corresponding changes in the social and physical environments. While accessibility promotes economic development and growth, at the same time, transportation systems cause social disruption. For instance, the damage to individuals and property in transport related accidents and the usurpation of land for transportation facilities are important sources of social disruption, particularly in urban environments.

Accidents — Since most transport related accidents in the developed countries are connected with the use of motor vehicles, we shall focus on motor vehicle accidents. Transportation accidents often result in fatalities, injuries, and property damage. In 1970, for example, over 58,000 persons lost their lives in the United States while engaged in transport. About ninety percent of those fatalities occurred in highway vehicles. Deaths result in a loss to society. Lost productivity accounts for part of the loss. Other parts, such as emotional stress, and family readjustments, do not lend themselves easily to quantitative or monetary evaluation when coping with the accident problem.

Numerous efforts have been made in recent years to increase safety in transport, and in most nations there is a regular inspection of transport vehicles and equipment. Also, there is a move to design vehicles and facilities that minimize the probability of accidents and minimize the damage done as a result of human failure. Because of these thrusts, according to the United States Department of Transportation (1977), it is anticipated that there will be a decrease of more than 24,000 fatalities per year by 1990.

Disturbance and Relocation — usurping land for transportation systems can split or destroy neighborhoods, lead to problems in relocating people and businesses, and remove land from park or recreational use (Morgan and Nielsen, 1973). With the urbanization of population occurring in most nations, there is a continuous need to expand the capacity of transport facilities. Such expansions usually require the use of land for freeways and transit lines. Morlok (1978) indicated that a typical city devotes approximately 25 to 30 percent of its land surface to transport. Since most of the land for transport must be in a continuous strip, it disrupts neighborhoods and changes activity patterns of the residents. Also, there is much displacement of families or industrial firms and other institutions which were in the path of the new facility.

Fundamentally, the possibility of unlimited individual transportation afforded by the automobile has been instrumental in shaping practically all our present-day environment from the decay and virtual abandonment of the inner city to the rapid creation of suburban areas. Current trends are to change this living pattern by changing the mode of transportation back to public transit. But, according to Simon (1975), "as it has taken over a half century to establish the type of environment we are accustomed to today, it is prudent to say that changing it again will take at least as much time." The automobile, therefore, will be with us for a long time. As is already evident, it may become smaller and hopefully, will be improved in terms of efficiency with alternative energy/propulsion systems. In addition due to urban congestion, the automobile may be limited in the inner urban areas after other modes of public transportation techniques become prevalent.

Conclusion

The environmental factors of transportation are very powerful and must be given top priority in planning new facilities. The private automobile has encouraged an urban structure which favors individualized transportation. Unfortunately, as the population increases and as more and more families have found it necessary to own one or more automobiles, the disadvantages of dependency have increased. This increase has caused undesirable environmental conditions like: (1) air pollution; (2) depletion of energy resources; (3) congestion; and (4) the usurpation of valuable urban space required for movement and parking. In addition, the problems of the young, old, physically handicapped and other disadvantaged persons who cannot drive or do not own an automobile have also become increasingly apparent (U.S. Office of Technology Assessment, 1975).

As new transportation systems are developed, it is important that they be evaluated prior to implementation. We need to weigh the detrimental environmental impacts of the system against the convenience and economic stimulation which the system is expected to produce. In the process of evaluation, two basic questions need to be answered: (1) What are the actual physical effects of a given system on the environment? (2) What are the levels at which these effects are undesirable or harmful? The entire society should participate to the fullest extent possible to assure that proper decisions are being made in future technology to protect all environmental aspects and not to endanger the quality of life.

TECHNOLOGICAL POSSIBILITIES FOR THE FUTURE AND THEIR CONTINGENCIES

It is extremely difficult to predict what changes in transportation technology might lie in the future, but nevertheless one can identify a number of directions of change which are fairly likely to occur based on current trends and problems. Presently, there are many efforts to develop new transportation technologies which will make the moving of large as well as small volumes of persons over varying distances more attractive and less costly (in a total resource sense) than existing technologies. For example, recent advances in transit systems show that modern technology can provide solutions to difficult problems.

The limitations of the automobile for urban transportation are the space it occupies, the energy it consumes, and the air pollution it creates. Clearly the dimensions of the energy crisis indicate a need for more efficient modes of transportation in the future. Energy limitations alone may have the greatest impact on the nature of future transportation technologies. Denis Hayes (1977, 308) states:

> In the new energy era, transportation would be weaned from its petroleum base even as improved communications and intelligent city planning begin to eliminate pointless travel. Energy efficiency and load factors

would become important criteria in evaluating transport modes and would be reflected in the costs of travel. Bicycles would begin to account for an important fraction of commuter traffic as well as of other short trips, and freight transport would be transferred wherever possible to more energy-efficient modes, especially trains and ships.

The conventional automobile may also have to be weaned because the high-density population regions can ill afford additional land area for more highways and parking facilities. In addition, the government is becoming less tolerant of air pollution from all sources. However, in spite of the limitations, the automobile will not be eliminated because certain spatial and temporal patterns which exist now cannot easily be served by other modes without major new investments in system and vehicles. Therefore, the current trend is to improve the system to reduce the present undesirable environmental factors.

Already there are prospects for potentially significant technological developments in automotive transportation. There has been a substantial reduction in pollution emissions and fuel consumption rates have been improved. In the future, these two concerns might also be achieved by the development of practical cars propelled by some other means. Automobiles propelled by electricity from batteries are already available on a limited basis. However, we will have to wait until perhaps 1990 for the next big step – a sodium/sulphur battery to propel personal vehicles with desired power and energy densities. Another major problem with the existing automobile system is the large number of lanes required to move large volumes of traffic. This may be reduced by automation of vehicle control, permitting the operation of platoons of closely spaced automobiles on freeways, (OTA, 1979).

Automobiles would be guided electronically, following cables buried in the road surface. Deviations would be corrected by automatic steering and the speed would also be controlled automatically. Another approach may be to have automobiles guided mechanically, as on a railway. Many design concepts for such "dual-mode" systems have been developed to the prototype stage. They simplify lateral control, but require additional wheels and appropriate guideways.

Transportation Alternatives

Some form of rail is the most obvious form of alternative surface transportation and a number of competing technologies are emerging to supply the anticipated new demand in the future. First are the improvements to existing equipment and roadbeds and various forms of steel-wheel-on-rail capable of higher speeds. Second are the air-cushion concepts which see the train supported on a pressurized air bearing. Third, are the magnetic levitation schemes in which magnetic attraction or repulsion holds the vehicle from mechanical contact with the rail or guideway.

The rail rapid transit systems provide the highest capacities and are useful in high-density corridors linking common origins and destinations. These systems are known as "people movers" and are classified into three categories of transportation systems: (1) Group Rapid Transit (GRT); (2) Shuttle and Loop Transit (SLT); and (3) Personal Rapid Transit (PRT). These systems called Automated Guideway Transit systems consist of driverless vehicles which operate over exclusive guideways. The guideways can be located on elevated structures, at street level, or below ground (United States Department of Transportation, 1977).

The rapid rail systems have indirect advantages over automobiles such as: less pollution, lower petroleum fuel consumption per passenger, and less diversion of land to transportation-related use. According to Bell (1978), these new transit systems currently lack public support but are here to stay. Fuel shortages and municipal restrictions on urban automobile use can be expected to cause large numbers of people to switch to public transportation in the short-term future.

For low-to-medium-density links, quiet takeoff or vertical takeoff and landing (S/VTOL) atmospheric vehicles will become prime candidates in the future. The vertical-takeoff implies a low-noise footprint for compatibility with urban locations and little time lost at the terminal to give high vehicle productivity. The primary inhibitions today are high operating costs, incompatible air traffic control, and some environmental questions.

There is much less consideration of radically new transport technologies being projected for goods movement than for person movement. However, numerous evolutionary changes seem to be made in the area of providing integrated multimodel services which may use each individual mode of transport for that portion of a movement for which it is most appropriate. For example, one might envision a containerized movement which involves truck movement from factory of origin to a central rail terminal at which the container is transferred to an intercity train, with rapid rail movement followed by truck movement to the final destination. There are other possibilities for multimodel service too numerous to mention here, such as: pipelines, conveyor belts, moving sidewalks, etc.

Conclusion

There is no doubt that the future will be different from the past. In the post-1990 period, when many of the current technologies will be making their first pervasive impact on society, the social and technological processes may be expected to have reached a stage of synergistic balance in which society directs transportation technology rather than being propelled by it. In the remainder of this century, we will not learn so much to do new things as to do *well* those things we now do poorly. In many areas, this will mean reducing the negative environmental and cultural effects of our technological society. In transportation, it will mean focusing on simplifying mobility, reducing both technical and institutional complexities that have grown up around our transportation system. We have learned that it is not "progress" to double the speed of our aircraft and then waste hours getting to terminals or waiting for baggage or wasting motion because we lack adequate information and directions.

We must realize that it is not only "high technology" that holds the key to the future. It is rather the most *appropriate* technology for each problem. We must aim at balanced, integrated solutions to transport problems that consider all reasonable options. These options include *high, intermediate,* and *low technology* alternatives ranging from exotic rapid transit systems to walking. Proper decisions must be made by the citizenry not to destroy the natural environment and impair the quality of life through the use of transportation technology.

TRANSPORTATION TECHNOLOGY/EDUCATION INTERFACE

The Problem

A paramount issue of our time concerns how transportation technology impacts society and the environment in ways we had not anticipated and at rates without historical precedents. Surely, humankind has progressed through the development of transportation technologies to overcome the intrinsic limitations of time and space. However, this progress has not been without fault. On the one hand, transport technique aided mankind while on the other, it has limited the quality of life. (Studor, 1973, 1) stated:

> Transportation systems can be at once the source and the solution to the problems of human density and distribution; they can both relieve and induce human stress and well-being. For this is one of several areas of human innovations where ends and means can become seriously imbalanced, where solutions can become problems very swiftly, and where conflicts between man and technology can be most profoundly felt.

Historically, transportation technology was merely produced, celebrated and accepted in all its manifestations as an essentially benign human phenomenon. The designing of systems was generally carried out by a limited group of elite professionals. The doctrine of progress, the ideal of the frontier, and the assumption of resources inexhaustibility were key pillars in the development of transportation facilities and techniques. This philosophy conditioned humankind to believe that applied technology could overcome most limitations in transport and related societal problems. The pattern in transportation development has been centered on the notion of pushing back technological limits until they reach theoretical boundaries. In recent times, it has become clear that we have reached the point of diminishing returns with this technical approach to solving problems in transportation.

Today we question the limitations of applying a purely technical criteria in the planning of transportation systems. We have come to the realization that the decision-making process based soley on technical criteria, generally overlooked the important environmental factors. The increasing trend of modern times is to question the limitations of decision-making based upon technical criteria relating to transportation planning and in the equating as to what is considered a "public good." A road or airport was almost always viewed as a "public good" in earlier times since it provided reliable communications, enabled food or services to be transported more rapidly or supported the establishment of industry with its attendant jobs and increase in living standards. Today, the same projects can be maligned and are often perceived by citizens as a "public bad" since they often duplicate existing facilities, bring uncontrollable noise and air pollution and are detrimental to a neighborhood. Citizen participation to assure that proper decisions are being made will be an important element in the future. However, the effectiveness of participatory decision-making will depend on how well all citizens will understand technical limits, economic limits, ecological limits and social limits and their relation to transportation activities.

Transportation Technology Education

As we are reminded almost daily, a major educational challenge of our time is the development of the human capacity to shape wisely and learn to control a rapidly changing modern technological society. This is a critical need, which must be met in part through education. Since transportation technology is a vital component in every society, appropriate curricula should be implemented within the industrial arts education program in order to move toward meeting this need. Indeed, preparing people for joining a technological society as capable and efficient "decision-makers," is a basic educational problem confronting today's society.

A curriculum for the study of transportation technology must be broad and comprehensive. We can ill afford to limit course content solely on the "state-of-the-art" of the technical elements used in transporting goods and people. Rather, the technical elements must be viewed as one component of many involved in the total "sociotechnical system" of transportation as it relates to four environmental mediums: (1) terrestrial; (2) marine; (3) atmospheric; and (4) space. The major emphasis should be on the interrelationships of the various technical transport modes in regard to environmental considerations and human purpose. A list of environmental considerations, grouped into five categories, is presented below. While each category does not necessarily constitute a full list, they do represent environmental parameters that can be applied in curriculum development for the study of transportation.

1. Social:
   - Human values and desires.
   - Enhancement of social, recreational, educational, cultural programs and facilities.
   - Health, well-being and safety of the people.
   - Service for handicapped and elderly.
2. Economic:
   - Transportation costs (capital & operating).
   - Access to employment opportunities.
   - Private, personalized and public transport.
   - Freight shipments by modes.
   - Efficiency.
3. Physical & Functional:
   - Effect on land use.
   - Design of vehicles and structures.
   - Convenience and comfort.
   - Adaptable to intermode operation.
   - Adaptable to future needs.
   - Flexibility.
4. Aesthetic:
   - General appearance in relationship to the surrounding environment.
   - Conservation of natural resources.
5. Interrelated:
   - Level of noise.
   - Air and/or water pollution characteristics.
   - Neighborhood growth and development.
   - Conservation of energy resources.
   - Accessibility.

The overall intention with the above environmental parameters is not to suggest a complete curriculum for the study of transportation technology. Rather, the intention is to illuminate the important problems and issues that should become an important part of the educational program. When you consider the impact transportation has on our everyday lives, it is necessary to know about and understand the technological environment and the reciprocal relationships among the human, social, technical and natural environments. The approach suggests a curriculum with a societal context at the core, with technical knowledge as a necessary component for understanding the total socio-technological system of transportation.

The study of transportation technology in industrial arts education should focus on the sum of humankind's technological endeavors in this area. The course of study should include an analysis of the transportation system, its major components, their characteristics, and how the system functions as a whole within each of the four major environmental mediums (terrestrial, marine, atmospheric and space). In addition, the study should cover the relationship between the transportation system and its environment, one of satisfying the human need for transport and also of producing various environmental impacts and consuming valuable resources. These characteristics of transportation systems and their environments provide the essential basis for the analysis of the various types of transportation problems.

The challenge for industrial arts educators is to carefully select relevant up-to-date technological-societal issues related to transportation and through proper learning activities to prepare young people for joining a society as capable and efficient "decision-makers" for social action. This action will enable us to make use of transportation technology and control it for the benefit of humankind in the future.

SUGGESTED LEARNING ACTIVITIES

Concept	*Strategy*
1. *Transportation Dilemma:* (Problems of transportation in terms of sociological, resources and environmental implications.)	Research basic problems of congestion, land usage, pollution, energy consumption and accidents.
2. *Transportation Environmental Mediums and Modes:* (Four environmental mediums and their modes through which vehicles may move.)	Identify advantages and disadvantages related to terrestrial, marine, atmospheric and space mediums.
3. *Technical Systems:* (Functional technical systems employed in all forms of vehicular modes of transportation.)	Define and give examples for of the six major technical systems used in the various transportation modes: 1. Propulsion 2. Guidance 3. Control 4. Suspension 5. Structures 6. Support

4. *Propulsion System:* (The process of causing a body to move by exerting a natural or mechanical force.)	A. Measure and observe the static thrust of a model solid fuel rocket engine with a Static Rocket Test Unit. B. Analyze model pulse jet performance through conducting experiments on a pulse jet test unit. C. Conduct experiments to measure small 2/4 cycle heat engine performance using various types of fuel on an electric dynamometer/ generator. D. Observe and analyze linear induction electric motor propulsion with the use of an electric powered curtain rod unit. E. Observe and analyze the operation of an external combustion converter with the use of a model steam engine. F. Conduct experiments to illustrate fluid, mechanical, and electrical form of power transmission.
5. *Guidance System:* (Information required to control a vehicle or vehicular system to operate in a prescribed path.)	A. Fabricate various types of pathway guidance systems used in terrestrial, marine and atmospheric modes of transportation. B. Visit a local airport and railroad station to view guidance systems employed.
6. *Control System:* (The mechanical or automated procedures used to control a vehicle and/or vehicular system.)	A. Study, analyze, and discuss the various manual and automated control systems employed to direct a vehicle on a path. B. Study the control of the movement of vehicles and the associated technical systems used to facilitate traffic flow.

7. *Suspension System:* (Methods employed to suspend a vehicle in or on a given environmental medium.)

A. Study and analyze the mechanical, fluid and magnetic suspension systems employed in vehicular suspension.
B. Fabricate a wind tunnel to test and observe student constructed aerodynamically designed vehicles and components. The wind tunnel should be a tunnel-like chamber through which air can be forced at controlled velocities to study the airflow measured by a monometer at various points to illustrate Bernoulli's principle.
C. Fabricate a vehicle path using magnets to suspend a vehicle along a pathway magnetically.
D. Construct a pathway with air injection to illustrate air suspended vehicles.

8. *Structural System:* (The structural makeup and design of vehicles and other systems physical components.)

A. Test vehicular construction materials to study the buoyancy characteristics for a variety of materials.
B. Study, design, and construct various types of bridges and test for bearing loads.
C. Construct a tube structure and vehicle to test gravitational and vacuum means of propulsion.
D. Construct a hovercraft whereby the structure is air suspended by a fan attached to the shaft of small engine and enclosed in a skirted shroud.
E. Fabricate model aircraft and space vehicles using appropriate design, materials and control features.

9. *Support System:* (Categories related to operations, economic and maintenance support of transportation.)	A. Study and discuss the total transportation operation, economic, maintenance support systems of transportation.

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Chapter 10

Recreation and Leisure: A Letter to a Young Industrial Arts Teacher

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Dear George:

It was good to see you again at the convention and to learn about your experiments with hobby activities in your classes. I was intrigued by your comment that there must be more to industrial arts than there is when it is dominated by career or vocational education. I said to myself, "Now, there's a sign of maturity in a young teacher. He's thinking bigger than he was taught in college." The more I have thought about your conviction, and I know you are dead serious, the more I feel like sharing some ideas with you along with some highlights among my findings about industrial arts and recreation.

You know, George, your concern about the richness, or the lack of it in industrial arts reminded me of when I first dared to challenge the status quo. I said and felt exactly as you did last week. I, too, was attending a national convention in which industrial arts was a seemingly minor part and had been invited to speak at a section meeting of industrial arts teachers on the subject of recreation and industrial arts, or perhaps it was industrial arts and recreation. My introduction to the group by the program chairman included the statement: "There is no place for recreation in industrial arts. When kids come to industrial arts they come to work, not play." It didn't take long to find out that he wasn't kidding, wasn't trying to bait me, or to be facetious. Immediately I began to wonder why I had been invited to speak, but as nonchalantly as possible I did, knowing that I was cast in the role of that fellow I had heard about in my high school Latin – persona non grata.

The chairman was apparently equating recreation with play and in so doing revealing his ignorance, so I kept comforting myself. Surely he must have known that even work can have recreational value for some people, if not for him. Having recalled this event many times, I know that the substance of my lecture did not change his thinking even though I thought I had an excellent rebuttal. Anyway, in my experiments in industrial arts emphasizing leisure time activities, I had found a richness and a vitality not seen in the traditional program.

The encounter whetted my intentions to establish a sound rationale for recreation through industrial arts. Since then, I have explored widely among the literature of the professional recreationists, consulted with many, pursued recreation as a field of graduate study and experimented for some four decades. With apologies to our program chairman, I found such effort to be great fun and unusually inspiring rather than work and am today still certain that there is more good in industrial arts than the profession as a whole sees.

While the chairman may have triggered me into greater action, I had already discovered that industrial arts teaching was great fun. This was as good a way to describe my feeling as I needed, although I knew I was being paid to work, not to play. I found, too, that my kids seemed to have as much fun as I and that many of them took their industrial arts interests home where they had additional time to work on them. I have wished often that I had kept count of the numbers of parents who expressed to me their appreciations for what I did to and for their children in industrial arts. There was, for instance, the father of two boys who came to me one noon to tell me how grateful he and his wife were and that I should let his boys have all the materials they needed, no matter the cost. He asked, "Do you know what we talk about at the dinner table any more? It's always about their industrial arts projects."

There was the Latin teacher who set me to thinking, too. She wondered what I did to my students that they had time at home for industrial arts, but not for Latin, even though they were the same kids. I later learned that she attempted her own solution as she introduced construction projects in her class. I know I was fortunate to be able to see beyond the economic, the vocational values in industrial arts during my school teaching years. I found so much satisfaction in this, and then at the university level too, as to have had two score years of pleasure, fun, and recreation with pay – that's hard to beat.

Our chairman's attitude about recreation probably reflected his professional up-bringing. He may have been taught as a student that to be effective and acceptable, learning had to be disciplinary and that teaching was to enforce this. Fun came at recess and the classroom was for work. Some of my undergraduate teacher education courses reflected this. I recall a class in industrial arts design, a subject I had looked forward to eagerly. The emphasis, however, was on memorization of the some 150 rules for design taken from that classic text, *Industrial Arts Design* by Varnum. By the way, George, you'd enjoy browsing through this. The final exam required that we return the rules to the professor in their proper categories and wordage. Somehow this emphasis stood in the way of my learning how to design in that course, and this was a disappointment, but I did feel for the professor having to read and correct twenty sets of rules; it was bad enough having to write them. The professor, no doubt, agreed with the educators of his time that learning must be disciplinary to be effective.

During this time in the evolution of educational thinking, a voice could be heard challenging the disciplinary concept of education and replacing it with a counter principle that learning must be pleasurable to be most effective. This was the voice of John Dewey daring to question the status quo and demonstrating an enlightened concept of education which since then has moved children to learn and to delight in it as well as teachers to teach with inspiration and imagination. Dewey claimed that learning should be a pleasurable experience, an idea so revolutionary that it still rocks the educational boat. I mention this, George, because I know you didn't get much exposure to Dewey's *Democracy and Education* in your undergraduate study. I hope you will read it because in my opinion, at least, it is the best guide to enriching American education in the past century. You will discover that Dewey insisted that education should have recreational values to be effective. I'll follow up on this a bit later.

In my searchings for support of a recreation function in industrial arts, it was necessary to go beyond our own literature. Here I found a number of early references, some of which were pre-World War I and contemporary with Dewey's *School and Society* as well as his *Democracy and Education.* I prized the statement by Richard Cabot, for example, "... We have ceased to think of play chiefly as indulgence, as a loosening of bonds, or even as pleasure. We have begun to admire it not only as recreation, but as re-creation." (Cabot, p. 100). This notion of recreation as re-creation became the core of the philosophical position of the profession of recreation, and it remains so. In essence, it held that in fully functioning recreation, the individual experiences a revitalization, a re-birth, a re-creation of self. You and I know of many instances in which persons, bored and tired with their work, come alive with excitment and enthusiasm in their hobbies and seemingly become new, different people.

Then Jay B. Nash (Nash, p. 89), one of the very first philosophers in the field of recreation, described recreation as having several levels of productivity. The highest level was that of the creative experience and the lowest, that of merely killing time. There were also, as he saw it, low levels in the use of leisure time. These were considered both anti-social and anti-personal in effect and included delinquency, vandalism, crime, and such.

A contemporary leader in the recreation profession, Charles Brightbill, offered that recreation be "a channel for free-time opportunities which lead to socially acceptable, productive pursuits for self-discovery and self-expression — the net results of which are personality growth and development . . ." (Brightbill, p. 314).

In the field of education, it was John Dewey, so far as I could determine, who first challenged the education profession to examine the relationships of work and play. He did this in 1916 in his *Democracy and Education* which now you might well reread for the ideas you missed the first time. In it, you will note:

> . . . Education has no more serious responsibility than making adequate provision for enjoyment of recreative leisure; not only for the sake of immediate health, but still for the sake of its lasting effect upon the habits of mind . . ." (Dewey, p. 241)

No doubt this challenge stirred educational leadership of the day because we find that three years later the National Education Association offered its *Seven Cardinal Principles of Education,* one of which was the "worthy use of leisure time."

Well, George, the preceding references, while but a very few of those consulted, served to spur my search into literature of industrial arts. I recall an interesting experience of paging through every issue of the professional journals which either included industrial arts or had had some relation to it, such as those in manual arts, manual training, and industrial education from 1900 to 1934. To my surprise, I found not a single reference to industrial arts and recreation. Even though recreation was being discussed in other fields, apparently it was not in industrial arts. I suspect one may conclude that work emphasis was generally dominant in industrial arts during this period. And, too, there was very little of this activity labeled industrial arts before World War I.

It was not until the Thirties that industrial arts leadership seemingly responded to Dewey's challenge and to the idea of the worthy use of leisure time as a part of general education. True, industrial arts did accept from Dewey what it already believed about learning by doing, but it was 1934 before a significant professional statement appeared in our literature in support of recreation, hobbies, and the avocational function of industrial arts. The *Ohio Prospectus,* a joint effort by professionals in the state stands today, in my opinion, as the most significant position on industrial arts to appear up to that time. By the way, George, I recommend this for your reading even though I'm not sure where you could find a copy. I might consider loaning you mine so that you could have it photocopied, providing you swore to its safe return. Among the one hundred pages are such statements as these:

> . . . The American people have never been led to experience the deep satisfactions and lasting pleasures to be derived in avocational interests possible of development in the arts. It is natural for people to want to make things. The rapid spread of home workshops and increasing sale of small

> power machines during the depression testify to the growing popularity of homecrafts, avocational interests or hobbies (Ohio State Committee for Coordination and Development, p. 36).

In a further statement the *Prospectus* concludes that

> The subject of industrial arts, while encompassing all ages and school levels, is included in secondary school areas for such purposes as . . . the development of avocational and vocational interests . . . (Ibid, p. 93).

Incidentally, George, with this state level pronouncement in Ohio, a vast program of exemplary industrial arts centers was developed throughout the state from very small rural schools to large metropolitan centers. It was my good fortune to spend several years in this program.

While you are looking for a copy of the *Prospectus,* look also for the federal publication, *Industrial Arts — Its Interpretation in American Schools.* This bulletin identified industrial arts on all levels for the elementary school through college, university, and adult. It included recommendations in each level for provision of activities appropriate for recreational emphasis and values. Note the following:

> ". . . Through such a program the pupil . . . increases in ability . . . to use effectively his recreational time . . ." (U.S. Department of Interior, Office of Education, Committee on Industrial Arts, p. 1).

Supported by these two documents originating within the profession at nearly the same time and lending both a state and national support, industrial arts was prepared to face the future with a new thrust. However, there had been ongoing friction within the industrial arts profession, probably from its inception, caused by conservative forces which accepted only the vocational, trade, career-type of value and the liberals who insisted that industrial arts must be general education. It was to be general in the sense of a wide selection of subject matter for all levels of instruction. Conservatives and liberals are always with us in every facet of American thinking, so why not in industrial arts. Have you typed yourself yet, George? Sitting on the fence isn't comfortable either. At present, it may appear to you that the conservatives with the carrot of federal monies have won the battle, but since I know of your strong feelings about greater values in industrial arts, I say, hang in there, George. Your group is not beaten, just slowed up. Your time will come; be ready for it.

To get on with this missive, I must add that eventually I bumped into the word "technology," not knowing what I had hit until some time later. But, after working my way through Mumford's *Technics and Civilization,* my horizons for industrial arts extended to a full 360 degrees. The more I studied technology as a concept, the greater became my enthusiasm for, and vision of, industrial arts. A psychology professor in my undergraduate days always addressed us industrial arts majors as the "whittlers." The label may have been more appropriate than we accepted at the time, but when I got into this technology thing, I could honestly and properly change it.

So much for all of this background chatter. Let's put some things together to help you see more clearly the possibility of recreation as a legitimate function of industrial arts. First, let's accept some interpretations of certain key terms we have been using. Let leisure be the time one has free from work or duty, as the time remaining after work, sleep, eating, and such necessities. You might like to calculate the amount of this time on a daily, weekly, or yearly basis. Discretionary time is that time one has when one is free to do what he wishes without the outside pressures. This may or may not be the same as leisure time.

Let's think of recreation as a process of re-creation in which, through appropriate activity, one experiences a type of re-birth through discovery and development of interests, talents, and abilities with their creative use providing enjoyment, pleasure, refreshment, relaxation, diversion, satisfaction, and excitement. The activity may be difficult and trying, but it is captivating. It may require study and practice and involve struggle and defeat at times, but by its very nature and effect on the individual, it calls for renewed effort. Never does it include boredom. In this recreation, one literally becomes a new person, if only during the time he is directly involved; although beyond this, it tends to affect the order of his priorities in living. The recreative experience provides a zest for living, perhaps even some gusto, of a type not available in cans or bottles.

By the term "work," we mean livelihood, earning a living; and play is simply amusing or entertaining oneself. As an aside, these two terms, defined as simply as we can for our use, are not limited in meaning in the dictionary. Take a look.

Since technology has a continuing impact on man and his leisure, let's accept it to mean, in its broad anthropological sense, the material culture, or the sum total of what man knows about and does with materials. This will include tools, machines, processes, products and all such material things, even toys, sports, and hobby gear. Technology includes the world of work and influences its nature.

Before technology, before the creature, man, became a tool maker and tool user, there was little or no leisure. Daylight hours were spent in providing food, clothing, shelter, and security. When the creature learned to use and then to make tools, even the simplest, he gained an advantage. The greater his tool usage, the greater the advantage not only in providing the necessities, but in time, beyond their requirements. Eventually, leisure became a part of living with the arts, sports, games, and such appearing therein. We can say that man, through his technology, has created leisure for himself. In today's consumption of leisure time, we see, too, that technology is involved in producing the materials and equipment used in leisure. There is a leisure industry and a technology of recreation.

I came upon a most interesting concept some years ago; it stated that the purpose of work is leisure. This idea, originating in philosophy, attempting to explain the relationship of man and experience, is expressed in many ways, but essentially it says that man works for leisure and that leisure is the basis of culture. To the practically-minded, this may seem ridiculous because he knows that the purposes of work are many. There is the personal for reasons of self-fulfillment; the economic, or earning the wherewithall to live by; the cultural, with work being the respectable thing in our culture; and numerous others. But, as we take a look at today's American, we see accumulating evidence that he lives for the time after work, for the weekends to get away from his work-a-day work. You will enjoy reading the special section entitled, "How Americans Pursue Happiness," in the May 23, 1977, *U.S. News and World Report*. In fact, I call it to the attention of all teachers of industrial arts, both conservatives and liberals, for a picture of that side of life with which they should be acquainted if they want to make real and meaningful contributions to a finer living for their students.

You remember, I'm sure, that Congress even changed the calendar not so many years ago making several three-day weekends of national holidays. The leisure parade which begins on Thursday or Friday evenings and ends on Sunday or Monday is something to behold, but not to get caught up in. Autos, pick-up trucks, campers, trailers, boats, motorcycles, snowmobiles, and whatever line the highways in both directions as today's Americans search for recreation. Even some churches schedule their services to interfere least with weekend recreation. So, it's easy enough to accept the notion that the purpose of work is leisure. Work provides the money, leisure, the time, and technology, the gear. Work has become the means to a greater end, not so much the end in itself.

Having been rather philosophical by nature about industrial arts and continually in search for greater values in it than the profession in general had seemed to imagine or accept, I came to a conculsion which kept bugging me. What a student does in his discretionary time at home is a good measure of what industrial arts is doing to and for him. It seemed particularly applicable to teenagers. I assumed that if the student used this time for loafing, vandalism, and such the school hadn't equipped him with better interests. If he were turned on by interests developed in industrial arts to the point that he opted to pursue them in his discretionary time, I could conclude that it was getting through to him. Of course, I knew that the school was not the only influence on teenagers. The church, the community, the gang, and the home all affect him, but my concern was for industrial arts as a part of the school. This notion took my industrial arts beyond the classroom and gave another guide for its evaluation. Do you agree?

Let's continue to assume that industrial arts has a contribution to make to the "worthy use of leisure time" and get down to some specifics. There are some of these in my book, *Tecnol-O-Gee* (Olson), in which industrial arts functions as interpreter of technology for the American school. Industrial arts recreation is an activity program involving individual interests and expression with materials for recreational purposes. It requires no course of study, no formal testing, no grading. The student follows his own interests with the medium; the teacher helps him with problems he meets in expressing them. Obviously, this kind of teaching-learning situation would give the old-line conservative teacher the fits, but not you young ones.

As one of the six functions I have established for industrial arts, I see recreational expression as avocational orientation and tryout experience involved in creative design with tools and materials as means to self-fulfillment and realization within discretionary time. With emphasis on the creative imagination as essential in the recreational experience, I am saying that the creative way is the natural way for man with materials. In his creative imagination, man is free to discover himself by himself. I am accepting the place of the creative imagination as the highest level of the human intellect and in industrial arts I assume that each student, at any level, has his own measure of it. Also, it takes creative teaching to draw out the creativity of students.

For the classroom situation, I see industrial arts as carrying out its recreational function in several ways.

1. Any industrial arts subject matter area at any level has within it the potential of suggestion to the student of do-it-yourself, take home, leisure-type activities.
2. Industrial arts has as a regular part of its curriculum at all levels, recreational courses emphasizing self-expression with the creative imagination, but without the deterrents of formalization common to other courses.
3. Industrial arts recreation provides opportunity for actual tryout, development, and promotion of hobby interests within the classroom as respectable, effective, meaningful, and pleasurable learning (with additional apologies to our friend, the program chairman).
4. Industrial arts furnishes assistance to the student in the design and construction of tools, machines, and equipment useful in his recreational activity at home.
5. Industrial arts helps the student set standards of excellence for his materials expression in his recreational activity at school and at

home, as well as standards for related consumership.

6. Industrial arts should promote recreational activity within the community through offerings of instruction as well as in the training of recreational leadership.

At this point, you have an idea of my position on the issue of industrial arts and recreation as a means to fulfilling its educational responsibility and in enriching itself. If you find that it makes good sense, use whatever you wish of it. I'm sure it won't turn you off as it did the program chairman. Perhaps, you will want to pursue the subject further in the attempt to arrive at a position which you feel is your own. If so, here is a good starting point: assume that what one does in his leisure time is fully as significant as what he does in his work time in determining his overall quality of living. You'll find plenty of support for this hypothesis.

If you haven't read the paperback, *Leisure the Basis for Culture,* by Josef Pieper, by all means do. His logic makes good reading for teachers who are reaching for the greater good in industrial arts. Such statements as these stir up the imagination.

> . . . can man develop to the full as a functionary and a "worker" and nothing else; can a full human existence be contained within an exclusively workaday existence . . . (Pieper, p. 36).
>
> and,
>
> Because wholeness is what man strives for, the power to achieve leisure is one of the fundamental powers of the human soul . . . (Ibid, p. 44).

And so, George, what started as a letter has become a rather lengthy discourse probably because I enjoy writing to a young teacher as much as I do talking with him. I hope that your interest in enriching industrial arts keeps on bugging you as it has me through the years. I doubt there is an effective repellent so long as we use our own creative imaginations in the search. I'll be watching for your contributions to the richness of industrial arts in the literature. Meantime,

Best Wishes,

Delmar W. Olson

Delmar W. Olson

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part iii

Additional Problem Areas, Strategies for Implementation and a Parting Perspective

Chapter 11

Additional Problem Areas

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I. AN INTRODUCTION

As individuals, a society and a global community, we are confronted with many complex issues. Some issues, such as housing, pollution, transportation, energy, materials, and recreation, have already been addressed in this publication. The issues discussed impact upon us now and will likely continue to be of concern in the foreseeable future. The issues presented are real, significant, and will draw very little controversy. Other issues, not discussed, may be less obvious, but plague the world in general and have great potential significance for the future. This chapter, "Additional Problem Areas," will attempt to identify issues of importance which have not been discussed by the authors of preceding chapters.

Many of the concerns of the future appear to be social issues with few implications for technology or the study of technology through industrial arts. The objective of this chapter, however, is to identify future problem areas without qualification as to whether or not they are technology related.

The authors dealing with previous chapters worked from a perspective of technology. Readers of this publication expect issues to be technology related. Technology, however, can be described in many ways. If technology is essentially an extension of human potential through the use of tools, machines and systems, then social systems and related issues are clearly justified as a part of this chapter. Furthermore, some will say that all significant social change and related issues are a direct result of technological development.

Until the 1950's, technological development was comparatively slow, and as a result, somewhat predictable. Since the 1950's, the rate of change has increased which makes development extremely difficult to predict. If, at the turn of the last century, someone would have attempted to predict 1980, chances are good that the events of recent years would have caused the prediction to be extremely inaccurate.

The amount of literature addressing future issues and problems is currently limited, but growing. Publications have been written, societies born, courses developed, and international conferences called. Some agreement can be found among individuals writing about future problems. Lists of projected issues and areas in need of additional study vary in length from comparatively few to many. Many people have opinions and biases about future problems. Most, however, concern themselves with crises of today.

The issues identified in this chapter are based on the writer's perceptions and seem accurate for now. Unforeseen circumstances could, of course, alter the direction of the near and distant future. Some of the issues presented may seem obvious to the reader, while other readers might believe the concerns are inaccurate or without adequate foundation. In arriving at these conclusions, other people were consulted and literature was reviewed.

II. SECURITY

Among the areas of concern, both now and in the future for many people, is that of security. Each of us, to some extent, strives to maintain or achieve security for ourselves and those with whom we are closely associated. Security can take many forms. Some concerns include fear of foreign aggressors, domestic crime, unfulfilled desires for someone to care, insufficient food supply, inadequate housing, poor health conditions, lack of self-esteem, diminishing resources, and dwindling energy supplies. Each serves as a threat in some way to someone. The list could continue.

Immediate security concerns vary depending upon the part of the world and type of environment in which people live. People living in countries with great military strength might tend to be less concerned about attack from foreign aggressors and more preoccupied with long-range security problems such as deterioration of the environment. Those living in poverty conditions will likely be concerned about finding health care, food and shelter for daily existence. People residing in cities with high youth unemployment and high levels of drug and alcohol consumption among young people will be worried about street crime. The elderly, living away from family, might rightly or otherwise believe no one cares; and those who have been led to believe they have experienced little success in life, may begin to question their own personal abilities.

Armed conflict is a major threat to individual security and, as a threat, possibly foremost in the minds of many people. This concern can be substantiated by looking at the vast budgets allocated for defense in this country and others. Distrust among people and nations is widespread. Ideological differences exist. Developing nations often have internal strife. The demand for food will continue to increase. Competition for dwindling resources will become more intense. The split will continue to grow between those who exist in poverty and those who live in comparative luxury. And, expectations of the poor will rise as they become aware of world conditions. These and other differences will too often be settled through armed conflict – a primitive, but to some, a viable alternative to existing conditions.

Non-nuclear warfare will be the threat within and between nations in attempts to settle differences when peaceful means fail. However, research in new weapons technology and a proliferation of these weapons will enable sophisticated hardware to be used. Large-scale nuclear war will be unlikely even though nuclear arms are available to more nations than ever. The balance of strength is too even for any nation to deliberately engage another power in nuclear conflict. A nation would not likely initiate a strike knowing it, too, could be destroyed in the process or that selected targets could easily be reached with nuclear warheads. Even though large-scale nuclear warfare purposely initiated is not likely, an inadvertent engagement could result from the complexity of systems, error in human judgment or faulty technology. This also remains unlikely, however, because of backup safety systems designed to minimize the possibility of such occurrences. Only if severely threatened by an interruption in supplies such as food or energy, would anyone consider the use of nuclear arms.

The world continues to figuratively shrink in part because of improved technology. Near-instant worldwide communications are a reality. Rapid transportation is available to more people than ever. As a result, people, in general, are becoming more aware of world conditions. People in developing countries are becoming aware of the differences that exist between and within nations – differences between those who enjoy affluence and those who live in poverty. Others, especially minority groups living in deteriorating city conditions, look at the more affluent suburbs with growing expectations of their own. High youth unemployment and the use of alcohol and drugs compound the problem. If expectations cannot be attained, unrest and violent demonstrations will likely result.

Limited resources of the earth will cause additional problems of security. Oil supplies will be among the most serious. Political and social decisions, in some cases, will be made on the basis of oil dependency. Those who have oil want to keep it and make it available to whom they wish and at prices the market will pay. Those who do not have sufficient oil reserves or alternative supplies, will continue to want the oil and under desperate conditions, consider taking it.

III. EDUCATION

Although most people would agree that education over the years has served the public well, it is presently being reexamined. Questions are being raised about the role of education in society today. Many people have different expectations. Some believe education should serve a utilitarian function – teach students to read, write, and do computations. Others believe education should lead to employment. A few people feel schooling should be a liberalizing experience, and advocate groups feel their causes should be addressed.

Cost is part of the reason for reexamination. As costs increase, questions are raised about productivity – what is the public getting for its money. Most people have experienced at least some schooling. As a result, most people feel justified in expressing an opinion on the subject.

Attitudes among young people are changing toward school. Some find it difficult to become interested. Lack of discipline is a growing problem. During recent years, the United States has experienced an increase in divorce. Traditionally, the products of broken homes have been expected to display undesirable behavior. If this trend is true, society can expect increased delinquency which will continue to find its way into the school.

According to a recent study, many adults do not possess the basic skills to function well in today's society – a society which is becoming even more complex. These skills include the ability to read, write, and do computations necessary for daily living. Another study shows that many people possess less than adequate communication skills and also display other inadequate behaviors. Those who lack communication skills are likely to be withdrawn, undependable, unknowing of health and safety, and unable to function as contributing members of society.

Teaching is an extremely interesting, but difficult, responsibility. Parents are raising questions about what and how teachers teach. Taxpayers are asking for accountability. Budgets are more limited, thus causing less equipment and supplies to be available. As social structure, expectations and technology change, course content is constantly in need of updating. Student attitudes toward education are changing, causing new human problems. In addition, teaching salaries are comparatively low which makes jobs in business and industry more attractive to capable teacher candidates. If the trend continues, we can look forward to a decline in the quality of teaching professionals in the future – a trend we can hardly afford.

Some projections show that between 50 and 75 percent of teachers now teaching will leave the field in 5 to 6 years. If this happens, and fewer young people enter teacher preparation programs because of the increasingly difficult task of teaching and low pay, teaching positions will go unfilled in spite of declining enrollments. Vacancies will occur in many fields, not only those which already experience shortages. In addition to the problem of shortage, the quality of future teacher candidates will diminish. This will occur, in part, because universities in general will be serving more students with a greater range of abilities resulting in lower standards which will serve to prepare less-qualified people in many fields. Also, students experiencing difficulties in more rigorous fields may enter programs of teacher preparation.

Control of education is, to a large extent, no longer in the hands of educators. Some believe this is good, while educators believe otherwise. State legislatures and the United States Congress pass legislation which imposes standards and requirements on local education agencies. Negotiated contracts consume large portions of budgets which leaves fewer dollars to be spent at the discretion of local boards of education. School superintendents are often expected to respond to community pressure groups.

More higher education will likely take place outside institutions of higher learning. This will occur because of high cost, slow responsiveness to changing conditions and decreasing utility. The cost of education will continue to increase. State legislatures will provide financial support; however, students will be expected to bear much of the increase. Social structure, the nature of work, and technology are continuously changing. If colleges and universities do not respond to this change, other forms of higher education will continue to emerge. And as universities serve more students, degrees will tend to resemble high school diplomas.

In a society that places high value on the use of information, it becomes increasingly important that people have the ability to locate, retrieve and use information effectively. Those who possess the ability to use information will continue to expand the use of technology to increase the use of information. Those who cannot use modern technology to gain information will continue to be at a disadvantage. As someone said recently, the more you have, the more you want and the easier it is to get. The information-rich get richer and the information-poor get poorer.

Although there are tremendous advantages to those who have the ability to locate and use the ever-expanding amount of information available, information systems and their use are not without the potential of technical problems and misuse. Most systems are computer based. The possibility of storing and retrieving vast amounts of information is a reality. The kind of information stored and ultimately used is dependent upon the people who have systems available and know how to use them. Deliberate misuse of information could lead to the loss of privacy. Intentional misuse of electronic funds transfer, as we make our way toward a less cash-dependent society as a system of monetary exchange, is another example of potential misuse.

IV. DISTRIBUTION OF WEALTH

We live in a world of growing population and diminishing resources. The problem is complicated even more by the difficulty of distribution – determining the extent to which resources should be shared and by whom. While population growth is increasing in some developing countries which are already having difficulties supporting the existing population, more developed countries are experiencing stable birth rates. Continued population growth places an increased burden on already scarce resources.

Among the resources already in short supply are fuels, materials, and food. The present energy problem will likely worsen before any improvement might be forthcoming. Some nations are relatively independent and have adequate oil reserves. Other countries, such as those in the Middle East, have far more oil than is needed to fuel their economies and, as a result, are in a position to export large quantities. Countries such as the United States and Japan are large consumers of energy and depend heavily upon foreign oil supplies.

Many materials supplies are not renewable. Some countries possess large deposits in raw form while other nations are completely dependent upon foreign supplies for some materials. The developed countries are by far the largest consumers of materials for use in construction and manufacturing. Although supplies of materials will not be exhausted in the near future, they will be more difficult to extract, not as readily available, and priced higher.

The availability of food is a major problem for people in many developing nations. Often times, the population is high and food production is low. These countries are dependent upon foreign sources for food. The need for imported food is not only limited, however, to developing countries; some developed countries also find themselves in a position of importing various forms of food products.

Much of the problem of shortage is caused by the fact that only limited supplies of fuels, materials, and food exist. Part of the problem, however, lies in the inability of our world society to determine how resources should be allocated.

Oil is presently more readily available in large quantities in some countries than in others. Some have it, others would like to have it. The issue in the near future is that of distribution. In the long run, when resources are exhausted, it really won't matter. The issue of distribution, however, is extremely complex. Monopolistic pressures exist. Nations are aligned politically making exchange very difficult. High prices are popular because of high demand and world dependence on energy. Balance of trade is difficult to maintain. Long interruptions in supplies could cause a major worldwide slowdown in economic growth which could affect everyone either directly or indirectly. Much of the same situation exists for the distribution of materials as does for energy. The predicament is not as critical, however, and probably won't reach the proportions of the energy crisis.

Many of the issues just discussed are of large magnitude and are extremely complex. None can be resolved easily; all are interdependent. In addition to the megaproblems that exist, many additional problems with somewhat different dimensions are of concern in the world today.

V. OTHER INTERRELATED SOCIETAL PROBLEMS

Within this chapter, some societal problem areas were identified and discussed. Other areas were mentioned, but not elaborated upon. And still other problems of the future were not mentioned. Some of these additional problem areas include:

- the effects on unemployment by exporting technology rather than manufactured products;
- providing low-cost housing for everyone;
- the deterioration of the family unit and the effects on individuals and society;
- maintaining an adequate water supply;
- developing a responsible and innovative work force;
- controlling ecological deterioration;
- the effects of changing weather conditions and food production;
- controlling worldwide population growth;
- determining what is best for most without losing individuality;
- maintaining continued improvement in the world condition while controlling the effects of inflation.

Many will agree that the issues addressed in this book and in this chapter are real and in need of resolution. It will take both time and effort by everyone to deal with the many challenges that face society. Unless, however, we learn to live together as a world society rather than to continue to engage in conflict in one form or another; food, education, energy, materials and the like will be of little consequence.

We live in a world of interdependence. In no way can a nation completely isolate itself. Although some nations strive for independence, world dependence, in one form or another, is inevitable. If the world, or parts of it, are in chaos for whatever reason, everyone will be affected. The world economy is based upon the exchange of resources that are plentiful to some and in demand by others. Food, petroleum, metals and technology are resources that are in demand by nearly everyone. We have but one environment in which we all must live. Regardless of who contributes to its deterioration, we are all affected. As a result, it is impossible to claim total independence from the world community.

As we strive to resolve problem areas of the future, it is nearly impossible to isolate any single problem to deal with separately from other issues. The total situation is extremely complex and interdependent. As any one problem is treated, others are affected and new ones arise. Although it is difficult, it is necessary to examine all issues at one time.

No single solution is known that will resolve the massive issues facing society; however, it does appear that two ingredients are essential. It will be necessary for the people of the world to develop a desire to communicate and an ability to do so. And, it will be necessary to improve systems of education to make people knowledgeable about issues so they can make intelligent judgments. These suggestions may seem simplistic, vague and maybe, idealistic. For too long, we have confronted problems on a day-to-day basis. We have used desperate brushfire, stop-gap tactics. It is now time to take a long-range, future-oriented look at problems and solutions.

Fortunately, some progress is being made. People of the world are beginning to realize the importance of communication to resolve differences and to solve common problems. The United Nations was established to facilitate dialogue. Individual nations are serving as third-party arbitrators during times of conflict. And, direct, extensive negotiations between nations are becoming more common. This is an encouraging start, but much remains to be done.

Existing communications technology is being improved and future developments hold tremendous potential. Vast amounts of dialogue will be able to take place by way of satellites, laser light and optical fiber. One day, any one individual may be able to communicate with another individual any place at any time. The technology will exist. The importance of communications, however, needs to be realized by more people.

Improved communications alone will not solve our problems. A partial solution to world problems lies with education. We must communicate intelligently. Through education, we must learn about one another, common issues, the use of communications technology, and possibly develop a neutral, universal language.

It is nearly impossible to predict revolutionary advances in technology which will shape the future. As a result, it is difficult to anticipate the challenges with which we will be confronted. If the challenges cannot be determined, how can students be prepared to deal with such uncertainty? If the partial solution to world problems lies with education, do we have an education process that will equip young people to handle uncertainty? Many agree we do not.

Much of education has been changing directions at the ever-changing wishes of the general public. Trends, social issues and advocacy groups have all helped to determine the role of education. The Sputnik era of the 1950's emphasized science and mathematics, not so much for the purposes of developing a more literate society, but to meet a threat to national security. Youth unemployment in the 60's caused an emphasis to be placed on education for the development of employability skills. The so-called back-to-basics movement asked for more emphasis on reading, writing and arithmetic; and cut-the-budget advocates have caused a slowdown in the growth and improvement of education at all levels.

These and other emphases have emerged in response to some form of pressure and have served as an attempt to confront perceived societal problem areas. If, however, we are to address the big issues facing society, it will be necessary to develop a long-range plan for the future of education, interpret the plan with accuracy, establish priorities and commit resources accordingly. Any plan that is developed must call for the development of better understanding among people and a technologically literate society. Both emphases have implications for industrial arts.

Most people do not consider industrial arts to be a subject area capable of contributing to the development of human skills or a technological literacy. They see it more as a place to develop manipulative trade skills useful in employment. This is evident when topics for study are discussed such as environment, energy, technology, metrics, economics, productivity and automation. Usually, social studies and science are the subjects considered to be able to deal with topics such as these.

Although it is yet to be defined and analyzed completely for study, technology seems to be the most logical source of content for industrial arts. Many definitions and several structures of content are available to the profession. According to at least several definitions, systems are included along with tools and machines. This enables enterprise to be studied as a legitimate part of technology. Additional categories of technology include transportation, communications, and materials. Technology should be the primary source of content for industrial arts, but not the only source. To be meaningful, technology must be taught as it affects people; therefore, it is essential that society be considered as technology is taught.

This proposal is not original or unique. Many general educators have made similar suggestions for other subjects. Some people in industrial arts have made proposals like this before. Although the proposal is not new, it does seem to have promise. No other way seems reasonable. Continuing as we are will not enable industrial arts to contribute to the intellectual development of present and future generations. In fact, as industrial arts continues to resemble trade and industrial education and issues related to economics, environment, productivity, energy and technology in general are considered by most people to be a part of science and social studies, industrial arts may not survive. We must ask ourselves, are students attracted to what we teach or to the smoke, sparks and chips created in a typical shop?

IN CONCLUSION

Presently the situation is this: we are confronted with serious problems in the world in general. Many are obvious and some are subtle. Because the problems are complex and interdependent, they must all be considered at the same time. Although many of our problems appear to be social, they are closely related to technology. Yet, many people are not prepared to understand technology. Furthermore, our schools are not preparing students who will be able to understand and direct technology in the future.

Industrial arts could make a contribution to resolving some future problems by helping students to be more technologically literate. If this is going to happen, changes must be made in what is taught and how it is taught. To expect change to take place in the field is unrealistic. First, it would be necessary to make teachers aware that change is needed, and secondly, it would be necessary to provide a great deal of assistance to help teachers change curriculum and methods of instruction. Sufficient in-service time and money is simply not available to make a significant impact.

For the most part, teachers are being prepared in much the same way as they have been for many years. It seems that change must occur at the colleges and universities that prepare teachers of industrial arts if any improvement can be expected. Some will, of course, point to the shortage of industrial arts teachers and successful placement percentages and argue that change is not warranted. Change is in order if schools are to be representative of present society and a change-oriented future. The teacher shortage comes, in part, from the fact that many teachers are attracted to better paying jobs in business and industry and that fewer students are enrolling in teacher education programs because of the difficulty of the job and low pay.

Colleges and universities have been faced with the challenge of providing leadership in education and supplying teachers to meet the demands of elementary and secondary schools. It has been difficult to do both. If teachers are prepared to meet job requests; i.e., woods teachers or metals teachers, we perpetuate the existing situation. Yet, if we try to provide leadership and prepare teachers for less traditional areas of teaching, we run the risk of not satisfying job requests.

The writer suggests that now may be the time to make rather radical changes in teacher preparation. A shortage of teachers exists, enrollments are still stable and most importantly, the people of the future must be prepared differently to cope with problems and to give direction to their technology. We no longer face the dilemma we once had of providing leadership and satisfying job requests. Teachers are in demand and if we assume some responsibility for educational improvement by preparing teachers with future-oriented capabilities, our graduates will be placed. Everyone will profit as a result.

Chapter 12

Getting There From Here: Strategies for Implementation

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If implemented, the ideas in this yearbook would change school practices considerably. Will these ideas ever reach the schools? Probably not, if normal processes for educational change occur. Good ideas in education creep slowly, if at all, into practice. As an aid to those who prefer planned, systematic introduction of the ideas presented in this yearbook into school practice over haphazard, chaotic processes, we describe in this chapter a number of impediments to educational change along with suggestions for a number of strategies that could be used to overcome these impediments.

WHY IDEAS IN THIS YEARBOOK MAY NEVER AFFECT SCHOOL PRACTICE

According to Ross (1958), the average American school lags 25 years behind the best practice. There is no reason to doubt that this lag time has changed since Ross observed it. Moreover, change in education rarely seems to occur in a systematic manner. Cawelti (1967) noted that "the haphazard way changes are introduced in schools leads to highly uneven effects across the country." Sometimes an innovator with charisma can convince a school board to adopt something only because it is new. Many times school boards adopt innovations with no more reason than that other schools in the area are using it and are receiving plenty of favorable publicity (who ever really knew what "career education" was?). In some cases, slick publicity sells an educational idea without any substance behind the glossy flyer, the complimentary journal article, or the endorsement distributed to help sell it. And, oh, the wonder of hardware. Bulbs . . . cords . . . computers . . . the things that can stir the "progressive" school administrator's imagination in budget allocation.

The lack of rational change in education constitutes an important problem, one for which there is a wide variety of explanations. A large part of the problem may be that educators cannot consistently agree on what is "best," even in particular, well-specified situations, and this makes progress difficult. As Brickell (1964) noted, "Virtually none of the present predominant practices, e.g., length of day, nature of curriculum, training patterns of teachers have any foundation in research finding." Another reason appears to be the virtual absence of systematic communication of educational innovations from producer to consumer.

Hood (1973) asserted that there is little or nothing in the way of theory to guide innovators interested in communicating good ideas:

> Currently, the situation with respect to both research and development on R & D . . . is a "messy" one . . . this particular R & D area still lacks a significant, organizing conceptual base. The relevant validated knowledge base is insufficient to guide responsible policy making for wise investment in major programs for R & D communication. There is a dearth of applied experimental research.

Wolf (1973) characterized the educational communications network as a rather disorganized hodgepodge of workshops, training sessions, journals, consultants, and the like which is almost totally ineffective in bringing about any systematic educational change. This ineffectiveness he attributed to the following reasons:

> The field lacks enough reliable knowledge producers; interpreters (of this knowledge) usually prove to be graduate students who have other competing concerns; market strategies seldom are seriously cogitated; and information storage and retrieval is in a primitive state. No well-defined and respected communication channel exists to effectively diffuse innovations to appropriate target audiences. A cadre of diffusion agents functioning at the grass roots level is absent. And, practitioners are accustomed to adopting innovations without clear-cut comprehension of their implementation. These statements, taken together, account for the chaotic state of innovation, diffusion, and utilization. (p. 24)

Case studies by Richland (1965), Wolf and Fiorino (1969), Leary (1970), and Crawford, Kratochvil, and Wright (1972) describe disorganized and ineffective channels available to communicate educational innovations to potential users. There have been few improvements in these channels since these studies were completed.

There seems little doubt that educators have had difficulty in translating theory into practice. Certainly this is true for industrial arts educators. Even the most pedestrian observer could see the disparity between emerging philosophies concerning the role for industrial arts in technology education and the "pound and shine" methods of what must be a sizable number of industrial arts programs at elementary, secondary, and teacher education levels across the nation. Assuming that the innovations discussed in this yearbook are acceptable to the profession – and they should be sifted through tight philosophic, economic, practical, and evaluative screens – the next section of this chapter contains suggestions for implementing these ideas, for "getting there from here." These suggestions have been scrutinized at a number of professional meetings (Passmore & Welsh, 1979; Welsh & Passmore, 1978a, 1978b) and were field tested with the diffusion of teaching improvement strategies developed by the Clinic to Improve University Teaching at the University of Massachusetts/Amherst (Welsh, 1977).

OVERCOMING IMPEDIMENTS

Industrial arts educators are not the only ones who have difficulty moving theory and innovation into common practice. Consider problems faced by a firm in encouraging consumers to purchase a new deodorant soap, by a pharmaceutical company in convincing physicians to prescribe a new drug, by agricultural extension agents in persuading farmers to try a hybrid corn, or by the World Health Organization in improving the understanding of health principles by peasants in countries less developed than the United States. These problems differ in specifics, but not in concept. At its root, each problem deals with the reluctance of people to try things in conflict with their established ideology, contrary to their experience, or perceived as loaded with risk and uncertainty almost rivaling the consumption of forest mushrooms. To be sure, reluctance to change often persists even though the developers of the innovation, experts, and authorities have strong evidence that the innovation will benefit the potential adopters in some way. What can be done?

One way to deal with reluctance to change is to dismiss it as due to ignorance on the part of the potential adopters. For instance, the potential soap users do not know how well they will smell if they shower with the new deodorant soap. The physicians are too busy to investigate new drug prescription possibilities. The farmers are too skeptical to try anything developed by scientists without field experience. The peasant could never understand the germ theory of disease. In similar ways, the lack of change in industrial arts education is attributed frequently to the lack of interest of teachers in maintaining technical awareness or competence.

But, perhaps this reluctance to change is a problem requiring leadership for resolution rather than a simple attribution of ignorance to field workers. A fruitful avenue for confronting reluctance to change lies in the *management* of change. Crucial to the development of this leadership capability is an understanding of the factors influencing change. Fortunately, research on these factors has been conducted in a number of disciplines: education, anthropology, marketing, and sociology (especially rural sociology) among others. Most of these studies have focused on a few (often just one) of the variables associated with change (e.g., the attributes of an innovation, the characteristics of the innovation's earliest adopters, etc.). Attempts at integration of this body of research are few, and these attempts have differed considerably in their focus.

Rogers and Shoemaker (1971) reviewed an enormous number of empirical and non-empirical studies and presented a series of generalizations about the process of change that have varying degrees of support in research literature. Havelock (1969) suggested that the development and utilization of innovations can be seen as essentially answering the question: *who* says *what* to *whom* by *what channel* to *what effect* for *what purpose*? The Innovative Process Model, proposed by Berman (1975), suggested that the characteristics of the agency adopting the innovation are of paramount importance. Clark and Guba (1965) proposed the Research, Development, Dissemination, and Adoption model, which suggested that agencies devoted to these four processes function as a linear system. The same authors (1974) subsequently disclaimed this point of view, substituting that the educational communication network is a highly decentralized group of co-equal but basically independent members whose goals are often in conflict with one another, and who usually view knowledge production and utilization functions as being of secondary importance.

Other models worthy of mention are the Social Interaction Model, the Problem-Solving Model (both described in Havelock, 1969), the Planned Change Model, the Action Model (both described in Sashkin, *et al.,* 1973), and the Problem-Solving Dialogue or Linkage Model (Havelock & Linwood, 1973). In addition, many researchers in the field of marketing have built strategies that are essentially focused on inducing systematic change.

Discussed below are strategies that have general support in the research literature on the diffusion of innovations, a literature that, as mentioned previously, covers many disciplines. These strategies could assist leaders in industrial arts to encourage the adoption of the innovations described in the various chapters of this yearbook. The categorization of strategies that follows draws on the work of Zaltman, Duncan, and Holbek (1973), Lin and Zaltman (1973), and Zaltman and Duncan

(1977), and the strategies themselves, although based on research, will not be surprising to many who have thought about strategies for change. These strategies have a common sense quality that should aid in their understanding and application.

Relative Advantage

The unique benefits of the ideas presented in this yearbook need to be described to those who may consider their implementation. One of these benefits might be the lower cost of these innovations compared to more traditional deliveries of industrial arts.

As indicated by Mort (1964) in a review of selected innovations in education, innovations that increase costs are diffused more slowly than those that do not. This rate of diffusion is probably due to the greater risks higher costs impose for the adopter. Additional support for the importance of keeping the costs of innovations low in comparison to their alternatives is provided from studies by Griliches (1957, 1960) and Mansfield (1968).

Using aggregate data from U.S. crop reporting districts as well as States, Griliches (1957) explained about 60 percent of the variation in rate of adoption of hybrid corn on the basis of profitability. Mansfield (1968) found that industrial innovations that are diffused faster than others are those with profit history and with low initial investment required.

Perhaps as important as low direct costs in portraying the relative advantage of innovations described in this yearbook are such non-pecuniary items as capacity to lessen conflict of industrial arts programs in the schools with perceived societal needs for technological literacy, to encourage achievement in complementary areas of study such as in the sciences, mathematics, and social studies, and so forth. These and other non-pecuniary benefits should be defined, verified, and entered into any cost/benefit calculus assembled for potential adopters.

The importance of a strong promotional effort in describing the potential advantages of the innovations presented in this yearbook cannot be overemphasized.

Among other research supporting the need for this effort are conceptual analyses by Rogers (1971) and Beal, Rogers, and Bohlen (1957) of the process of diffusion along with work by Coleman, Katz, and Menzel (1966) on the spread of medical innovations. As a supporting case, witness the rapid spread of driver education programs described by Ross (1952). Whereas 15 years were determined by Ross to be required for an innovation to be adopted by three percent of the public schools in the U.S., driver training was adopted by 87 percent of U.S. schools in 15 years. Why? Strong promotion by change agents, car dealers, AAA and insurance companies emphasized the importance of driver training as did the national attention on high teenage accident rates.

A major assumption behind the strategy of presenting the relative advantages of the ideas in this yearbook to potential adopters is that these innovations will meet needs felt by the adopters. The validity of this assumption is a factor in the success of many types of innovations, from improvements in health care (Saunders & Samora, 1955) to departures from traditional agricultural practice (Dobyns, 1955). Clearly, preservice and inservice industrial arts teacher preparation programs as well as graduate programs preparing master teachers and teacher educators must bear responsibility for making this need felt. The leadership role of universities and state departments of education will be highlighted in moving the ideas contained in this yearbook into practice.

Compatibility

There is evidence from studies of innovations in other fields that suggests that ideas presented in this yearbook have a greater likelihood of being adopted if they are compatible with existing values, experiences and the scheme of social relations binding industrial arts educators. For instance, Rogers and Shoemaker (1971) reported attempts by change agents to improve Bolivian indians' potato diet by the introduction of llama milk. This attempt failed because, among indians in the Bolivian Andes Mountains, llama milk is perceived as a type of animal excrement similar to urine. Similar problems were cited by Suttles (1951) in a study of the introduction of the potato among the Coast Salish. And, Mead (1955) recorded interesting anecdotes showing the relationship of cultural patterns and experiences to skepticism about the value of technological change.

Although compatibility with predominant industrial arts ideology will increase the likelihood of adoptions of innovations contained in this yearbook, this relationship is a bit of a paradox because any idea new to a group is likely to be incompatible in some way – otherwise the idea would not rank as an innovation, would it? Therefore, resolution of incompatibilities probably will be required and must be managed carefully.

Management of these incompatibilities promises to be difficult, especially in the promotion of philosophical principles undergirding the innovations described in this yearbook, if past heated disputations are any guide. Moreover, even if commitment is received from policymakers and teacher educators to the philosophy, content and methods suggested in this yearbook, these innovations may never pass through the sanitary cordon of tradition erected around many public school industrial arts programs.

Contrary to most conceptions of change, Nisbet (1969, pp. 270-304) asserted that a faithful interpretation of empirical history would summarize the process of change as neither normal, ubiquitous nor constant. Accepting these characterizations of change, then, consider the day-to-day changes that would be required in many industrial arts programs if the ideas in this yearbook were to be implemented. Who knows? Would walls need to be torn down? Would tried and trusty machines never need to be used? Would plastic carving, small engine repair, and grandfather clock building no longer be considered important by curriculum coordinators even though strong student demand for these activities remained? Would an additional fresh, young teacher with skills appropriate for the delivery of these new programs need to be hired? Would the shop need to be re-keyed?

The innovations described in this yearbook may threaten existing social relationships in the schools to an extent adopters at the grass roots level may fight vigorously to bar their implementation. A number of techniques are available to combat opposition to change: facilitation, persuasion and use of power.

Adoption can be *facilitated,* that is, made easier to implement, through use of support services such as training, funds or released time. Sasaki (1956), reporting about a Navajo irrigation project, and Miles (1964), describing the diffusion practices of several national curriculum projects, provided examples of facilitative techniques. These techniques, however, require groups committed to change. For instance, dispensing contraceptives free of charge to Hindus will not necessarily guarantee that these devices will be used as intended.

A technique that capitalizes on the irrationality of most change in education is the use of *persuasive* techniques. Does the sizzle sell the steak? Maybe not by itself, but it helps. Examples of persuasive techniques include use of attention toward secondary characteristics of the innovation, endorsements by prominent figures in the field or Madison Avenue ploys to focus attention on the innovation. Kasulis (1975) demonstrated that openness to change is measurable and that persuasive techniques are more effective with teachers who are less open to change.

An unappealing topic of discussion (though frequently applied) for many, the *use of power* can be a useful way to affect change. Power coerces by manipulation or by threat of manipulation. The power relationship is based on an obligatory relationship between a change agent and the target of change. The strength of the power relationship is a function of the degree of dependency of the target on the agent.

There are numerous examples of the use of power to attain ends. After failure of appeals to social obligation and fear, head restraint and seat belt legislation was passed (Sweetser, 1967; Robertson, 1974).

Zaltman and Duncan (1977, pp. 163-165) described the actions of HEW in threatening to not approve doctors' requests for authority to do bone marrow transplants unless the doctors complied with procedures for informed consent by patients. Changes in regulations for the use of food stamps have been used to improve nutrition behavior of low income groups (Zaltman, 1975). State departments of education could devise power techniques to assure that schools adopt innovations described in this yearbook; but, without requisite resources for making change, schools could become mired in regulation.

Reduction of Risks

The profession needs to observe the innovations described in this yearbook in operation, and needs to have opportunities to try these innovations, even on a small scale. The observability and trialability of innovations are positively related to their rate of adoption by allowing potential adopters to see and try the innovations *in vitro* without actually making a commitment to adopt the innovations.

Rogers and Shoemaker (1971, p. 156) provided an illustration of the need for observability of an innovation in describing the case of weed killers that are sprayed on a field before the weeds emerge from the soil. The rate of adoption of this idea by midwestern farmers was slow in spite of its relative advantage because there were no dead weeds which the farmers could show their neighbors.

Marsh (1964) found that some teachers rejected the experimental PSSC high school physics program because they had no visible proof that the curriculum materials actually worked under regular school conditions. On the other hand, adoption was facilitated by teacher observation of PSSC supplies working in ordinary classrooms. Kivlin and Fliegel (1967) felt that the willingness of some farmers to take what appeared to be greater risks by adopting quickly "may reflect a lesser need to experiment because of greater vicarious experience with the innovations as a result of observing . . . neighbors or other innovators" (p. 87). Polgar (1963, p. 110) and Rogers and Havens (1961) provided additional support for the need for innovations to be observable.

In addition to personal observation of the innovation, potential adopters can observe the innovations in operation by watching from a distance through articles in professional journals and other media. One idea that has been used effectively with many new ideas in industrial arts is the display of innovations at local, regional, state, and national conferences. Whatever the medium of observation, early reports of success of the innovation seem to be important. Erasmus (1952), discussing an innoculation program in Ecuador, observed that a spectacularly successful yaws eradication program more rapidly replaced folk medicine than programs of preventive medicine with theoretical justifications. Of course, the need for rapid description of innovation success poses a dilemma. When can the success of an innovation be known, and is it too late to spread the news after success is known for certain? The effects of yaws innoculation are identifiable, rapid and demonstrable relative to the effects expected from the innovations described in this yearbook and, for that matter, the whole of education.

Sixty-nine percent of the studies reviewed by Rogers and Shoemaker (1971) supported the need to have innovations be trialable. Marsh (1964) found trialability an asset in the diffusion of the PSSC physics program. An important dimension of trialability is the *divisibility* of the innovation. Can potential adopters try a small portion of the innovation? Some of the innovations presented in this yearbook are not divisible, while others are. Professionals preparing these ideas for diffusion could profitably spend their time considering whether there are *parts* of the innovations that can be tried.

ACTION AGENDA

In this chapter, we have tried to detail some of the impediments blocking movement into practice of the innovations in industrial arts described in this yearbook and to outline strategies that could be used to reduce or remove these obstacles to implementation. Major impediments identified can be segmented into two categories – lack of agreement about "best" educational practices and absence of systematic means for communicating new ideas in education. Strategies offered for overcoming the latter impediment included: description of the relative advantage of the innovations; ensuring the compatability of the innovations through facilitative, persuasive, and power techniques; and reduction of risks of adopting the innovations through allowing the innovations to be observed and tried.

Walt Disney's First Law – wishing will make it so – rarely operates for the diffusion of innovations, so there is no reason to expect that the ideas developed in this yearbook will be adopted just because they have appeared in print. Specific plans should be drafted for the diffusion of these ideas as soon as possible (of course, this was the *raison d'etre* for having this chapter accompany the previous chapters). Among the immediate needs for this diffusion effort is an understanding of the *client system,* a term used by Jones (1969, p. 16), that is to be served by these innovations. Who should adopt these ideas? Where are they? What are the most credible lines of communication to these potential adopters?

Particularly important in this diffusion effort will be the identification of innovators and opinion leaders in industrial arts so that initial communications can be focused on them. Innovators can be identified by their record of adoption of similar new ideas, or, if such evidence is not available, by their higher status in the profession (see Carlson, 1965; Rogers, 1958; Madigan, 1962), propensity for using mass media (see Coleman, Katz, Menzel, 1966; Gross & Taves, 1952), or by the size of the school system to which they belong (see Carlson, 1965; Cawelti, 1967). Opinion leaders can be identified by their relatively high status in the profession (Carlson, 1965; Emery & Oeser, 1958), and by a general inclination toward innovativeness (Madigan, 1972; Emery & Oeser, 1958; Carlson, 1965). Contact with opinion leaders and innovators is doubly beneficial if they decide to adopt, as the mere fact that they have chosen to use the innovations in this yearbook will have a considerable effect on the rest of the profession.

As asserted at the beginning of this chapter, the ideas provided in this yearbook hold the promise of changing the character and practice of industrial arts in the schools. To translate these ideas into practice will take more than just the will of the profession. Careful planning and execution of this translation, coupled with genuine hard work, will be needed also.

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Chapter 13

In Summary — A Parting Perspective

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IN SUMMARY

Part One of the yearbook focused on the background of the complex myriad of ideas which form the foundation for the technology and society interface with industrial arts. Kasprzyk, in Chapter One, highlights the difficulty people have had in becoming aware of the pervasive phenomenon of technology. While technology has been identified by scholars in the field as being *the* major driving force in shaping and advancing our culture, we still today even struggle with a definition of it. Chapter One develops the concept of technology, defines it, and elaborates on the all-encompassing dominance it has in human endeavors. Kasprzyk points out that it is important in all discussions regarding technology to realize how it differs from science and technic.

Chaplin, in Chapter Two, described the *role* that technology plays in society. Through a historical evolvement, he pointed out how technology has carried out this role in providing goods and services for mankind. Chaplin used several illustrations in areas such as food, shelter, security and transportation, etc., to illustrate this role. A concern is expressed by Chaplin that a heightened awareness is needed for an increased social responsibility regarding technology. This awareness must be internalized by our decision-makers on all levels, and the way to bring this about is through education.

Chapter Three was dedicated to an examination of what education, and specifically industrial arts, has done in meeting the challenge in educating our populace so that we are technologically literate.

In a critical and insightful analysis, Streichler has found our profession "wanting" in meeting the challenge. What started as a noble idea, industrial arts has yet to come to grips with the interpretation and implementation of any sustained national programmatic effort that meets the expectations of our founders. With the exception of isolated cases, such as the Maryland Plan and a few other "innovations," the profession has not brought its "grass roots" programs up to the original tenets which were originally set forth. In general, our vision far exceeds our practice.

The existing gap between theory and practice in the field, and the apparent difficulty in the profession to narrow this gap in the study of technology, was the prime factor for including Part II in the yearbook. It was felt by the editors that ideas, resources and activities for "getting started" needed to be presented in some of the most significant and crucial problem areas. Hence, the problems centering around energy, pollution, materials and resources, the industrial work environment, transportation, and housing, were examined extensively from historical, current and future perspectives. This examination, along with some suggestions for student learning activities for use in initiating a study of technology were presented. An element of frustration was voiced by the writers in Part II as they were constantly being reminded of the space limitations in a yearbook. As a consequence, much had to be cut from the chapters, but what remains is an excellent set of ideas, concepts and challenges to the profession.

Part III of the yearbook was established to accomplish two major objectives. For the professional who finds it comfortable to be working in the major problem areas presented in Part II, attention should be drawn to Sterry's chapter on "additional problem areas." Our society will never run out of problems to be solved, and Chapter 11 highlights a series of rich and relevant learning directions and opportunities.

Passmore and Welch draw our attention to the necessity for being cognizant of the process of change. By studying this process in the context of a variety of other fields, they bring to the profession some fresh and promising possibilities. We become very aware that to improve we must change, ever painful or exciting as it may be.

A PARTING PERSPECTIVE

Industrial arts, as we now know it, is in serious trouble if we do not as a profession bring our programs into focus with the current state-of-the-art of technology. We can no longer cling to a few selected activities which were based on a technology of half a century ago and pawn it off as relevant!

It is equally interesting to note that our society is also in serious trouble as it grapples with problems, both of a local and world-wide nature. Many of these problems have possible technological solutions. Leaders around the world are speaking in terms of "mega problems" as the complexities of each of these problems become integrated and intertwined with each other. What is needed, say many of these leaders, is a technologically informed public, with fortitude, ingenuity and a resourcefulness to see us through. This is a golden opportunity for the industrial arts profession to "grab on with both hands and run with it!"

The writers in this yearbook have pointed the way for us to make a major impact, not only on our profession, but on our society as well. A careful gleaning of these ideas is presented for internalization:

1. Teaching Methods

There needs to be a significant change in the methodology that we use in teaching industrial arts. At present, the predominant method being utilized is the lecture/demonstration which puts learning in an imitation/replication mode. For example, the teacher is precise and prescriptive in showing how something is done, and the student repeats or imitates it as closely as possible. Learners, when this approach is used extensively, tend to be limited by the knowledge and competence of the teacher. Hence, students have a "limiting" education which teaches them to lean on the expert and thus hold back on their own initiative.*

While some prescriptive teaching methods will always prevail for reasons such as safety, efficiency, and as a base to work from, a significant increase in the use of problem solving needs to be instituted. While problem solving experiences have been in successful practice for decades, we need a *major increase in the proportion of time* that we permit learners to function in this mode. It has also been stated by many that children are in position today to begin learning in a problem solving learning format at an earlier age and for longer sustained periods of time than they were fifteen years ago.

2. Research and Development

Building a program around technological problem-solving is *one* way to ensure a dynamic and ever-changing curriculum. It changes in "keeping up with times" by the very nature of its organization. Hence, if programs are going to expand their problem-solving dimension, we will see more *research and development* (R & D) lessons, units and/or courses in our programs. When students are working on research and development activities, whether the problem is historical, contemporary or future oriented, relevance is almost automatic. Also, when students are involved in the selection of the R & D problem, we find that interest levels soar!

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*NOTE: Tony Schwartz, Author/Advertiser, states, "The school of the future may very well be a TV or radio studio. A child enters the classroom today with the world stored in him. He possesses more information than any school could teach him. As a result, the education process has been reversed. Rather than cram new information into an empty shell, the school's function is to order existing knowledge." (Schwartz, p. 1)

3. Curriculum Structure

A technology based program, utilizing extensive research and development activities, would probably find its course titles shifting from the somewhat limiting designations such as woods, metals and drawing to titles such as transportation, production and communications. Further development of problem-solving experiences would find learners working, either individually or in small groups, on production, environmental, energy, service and shelter problems. Actually, the imagination is the only limiting factor to the field of study.

4. Service Technology

Several of the writers in this yearbook identified student activities and experiences which could be classified as being "service" oriented. Our present state-of-the-art seems to be production focused with the exception of our limited number of "mechanics" type courses. With the service industry currently outstripping the production industry in contributing to the gross national product of the United States, should we be putting more attention to service type learning experiences? It is proposed that we should be offering an enterprise activity focused around "service" with as much frequency as we do in mass or custom production. This will require a considerable amount of time, effort and creative work, but it would yield tremendous dividends for society.

5. Systems Technology

It is apparent that much of what we are teaching as "current content" is in reality a historical approach. We are teaching hand crafted furniture making, cabinetry and cedar chests to the youth of America under the guise that this is the way it is done. Many of us, when we are questioned about learning all the parts of the hand plane, tend to hide behind the smoke screen that it is one of the "basics." However, when one looks ahead to a life in a technological society, (and assuming that industrial arts is a part of general education) then it is readily apparent that we will be using a microprocessor (hand calculator, etc.) much more frequently than we will a hand plane as an everyday function.

Hence, we must realize that systems are *as important* as the tools and the resources of technology, and that the systems be integrated into our instruction and viewed by the learner as the powerful element that it is.

6. The Dimension of "Affect" in Technology

The study of values and attitudes in industrial arts will dramatically increase as more focus is given to the study of technology. Society has to realize that technology is amoral; it is neither good nor bad but is neutral. Isaac Asimov states "one does not cure evil by stopping science and technology. No, it comes by using it wisely, and by using it to neutralize the evils that result as a side effect." (Asimov, 1978)

It should be pointed out that many technological solutions to our problems have been merely brought about because of our lack of ability to make a social decision. During the era of high and unsafe highway speeds we kept searching for a technological solution for the exorbitant rate of death and injury. We pushed technical solutions such as better tires, hydraulic and disc brakes, padded dashes, collapsible steering wheels, seat belts, warning buzzers, absorbing bumpers and air bag restraints. We, however, were not willing to make the social decision to drive slower and safer. As a result of our *energy crunch,* not because of a safety element, we eventually made the decision to reduce our highway speeds by 10-15 mph. Lo and behold, many in our society were astonished to learn that because of this social decision, we had cut our national highway death rate in half!

Attitudes and values will play an important role in whether or not we as a species survive in this complex technological world.

Courtland D. Perkins, President of the National Academy of Engineering, points out that one of the great challenges of the next 100 years is to solve the multiple world problem which encompasses energy, environment, food and defense. He, in addition, points out that if we do not solve the problem of how to live with each other, we may find that many of our problems will become "non-problems." Perkins also raises an interesting aspect about technologists in that they are not used to working in an environment where sociologists and economists must work cooperatively with them on a hand-in-hand basis. (Perkins, 1978) It seems natural that industrial arts can bridge this gap between the social and the technical dimensions of technology as the perceptive teacher carefully blends these elements together.

7. Meeting the Challenge

On a national basis, if industrial arts programs fail to move into the study of contemporary technology, we will find other subject areas in our schools ready and willing to take on the challenge. At the present time there is a considerable amount of curriculum work being done by social studies in the area of mass production, automation, cybernation, transportation and in the study of technology and society. Likewise, there has been much work done in the science area where teaching materials are being produced to solve communication, microprocessing, environmental and energy problems. The opportunity is still presenting itself to us, but we must, as a profession, act before society and our schools go elsewhere for resolution of the problem.

SIGNS ON THE HORIZON

There is an adage that we see what we want to see and hear what we want to hear. Going hand in hand with this adage is the posture that we wish to take as we analyze our professional situation. Professionally, we have the option of being optimistic or pessimistic for the future. The fact that this yearbook was undertaken was an act reflecting optimism.

An optimistic look at the signs on the horizon indicates that the movement is underway! It will need positive strokes, patience and nurturing but with our careful and resourceful attention, we can bring it to fruition. At the dawn of the age of electricity there was a feeling that something was happening but not everyone knew what it was. It was stated:

> Something was stirring – the people of the last quarter of the last century sensed themselves on the brink of something momentous. They knew they were about to undergo, or were already undergoing, a profound transition from one style of life to another. Only the form of the change was not yet clear. (Creating the Electric Age . . . 1979)

The signs of the times in industrial arts programs are also pointing the way. An examination of the increasing amount and variety of curriculum resources, guides, bulletins, studies, courses, and books reflecting the study of technology is indeed encouraging. The roots of industrial arts are a result of an educational response to the change in society brought about by the industrial revolution. The magnitude and pace of technological change that we are presently undergoing, and thus feeling its impact in our society, can be compared to ten reformation periods and industrial revolutions all rolled into one. Needless to say, the opportunity has never been so open for our profession to make such a significant and hallmark contribution.

Welcome aboard, it is time to get on with the task.

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