Requirements for Fulfilling a National Materials Policy

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REQUIREMENTS FOR FULFILLING A NATIONAL MATERIALS POLICY

PROCEEDINGS OF A CONFERENCE
ORGANIZED BY THE FEDERATION OF MATERIALS SOCIETIES
FOR THE
OFFICE OF TECHNOLOGY ASSESSMENT
UNITED STATES CONGRESS
AUGUST 11–16, 1974

REQUIREMENTS FOR FULFILLING A NATIONAL MATERIALS POLICY

Proceedings of *an*
Engineering Foundation Conference
Held at New England College
Henniker, New Hampshire
August 11-16, 1974

Edited by
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Congressional Research Service

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PREFACE

National materials policy has emerged into prominence in the United States. Recent developments have included the Report of the National Commission on Materials Policy, June 1973; the Report of the Committee on Materials Science and Technology (COSMAT) of the National Academy of Sciences in early 1974; the succession of petroleum-related shortages of industrial materials in 1974; the inflationary consequences of industrial disruptions associated with these shortages; and the concerted plan for legislative action, agreed to by legislative and executive leaders, to monitor the Nation's supplies of essential industrial materials.

The first Engineering Foundation Conference on National Materials Policy, held at New England College, Henniker, N. H., in 1970, provided a warning of future difficulties. It called attention to the functional relationship of materials, energy, and environment. The following October, the Congress by statute created the National Commission on Materials Policy.

The second Engineering Foundation Conference on materials policy, also at Henniker, was convened in 1972 with active participation by the Chairman and staff of the National Commission. It explored eight issues that were later to comprise the gist of the Commission's final report. It stressed the need for a cooperative interaction of Government, academia, and industry in the resolution of these issues.

The third conference, in August 1974, examined options in implementing a national materials policy. It stressed the need for reliable and accessible information on all aspects of materials management, the symbiotic relationship of technology -economics-institutions in implementing national policy, and the interdependence of nations with respect to the production, exchange, and the use of materials.

The purpose of this publication is to present the proceedings of the third Henniker Conference on National Materials Policy. Like the first two conferences, it does not recommend or advocate. Its "findings" are exploratory. The conference searched for options and alternatives. (Although the second conference was subtitled "Resolving Some Selected Issues", it searched for ways to resolve the issues, rather than for resolutions.) The "findings" and "recommendations" contained in the present report are the products of task forces, largely self-selected, of the conferees. No individual responsibility for these reports should be inferred; they stand on their own merits and should be so regarded.

Likewise, as managing agency for the 1974 conference, the Federation of Materials Societies assumes no responsibility for the substantive product, Its purpose in supporting this activity was to sustain the national interest in materials policy as a subject deserving of close and continuing public attention.

Arrangements for publication of these proceedings were handled by the American Society for Metals, a member of the Federation of Materials Societies.

Foreword

The Office of Technology Assessment (OTA) of the United States Congress is directed to provide early indication of the probable benefits and adverse impacts of technology and to develop other coordinate information which assists the Congress. Among other specific functions the OTA is charged with identifying impacts of technology, ascertaining cause and effect relationships, identifying alternate technological methods, identifying alternate programs, comparing the impacts of alternate programs, presenting analysis to appropriate legislative bodies, and identifying areas where additional research or data collection is required.

Recognizing that the cycle of materials usage, including the associated use of energy and environmental impacts, would become increasingly important in Congressional deliberations, the House Science and Technology Committee requested that OTA perform a comprehensive assessment of this subject and the Senate Commerce Committee asked for an assessment of resource recovery systems. In response to these requests, Materials was chosen as one of the first OTA program areas, together with assessments of food, energy, health, ocean technology, and mass transportation.

As a broad strategy for its materials program OTA has made a systematic examination of the total cycle of materials use. Ideally materials should flow through all stages of this cycle to supply adequate amounts of materials and energy for the basic requirements of nutrition, shelter, and health while sustaining a dynamic economy and with minimum waste and environmental impact. OTA has examined materials technology throughout this cycle to determine where undesired side effects, unexploited opportunities, or barriers require assessment. The initial findings are discussed in the postscript to these conference proceedings.

In developing its materials program, OTA is seeking the assistance of materials experts and groups of people impacted by materials technology. The Henniker Conference series on national materials policy is one mechanism for obtaining assistance. This conference sought to sharpen the definition of issues, suggest methodology for developing answers to problems, and, in some cases, to suggest answers. Such answers are not likely to be clear technical solutions fully acceptable to everyone, but rather institutional means for optimizing the application of a technology on a continuing basis with a reasonable balance among conflicting needs. The proceedings of this conference should be considered as a progress report in this continuing process.

Emilio Q. Daddario
Director
Office of Technology Assessment

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Introductory statement by the Chairman

Welcome to the third Henniker Conference on National Materials Policy.

The context of this third conference is one of quickening pace, of movement toward the implementation of organizational ideas and suggestions for action discussed in the two preceding conferences.

The objectives of this third conference are to sustain national interest in the subject of materials policy, to generate ideas for possible legislative consideration, to demonstrate consensus on main themes of materials policy, and to focus national attention on the need for a strong, effective national network of materials information systems.

The first Henniker Conference, in the summer of 1970, was convened here at the request of Senator J. Caleb Boggs, the author of the bill that became law two months later—under the title National Materials Policy Act of 1970. At that first conference, we had a succession of prepared papers by leading authorities who collectively demonstrated the scope of the concerns that would need to be dealt with by the National Commission on Materials Policy. Incidentally, the idea of a Federation of Materials Societies was reinforced and strengthened at this meeting, after receiving encouragement at a 1967 meeting of the National Research Council.

The second Henniker Conference on National Materials Policy, in 1972, was organized with the encouragement and support of the National Commission. Commissioners and staff members were closely involved in the 1972 meeting. Its purpose was to examine in depth eight of the principal issues before the Commission. In addition, members of the Committee on the Survey of Materials Science and Engineering of the National Academy of Sciences discussed their forthcoming "COSMAT" report. The policy studies of the Department of the Interior under the National Minerals Policy Act of 1970 were described by Assistant Secretary Hollis Dole and by the Bureau of Mines Chief Scientist, Earl Hayes.

Since 1972, there have been many further developments in national materials policy. The National Commission made its final report June

30, 1973. The COSMAT report appeared in early 1974. The leadership in Congress, after meetings with leaders of the Administration, proposed legislation providing for Federal sponsorship of a comprehensive materials information system and a materials policy agency—in S. 3523 introduced by Senators Mansfield, Scott, Byrd, Griffin, Javits, and Brock. * Many other legislative proposals dealing with recommendations of the National Commission are also pending in Congress. Materials policy studies are commanding the attention of the Environmental Protection Agency, the Federal Energy Agency, and the National Science Foundation, as well as of the Departments of Interior, Agriculture, and Commerce.

This third Henniker Conference came about as the result of a proposal from the Board of Trustees of the Federation of Materials Societies to the Engineering Foundation, a year ago. It was suggested by the FMS that the precedent of two biennial conferences on national materials policy be continued by holding a third conference in 1974, under FMS management. It is my hope that this tradition will be continued in the future.

I had hoped to relinquish the chairmanship of this third conference to Mr. Nathan E. Promisel, whom all of you know as one of our most outstanding leaders in the field of materials policy. Unfortunately Prom had a series of medical mishaps that kept him from this service, but I hope that we will have the opportunity to meet under his leadership at a future policy conference.

The 1974 conference will focus on five problems: information systems, the international flow of materials, materials conservation through engineering design, materials recycling, and the role of the technical societies— stressing the international aspects. I would expect that in all of these subjects, attention would be given to the interaction of materials, energy, and environment. This theme of interaction was stressed at the second Henniker Conference and was the focus of the National Commission's report.

We will devote most of this opening day to a series of tutorial papers on the five topics of the conference. The next two days will be devoted to task force consideration of the topics. It will be the responsibility of the task force chairmen to prepare brief written reports to be distributed to all conferees by Thursday morning. Thursday will be devoted to plenary sessions at which the ten reports, two on each topic, will be reviewed.

Thursday night we will hear a more formal paper by Dr. Richard Roberts, Director of the National Bureau of Standards, Tonight we will hear from Dr. Julius Harwood of the Ford Scientific Laboratory on the auto industry's views on materials policy.

The closing day of the conference will be reserved for a number of shorter papers and a summary description of what the week has produced.

This proposed bill was subsequently enacted as a part of the Defense Production Act Amendments, P.L. 93-426, approved September 30, 1974.

Now it is my pleasant duty to introduce the keynote speaker of this conference, Mr. Emilio Q. Daddario. I should remark that I have been trying for four years to persuade him to find time in his busy schedule to attend one of our Henniker Conferences and I am delighted that he was finally able to do so. Unfortunately he will not be able to spend the whole week with us because he has a speaking engagement on Wednesday before the American Bar Association meeting in Hawaii.

While we were planning this conference here, Mr. Daddario took a keen interest in what we were attempting to do. In his present role as Director of the Office of Technology Assessment, Mr. Daddario has recognized the importance of assessing materials policies for the Legislative Branch. He has enlisted the support of the Federation of Materials Societies to survey the state of materials information systems. He has convened an advisory panel of materials experts to advise OTA. And he is formulating a program of assessments in the field of materials to meet the needs of Congressional committees in developing legislation.

It gives me great pleasure to introduce our keynote speaker, Emilio Q. Daddario, Director of the Office of Technology Assessment.

F. P. Huddle
Senior Specialist, Science & Technology
Congressional Research Service

KEYNOTE ADDRESS: EMILIO Q. DADDARIO

Ladies and gentlemen, I feel very much at home meeting with you here today at this third Henniker Conference on National Materials Policy.

Regretfully, I have been unable to participate in the two previous Henniker conferences. Yet, nonetheless, I appreciate the vanguard efforts of this conference in creating awareness of the critical nature of natural resources scarcities.

The "Spirit of Henniker" is identical to the motivating force behind the long drive to create the Office of Technology Assessment as an early warning mechanism to alert Congress to the full spectrum of consequences—both good and bad—of our expanding technology.

Nor is it at all surprising to find that the great majority of OTA initial assessment topics are tied together by the common thread of concern about the availability y of natural resources and materials supplies. Not only are we developing an assessment in the specific area of materials resources, which I'll discuss in greater detail shortly, but we also are undertaking studies in the vitally related areas of oceans technologies, world food supplies, and the overall energy picture. The selection of these topics as OTA'S first and highest priorities directly reflects the priorities set by the Congress through its standing committees, in expressing its need for legislative assistance.

So I think it is quite fair to say that the message of the previous Henniker Conferences have been listened to in the Congress. And I can assure you that there can only be increased Congressional interest in the findings of this year's conference, and any future work accomplished in this important area,

To underscore this point, I'd like to review the record of Congressional response to the past results of the Henniker sessions.

At the first Henniker Conference on National Materials Policy, back in 1970, the topic was "Problems and Issues". The proceedings of the conference were published by the Senate Committee on Public Works. The keynote speaker was Senator J. Caleb Boggs, author of the bill that created the National Commission on Materials Policy.

That bill passed the Congress less than two months after the conference here, with no recorded dissent.

Just for the record, let me recall to you some of the names of the speakers at that first Henniker Conference: James Boyd, William J. Harris, Jr., Elburt F. Osborn (better known as "Ozzie"), S. L. Blum and N. E, Promisel. The reason for mentioning these particular speakers is that they are now serving on an ad hoc committee to advise the OTA on its program of materials assessments.

The second Henniker Conference on National Materials Policy, in 1972, was titled "Resolving Some Selected Issues". It was held while the National Commission was in its final year of deliberation. Speakers at that conference included the Chairman and Executive Director of the National Commission, the Director of the Bureau of Standards, and four past, present, or future Directors of the Bureau of Mines. Also present were most of the members of the Interagency Council for Materials. The point is that Henniker 11 afforded an opportunity for interchange between the Commission, created by the Congress, and materials experts drawn from the Executive Branch. Increasingly we have seen this pattern. Data collected and organized by executive agencies are analyzed by congressional agencies as the basis of policy determinations which the Executive Branch then is charged with implementing.

Recently in the Senate debate on S. 3523, a bill I shall say more about later on, the proceedings of this second Henniker Conference were cited in justification for the proposed legislation. The point is that when leading students of national materials policy assemble in a forum like this one, the Congress gives ear to their conclusions and findings. You are not wasting your time or the public's time when you sit down here to think about hard problems.

Last fall, there was a joint meeting of the National Academy of Sciences and the National Academy of Engineering to review the findings of the Commission, the COSMAT Study, and the second Mining and Minerals Policy Report. Congressman Mike McCormack was one of the principal speakers, and attested to the interest of his Energy Subcommittee of the House Committee on Science and Astronautics on materials matters.

I should take note also that Professor Morris Cohen of MIT, who chaired the COSMAT Study that produced the excellent report, "Materials and Man's Needs", is with us here at Henniker III. * And let me add that this report along with the report of the National Commission on Materials Policy, is receiving close study at OTA by our ad hoc committee on national materials policy.

Over the last year something like a hundred different bills have been offered in Congress dealing with materials subjects. There have been a score of hearings and numerous reports and committee prints on materials subjects.

For example: Industrial Materials, Problems and Issues for the Congress. Resource Conservation, Resource Recovery, and Solid Waste Disposal. Special studies on solar energy materials, oil shale, lignin, waste materials recycling, substitutes for bauxite, corrosion, Rhodesian chromite, strip mining, and a host of other problems are right now receiving Congressional attention.

An interesting contract has been placed with the National Materials Advisory Board in the Academy of Sciences to investigate lagging technology and opportunities for technological advances in the basic materials industry. This study was placed with the Academy by the Congressional Research Service at the request of the House Committee on Science and Astronautics and is scheduled for completion this year. It represents a first use of the Academy on an in-depth technical study for Congress in materials management and a further recognition that technical advice on legislative issues can be systematically contracted for by Congress from the Academy.

I can see ahead of us a large prospect of further Congressional interest in securing technical underpinning for legislation. Take, for example, the recent article by Senator Tunney in the Washington Post, in which he declared:

> "We must accelerate research and development efforts to use existing materials more efficiently in products and systems, and to prepare substitute materials. In addition, the recycling of solid waste, the development of energy-efficient, nonpolluting automobile engines, the mitigation of metal corrosion, and changes in energy pricing structures—all issues presently before the Congress, and all with a potential for vast mineral and material savings—can go far to meeting our needs now and in the future."

I am informed that at your meetings of technical committees, Academy panels, and the like, the question is repeatedly raised as to whether anybody is listening. Believe me, somebody is. A hundred legislative proposals is something to contend with. I do not mean to suggest that they will all be passed into law. The legislative process is something we all need to understand better. A bill is only the first step. The second step is to convince a Congressional committee that the bill warrants attention so that hearings are scheduled. The third step is to present evidence at the hearing that the measure is sound, needed, useful, and publicly supported. The hearing also serves the important

* *Unfortunately, Dr. Cohen was prevented, by an illness in the family, from attending this conference.* His absence was *deeply regretted.*

function of building a national consensus. Here the technical societies can help by educating the public on the issue, its meaning, and its public value. Ordinarily, when a bill is intelligently explained to the public and to the Congress, if it has merit it receives favorable reception in the Congress and becomes law. Increasingly, the bills in Congress are coming to have a technical content. That is an important reason why OTA was created. I propose to say something later on about the role of OTA in the field of materials. But first I want to tell you about a bill that could have a large impact on the materials community in the very near future. I refer to S. 3523, the "Mansfield Bill", which proposes to create a temporary "Commission on Supplies and Shortages'.

The bill was conceived in principle at the first meeting of majority Senators, last January 24. It was discussed in Senator Mansfield's speech, February 1. It was the subject of a letter from Senator Mansfield and Senator Hugh Scott, minority leader, to the President, February 19. It was converted into a bill, with Executive Branch concurrence and bipartisan support, May 22. It was reported from the Senate Commerce Committee June 5, and was passed by the Senate June 12. Since then the measure has been under consideration in the House Committee on Banking and Currency. In view of the strong bipartisan support the measure has received, I would expect it to pass this year and become law. (Ed. note: The measure became law.)

Briefly, the bill provides for two things, First, it sets up a temporary commission to design a permanent institution to keep tabs on materials, to sound the warning in case of threatened dislocations, and to propose remedies. It must report its recommendations on this matter within six months. Second, from the moment it is established, the temporary commission will also serve the function of the permanent institution until Congress has had time to act on its recommendations to create the permanent institution.

Basically, the first function is a task combining technical understanding with political science. What is needed is an agency to coordinate the collecting of materials data, to perform analyses of the data, to draw conclusions, and to design remedies to correct dislocations.

This concept was first proposed by the Paley Commission in 1952. It was revived by the National Commission in 1973, and the need was dramatized by the petroleum crisis—or energy crisis, if you like—-of this past winter.

The Congress, increasingly, is concerned with this vital matter of monitoring our nation's materials well-being. It is my hope, also, that the Office of Technology Assessment will be permitted at constructive role in support of Senator Mansfield's plan. I believe we have the charter, and the interest, and are gathering the resources to contribute to this essential endeavor.

Let me conclude my talk with a description of what OTA is doing in the field of materials.

The Office of Technology Assessment, to give OTA its formal title, was created by statute in October 1972. It has gotten underway carefully because it is a new and highly experimental venture, a new social invention. Its purpose is to provide sound technical advice to the Congress on legislative issues, to give early warning of technical opportunities and dangers, and particularly to look at all the consequences of technical decisions and innovations. Yet it has already issued an assessment on "drug bioequivalence" and has ongoing programs in solar energy, rapid transit systems, food, and the oceans. These are being performed at the request of Congressional committees and are sure to have an effect on legislation of concern to those committees.

Organizationally, OTA consists of a board of six Senators, six Congressmen, and the Director of OTA; a Technology Assessment Advisory Council, and a working staff.

Our first step in defining our universe was to ask the Congressional Research Service in the Library of Congress to tabulate for us the major technical issues confronting Congress. This was an impressive task that presented us with two large volumes of issues that might be candidates for assessment. A number of these issues involved materials.

Next, we invited the chairmen of Congressional committees to identify for us the issues they wanted us to study. In response to one such request, Representatives Olin Teague and Charles Mosher, Chairman and Ranking Minority Member of the House Committee on Science and Astronautics, replied, January 22, asking that OTA

> Focus particularly on what materials problems are likely to develop in the next five to ten years with regard to those metals, rare earths, and other materials on which the United States predictably will have to depend for a substantial part of its needed supply through imports. We should also like to know what magnitude of materials R&D should be launched in the relatively near future in order to alleviate problems of this kind.

Late in 1973, with some help from the Congressional Research Service, we outlined a program of materials assessments for Board approval. The plan was divided into short-range and long-range assessments. The short-range program, in its present form, has four items: (a) an assessment of the present adequacy of materials information systems; (b) an assessment of ways to conserve energy through materials management; (c) an assessment of ways to ease U.S. materials vulnerability through production of domestic materials; and (d) ways to use the stockpiling principle to encourage domestic minerals production, put recycling of materials on a sound economic footing, stabilize prices, and reduce our vulnerability to foreign actions.

Last January 3rd, I wrote to the Federation of Materials Societies inviting their help in assessing materials information systems. The Federation agreed to help, and later in this program you will hear a report from Dr. Jack Westbrook, chairman of the Federation's Materials Information Committee, on what has been learned about materials data systems, their adequacy, completeness, and accessibility.

I recognize that this investigation is only at the close of its first phase. There will be much more hard work ahead. One of the five tasks before this Conference will be to give us guidance on how to proceed from here.

In our search for techniques to enlarge the competence of OTA, one scheme has been to organize advisory groups or panels to provide technical advice, analyze our programs to recommend changes, and provide a bridge to the broader technical and also nontechnical community. A week ago today in our conference room we held a first meeting of our OTA ad hoc committee on national materials policy. We asked this committee to suggest ways in which the OTA could best benefit from the Henniker 111 Conference, and that topic occupied a considerable part of the meeting. I hope you appreciate the purpose of this action, which is intended to ensure that your deliberations here receive maximum visibility to the Congress as it takes up materials issues.

Another request to the Committee was that it examine our OTA program of materials assessments, recommend additions and deletions, suggest priorities, and help us design assessment studies.

A third question was as to how OTA could best serve the proposed Mansfield Commission when it became a fact. On this point, the Committee advised us that our plan to assess materials information systems, already in progress, would be invaluable, and should be pursued with vigor.

Finally, we asked the Committee to recommend the form that a permanent OTA materials panel should take. That question is expected to be on the agenda of the second meeting of the Committee, September 20.

To conclude this recital, I want to express my appreciation to all those in attendance at this conference. In turning your attention to national—and, indeed, international—aspects of materials policy, you are contributing to the development of an economically sound and stable society. Avoidance of dislocations in supply-demand is important for all of us. An orderly global flow of materials is basic to world peace. The frugal use of materials is a practical necessity in our shrinking world. So is the recycling of our wastes into reuse. And worldwide technical cooperation to share expertise to these ends is an eminently sensible way to their achievement.

WELCOMING REMARKS ON BEHALF OF THE FEDERATION OF MATERIALS SOCIETIES

John B. Wachtman, Jr.
President-Elect,
Federation of Materials Societies

I would like to add an expression of welcome on behalf of the Federation of Materials Societies (FMS) which is responsible for organizing and managing this conference under the general sponsorship of the Engineering Foundation.

Our Federation president, Dr. Eugene Merchant, is in Australia on a business trip and our executive director, Mr. Nathan Promisel, is indisposed. Both had wished to attend and both regret not being able to be here. On their behalf and on behalf of the Board of Trustees of FMS I would like to express our pleasure at having all of you here. This is a working conference and we count on your active participation to make it a success.

It is very appropriate that FMS should be the organizer of this third Henniker Conference on National Materials Policy because the organization of FMS itself took place partly at the first of these Henniker Materials Conferences four years ago, FMS was formally incorporated in June two years ago with the general goal of providing a national focus for materials activities of such broad character that cooperation between individual technical societies is required for most effective execution. The members of FMS are materials-oriented societies, not persons. Current membership includes ten member societies and half a dozen observer societies; through these member and observer societies FMS seeks to represent the broad materials interests of some half million materials scientists and engineers and to serve the public interest in materials.

Time does not permit me to review the full scope of FMS activities but I would like to give you two examples. First, an FMS committee under Doug Ballard prepared a report to Jim Boyd of the National Commission on Materials Policy dealing with materials conservation through effective utilization. Second, an FMS committee under Jack Westbrook is currently responding to a request from Mr. Daddario, Director of the Office of Technology Assessment, for assistance in evaluating the scope and quality of the sources of materials information. We will have an interim report from Dr. Westbrook later in the conference.

We have a challenging week ahead of us. I hope you will find it interesting and worthwhile.

MATERIALS RESEARCH: A STRATEGY TO IMPROVE THE PERFORMANCE OF MATERIALS

Richard W. Roberts
Director, National Bureau of Standards

Back when I was in high school, I can remember my English teacher making us memorize a poem. By now I've forgotten the title; I've even forgotten the author. But the first couple of lines of that poem still stick in my mind. And they are:

> "Back of the beating hammer, by which the steel is wrought
> Back of the workshop's clamor, the seeker will find the thought . . ."

Now that poem never won a Pulitzer Prize, it never made the author rich, but it did make an impression on me. Today we still have the clang and the clamor, we still have the beating hammer. But more than ever we need the thought. True, the seeker can find it if he looks long enough, looks hard enough. But the balance must shift. The poem refers to a time in which raw power, raw materials, raw labor, were able to transform this great land of ours. Today we live in a different age. The thought, the research, the innovation, the synthesis, all of these must go together in a much stronger way if we are to advance our way of life. And that's why we're here—to talk not so much about the clang and the clamor but to talk about the thought. To talk about new ways of advancing or even maintaining our life style without doing great damage to our environment, our economy, our succeeding generations.

Given that materials are fundamental for the well-being of the American people, given that we expect to continue economic growth, and to meet the requirements of an increasing population, we have no choice but to take a hard look at our materials usage. To maintain economic growth, in view of limited resources, we must develop intelligent plans that impact every phase of the materials cycle. We need to assure a reliable supply of raw materials. We need to develop innovative techniques for recapturing and reusing materials after their original function has been served.

These problems, of course, are not trivial. If they were, we wouldn't be here today. And they aren't new. The search for guidance officially began in 1930, when President Hoover established the first commission on materials policy. In the 44 years since that time, materials technology has undergone an explosion in areas like aerospace, electronics, nuclear technology and the plastics industry. These advances, if anything, have increased the urgency of the quest for firm materials policy.

In my opinion, there are two distinct but nonetheless overlapping aspects of our materials problems. One aspect is that of policy, the framework of principles and rules that is used in deciding a course of action. The other part of the materials complex—I prefer that word to problem or crisis—concerns the how of implementing that course of action. But, of course, the two are by no means separate; there is an interrelationship between policy and procedures that is as hard to unravel as the question of the chickens and the egg.

For the sake of convenience, let me divide my remarks roughly into two broad areas. First, I'll talk about the materials cycle—especially the area of use—and then I'll concentrate on policies affecting the cycle, and how they can be firmed up.

It's obvious that we will continue to use materials. If, however, we can build our materials so that they last longer, and perform better, then it is obvious that the cycle from raw material to scrap can be extended. By improving the performance of materials, by making them work better and last longer, we can indeed make a strong contribution to materials conservation, and a lasting contribution to assuring the resources of future generations.

To be fair, I must point out that some economists claim we have nothing to worry about, that if the price is right, we can always recover scarce materials from low grade ores, or we can develop new, substitute materials. But lacking this absolute faith, I feel that materials conservation especially through the mechanism of improved performance, is the immediate, and probably the long-term answer to many of our shortage problems.

In terms of fuels, which I'll touch on but briefly, there are tremendous savings to be made in our use patterns. Both the daily papers and the technical journals have been filled with articles on how to use our present fuels more effectively. The organization that I represent, a group of 3,600 people in some 30 major buildings in Gaithersburg, Md., Boulder and Fort Collins, Colorado, and Kekaha, Hawaii, has cut total energy consumption by about 20%, doing so without major discomfort to the staff or disruption of our technical programs. In a very real sense that is, indeed, improving the utilization or performance of a critical raw material.

But in a more complex sense, if we can improve the performance of other materials, we can also go a long ways towards achieving our goal of energy self-sufficiency. The implications for improved performance in this area are clear. If we can develop the right materials, we can assure higher efficiency, greater reliability, longer life and reduced cost for the projected processes for coal gasification and liquefaction and new energy conversion systems such as high temperature gas turbines, fuel cells, MHD, combined cycle power plants and nuclear reactors. But developing new or adapting existing materials is just one small part of the large framework needed to support the goal of energy independence. This goal, like everything great or small, has its price, and in this case, according to the National Academy of Engineering report, the private capital investments alone are expected to run $500 or $600 billion. The magnitude of the challenge and the problem of capital availability are strong incentives to do the job right the first time. For instance, when a single pressure vessel costs tens of millions of dollars, a few failures can spell economic ruin.

There are other imperatives calling for improved performance arising from many forces in our society. For instance, in recent years, we have seen increasing militance on the part of the American public in demanding upgraded performance and improved safety. We have institutionalized these demands somewhat through creation of a Federal independent regulatory commission, The Consumer Product Safety Commission and private sector groups such as the Consumer Federation of America. In addition, there is strong pressure to bring into being a Consumer Protection Agency. Precedent-setting court decisions involving product liability provide a strong incentive for manufacturers to improve the performance of their products. In the private sector, insurance agencies have been putting increasing pressure on their corporate clients to attend to the details of performance.

It should be clear by now that if we somehow increase the performance of materials, we will probably pay an initial economic penalty. Notice I said initial economic penalty. However, if judiciously undertaken, actions to improve performance will prove beneficial over the long term.

But if a product lasts longer, and requires less maintenance, then its life cycle cost is likely to be lower in the long run. This concept, however, is one that is not readily understood or is now accepted by the public, and educational efforts will be required. Equally important is the education of our designers, whose traditional approach has often been one of working towards low initial cost.

The designer, as well as the product line manager, must also concentrate on techniques of production. Not only need the best material be chosen for a particular application, but better fabrication techniques as well must be considered in the quest for better products.

And while improved performance would aid the materials conservation and utilization goal, it could also have the beneficial effect of allowing better products to capture a larger part of the world market.

Consider the current status of United States goods. Factors like the high cost of labor in the United States impede our ability to compete for certain markets. Couple that with the fact that much of the world is now catching up in many areas of technical sophistication, and we have to accept that we no longer enjoy our former competitive advantage or reputation. The last fact was brought home to me a few weeks ago by a comedian on T.V. He said, "Take Japanese technocracy and you get radios. Take German technocracy and you get cars. Take American technocracy and you get Japanese radios and German cars". The comment wasn't complimentary to any of the parties mentioned. And as is most humor, it was a perversion of a small element of truth. But it came off as funny, not because it said anything about technocracy, but maybe because it reflects trends in the marketplace that exasperate Americans. The place where the United States could and actually should be competing more effectively is in the area of high technology, high performance. Look at the success of our aircraft. Defense needs have been largely responsible for improving performance in this area, and those improvements have carried over, sometimes by mandate, into commercial practice. As a result, our aircraft are not only highly reliable, they are also more durable than others on the market and so require less maintenance. We are, therefore, virtually without a competitor. And the same is true of computers and other high technology items.

By now 1 hope it's clear that improved materials performance is imperative if we, and other nations, are to maintain or achieve a high standard of living. The question at hand is how do we achieve better performance? Take a look backwards for a moment, to a point 20 or 30 years ago. How did materials science advance from that time to the present? How did we produce new metal alloys, refrigerants, polymers, lubricants? By research and its application. That formula worked and worked well in the past, and will continue to work well today.

True, things are more complex today, but progress will continue to depend on materials research. To achieve improved performance, there are at least five technical options we can use either singly or in consort. These options are:

1. Development of new materials.
2. Development of new processing techniques.
3. Improvement in manufacturing and fabrication techniques.

4. Improvement in nondestructive evaluation techniques.
5. Improvement in design theories and concepts.

Now, to get from here to there, from current knowledge to improved materials, will take a full range of talents, from the brilliant fundamentalist to the pragmatic production specialist. There must be a climate that encourages innovation. Ample rewards must be given to those who ‘‘dare’ try a new approach to solving a problem. and alternative pathways must be available to those whose work has come to a nonproductive point.

Except in those cases of overriding national interest, such as defense, nuclear power, or space exploration, the bulk of materials performance improvement falls in the private arena. After all, the pressures of the marketplace, the force of law, the demands of the public, and the actions of their competitors all impel a firm to product acceptance, which we hope will mean product improvement.

And, of course, we all recognize the great and continuing materials contributions made by universities. Sound theoretical and applied work is generated across a broad spectrum, and better mechanisms are needed for coupling this new information to areas where it is needed. The value of both the Federation of Materials Societies, and the local chapters of the technical and professional societies must be fully recognized, for these organizations provide the grass roots forums where the academician and researcher interact with the engineer and technologist on an interorganizational basis to discuss their individual needs and ideas. Expanded company support for the continuing education programs sponsored by the technical and professional societies, and conducted by people who are leaders in their particular fields, would allow industry to capture broad experience and new ideas at minimum cost.

Previously I said that responsibility for improving performance rests largely with industry. But it is not a one-way street. There are opportunities for government, industry, universities, and technical societies to cooperate in a four-way effort. Such cooperation is, in fact, absolutely essential to success in certain areas. Let’s look at coal gasification and liquefaction technology for a moment.

At the present time, the Federal Government and the private sector are trying to create an economically viable synthetic fuels industry. Central to the creation of this industry is the development of materials which will be capable of withstanding the hostile environment of these processes. When developed, these improved materials will be used to build pressure vessels, and they must be acceptable to the American Society of Mechanical Engineers’ Boiler and Pressure Vessel Code. If they were not accepted, it would be difficult, if not impossible, to build plants using the new materials because the Boiler and Pressure Vessel Code have become part of the local building codes. In addition, insurance companies would not provide coverage for a facility which did not meet the minimum standards of the profession. Therefore, cooperation is needed at almost every step in the process.

Various Government laboratories are capable of making general contributions to improving performance, and the National Bureau of Standards is one. One of our strategies is to promote the exploitation of nondestructive evaluation techniques (NDE) and to concentrate on improving design theories and concepts. I choose NDE because it is essential to assuring improved performance and because it is measurement intensive. Design theories and concepts are chosen because their successful implementation depends heavily on our being able to characterize and understand the properties of materials.

If we look at the gas turbine, we find an excellent example of how NDE and design can go hand in hand to improve materials performance. In order to improve the efficiency of gas turbines, we must go to higher temperatures. But higher temperatures create a materials problem, as most metals will melt at the desired operating conditions.

Ceramic turbine blades can, indeed, withstand the higher temperatures, but until recently their fracture characteristics have eliminated them from serious consideration. Recent major material innovations, in the private sector, have led to the development of a class of fracture-resistant ceramics. Research pioneered at the National Bureau of Standards on crack propagation in glass and ceramics has shown that it is possible to predict the length of time to failure of brittle materials operating under stresses. The ability to determine when and under what circumstances the material will fail coupled with a full knowledge of the characteristics or properties of materials will make it possible to design around the difficult problems that remain.

We need stronger measurement support in many areas for improving the performance of materials. Until very recently, NDE has been mainly a qualitative tool, very useful for the detection of major flaws in materials. However, with the advent of a drive toward fracture safe design, NDE is moving to a higher level of precision.

Despite the advances that have been made, NDE is not yet a precision technique. Consider ultrasonic testing, one of the most popular NDE approaches. No standard is available against which to make meaningful calibrations; phase and frequency data that could greatly increase the information output are ignored; and automation to increase efficiency and reduce operator variability needs to be more widely used. Similar problems are common to other NDE techniques, and a great deal of fundamental work lies ahead if NDE is to become a truly useful, quantitative tool.

Looking toward the future, we can discover other areas of materials technology that government, industry, and academia will have to support more fully in order to meet the needs of improving performance. We will have to increase the study of materials in extreme environments, improve and develop new nondestructive evaluation techniques, further exploit predictive testing and concentrate on safeguarding materials through work in corrosion prevention of metals and in the abatement of the aging and deterioration of plastics, and so on.

I have directed the first part of my speech to the need for improving material performance, a need stimulated by a demand for increased efficiency, for product safety and an opportunity for materials conservation, and have reviewed the strategy for attaining it. Basically, we see that we face difficult technical problems, and, for the most part, achieving improved materials performance will take a cooperative action at the technical level involving industry, government, academia and the professional societies. But, above the technical concerns, we need a well-defined policy framework to guide the country in managing its material resources. It is to the broad subject of materials policy that I would now like to direct my remarks.

We might now ask the question, "Does the United States have a materials policy?" I believe that one of the clearest statements of materials policy is set out in the Mining and Mineral Policy Act of 1970. This Act implies that, for the most part, supply and demand will be left to the economic forces in the marketplace. Other policy elements were in existence before the passage of this Act. They are a collection of diffuse, uncorrelated, and often contradictory strategies which govern specific areas related to materials supply. They consist of executive orders, administrative rules, and statutory and common law. If one has the time and inclination and knows where to look, one can find them set out in multiple places in the United States Code, The most notable description of the policy elements are laid out in the following acts of Congress:

The Organic Act for the Geological Survey 1879, The Organic Act for the National Bureau of Standards 1901, The Organic Act for the Bureau of Mines 1910, Strategic and Critical Materials Stock Piling Act 1946, Defense Production Act 1950, Atomic Energy Act 1954, Internal Revenue Act 1954, Domestic Minerals Act 1953, Agriculture Trade Development Act 1954, Helium Act 1966, Mining and Mineral Policy Act 1970, Resource Recovery Act of 1970.

As you can see, the predominant impact areas of these policy elements are the development of resources and production capabilities. In other words, they cluster around the supply end of the materials spectrum. At the other end of the spectrum. the disposal end. we see a newly developing area of policy. With either end of the materials spectrum pretty well covered or at least accounted for, we now face the no man's land of materials utilization and performance where policy has not yet made significant inroads.

How is policy formulated and who are the policy makers? Policy is created through a variety of techniques. The three predominant methods are Congressional action in creating new laws, administrative rule making and Executive Order. The first two methods work on the principle of establishing a thesis and creating a public forum to elicit comments. The forum consists of public testimony before a Congressional committee or, in the case of administrative rule making, a hearing before an examiner. Once a policy has been established through the legislative procedures, administrative rule making or Executive Order, its validity can be tested in court where it is upheld or overturned, based on the interpretation of the court. An Executive Order is established without public hearing, but it is subject to the same test by the courts as the legislative and administrative approaches. In some cases, policy can be established by the courts through the interpretation of common law, the body of precedents that was created by previous court decisions.

In response to the question, “Who creates the policy?”, I would say that theoretically the individual is capable of creating policy. The individual can establish a need by pointing out to his elected representatives that a certain course of action would be beneficial. However, since the individual is usually not sufficiently prepared to take on the problems of promoting a policy idea, such groups as trade associations, technical and professional societies, private industry, labor unions, and consumer groups can and should make their views known.

The obvious conclusion is that this country has a fair capability to formulate recommendations for a materials policy. What we lack is an authority in the government whose prime interest is in guiding the materials policy on a day-to-day basis.

If you look at how recommendations for materials policy have been handled over the past five to ten years, you will notice that advisory groups, such as the one here this week, are called together for a short time to review the current status of materials policy and to write a report. They then disband. In fact, in the last ten years, seven different groups have passed through the ritual of preparing reports and disbanding. Despite the great effort by these groups, until there is a well-defined organizational structure to take the recommendations of advisory groups such as this one and fight for them through the legislative process, I can guarantee that no unified materials policy will ever be established or implemented.

Some tentative progress indicates that we are maturing in our approach to managing materials. For example, the Interagency Council on Materials was intended as a forum for discussing materials problems at a high level in Government, but it has virtually become inoperative. However, a counterpart to ICM, the Committee on Materials, is being created as a subcommittee of the Federal Council for Science and Technology—the advisory group most directly linked to the Executive Branch of Government. The Congress has created the Office of Technology Assessment to “provide early indications of the probably beneficial and adverse impacts of the applications of technology and to develop other information which may assist the Congress”. OTA’s willingness to utilize the Federation of Materials Societies shows that the office is basing its work on a solid foundation of competent and wide-ranging technical expertise.

What we see taking shape is the organizational framework necessary to guide the development and implementation of a unified materials policy. We have to see that framework through to completion if we are to receive the support we need to carry policy and strategy through at the technical level.

So, in my presentation tonight, I have outlined the need and the strategy for improving the performance of materials. To make the construction complete, I have tried to sort out where we stand and where we need to go with materials policy. And now, briefly, I would like to bring the parts together again by reviewing the basics.

To realize the essential materials improvements, we have to adopt a strategy based on research and risk taking. We have to take our five technical options: materials development; processing; fabrication; design; and nondestructive evaluation, and exploit them.

These innovations will take money to develop, and more money will be necessary to see them through to the marketplace. Consumers, large-scale consumers like industry and Government and the individual consumer, must be willing to pay the price. The acceptance of this new philosophy, especially by the individual consumer, will come about only after a thorough education program to get the consumer to consider life cycle costing as a major factor of customer acceptance.

We have seen that this country has on numerous occasions asked eminent groups to review our materials problems and make recommendations. Over all, good advice has been generated, but we've been guilty of a major failing: We have not acted on that advice. The time to start correcting our error is now. If we continue to fail, we will have to accept that the situation will only go from bad to worse.

This is the third Henniker Conference. The previous participants have worked long and hard at identifying problem areas in the materials field. We have done so at this meeting as well. But the time has come for more than discussion, argument, agreement, and resolutions. The time has come for us, as individuals, as technical managers, as members of influential societies, as concerned citizens, to call for, to participate in, and to implement a national materials policy.

MATERIALS RESOURCES—R&D RESPONSE

Extracts of a paper by Julius J. Harwood,
Director, Physical Sciences
Scientific Research Staff, Ford Motor Company

The paper summarized the rising interest in national materials policy following the appearance of the report of the National Commission. It cited the COSMAT report, the earlier Henniker Conferences, and the emergence of the Federation of Materials Societies. However, the main driving force was pervasive shortages of materials, intensified by the shortage of petroleum. In response, said the author, many industries were undertaking their own analyses of the materials crisis. One such analysis had been performed at Ford Motor Company. The rest of the paper dealt with some of the findings of this analysis.

Issues examined included:

(a) 1. Economic and availability trends for major automotive production materials for the 1976-1980 period, and the general conditions which might be expected to affect the availability and supply of materials for the remainder of the 20th century.

2. Identification of critical problem areas in materials in future requirements.

3. Elements of a supply strategy to minimize future materials

TABLE 1. ROUGH WEIGHT OF MATERIALS IN 1974 FORD COMPOSITE VEHICLE.

Material	Pounds per Vehicle	% of total
steel	3,368	71.8
Ferrous Castings	761	16.2
Aluminum	65	
Copper	36	0.76
Nickel	2	0.04
Zinc	58	
Lead		1.2;
Glass	115:	
Plastics	120	2.4
Rubber	132	2.8
Total	4,689 lbs.	

availability risks and contingency plans to adapt to changing supply situations.

4. Influence of materials costs on future utilization patterns.

5. R&D needs for the development of new or substitute materials and the potential of enhancing materials availability through recycling and solid waste disposal of scrap materials.

6. Industrial facilities and capacity needs with respect to future requirements and demand/supply balance.

The study identified the pattern of use of materials in auto manufacture. Findings were summarized in Tables 1 and 2. As an afterthought, the speaker noted that the impact of catalytic converters in 1975 would be significant:

(b) Introduction of catalytic converters in 1975 will turn the automotive industry into a predominant consumer of platinum/palladium precious metals. 1975 catalytic converter volumes will require as much 409 type stainless steel as the steel industry produced in 1973 overall. Limitations in melting and fabricating facilities capacity in the industry and shortages in

TABLE 2. AUTOMOTIVE INDUSTRY MATERIALS CONSUMPTION (1972).

Material	Automotive as 92 of U.S. consumption
Plastics (1974)	5
Copper	8
Aluminum	9
Nickel	11
Steel and cast iron	20
Zinc	33
Rubber	66
Lead (battery and T. E. L.)	68
Platinum (est. 1975)	70

Source: a) Motor Vehicle Manufacturers Association of U.S.
b) Third Annual Report of the Secretary of the Interior (1974).
c) Supply Staff and Plastics Development Center.
d) Bureau of Mines Information Circular 8565 (1973).

ferrochrome supply may make 409 stainless a troublesome supply situation for the near future,

Next, the analysis addressed the question of materials resource availability as it related to the auto industry. It identified materials in which the United States is dependent on foreign sources (Table 3), discussed domestic sources of materials (Table 4), and assessed the rising needs of other countries (Table 5). It concluded:

(c) While the overall resource availability picture for the next decade is reasonably encouraging, competition among nations for the World's raw materials and energy will be more intense than during any time in the past. We anticipate therefore, that material shortages will continue to be prevalent and materials supply problems will be an ongoing way of life. All of this assuredly will mean higher materials costs.

Materials costs are an important consideration for the auto industry. Inflationary trends in materials "have pushed the materials fraction of our total costs to an all time high". The trend is expected to continue (Table 7). For this and other reasons the scenario of auto materials supply, as perceived by the auto industry, is as follows:

(d) During the remainder of this decade materials will be an irritating and periodically critical supply problem area. Materials shortages will be prevalent. Not only in some individual commodity areas will there be insufficient capacity to satisfy demand, but there will be unprecedented world wide intense competition for materials. Some projections for the steel industry indicate a 2-10 million ton shortfall between demand/supply by 1980. The United States share of available world resources will decrease. We anticipate as likely possibilities materials embargo pressures

TABLE 3. SOURCES OF U.S. MINERAL REQUIREMENTS (1972).

Mineral	U.S. requirements imported, %	Major foreign sources
Metals		
Chromium	100	USSR, South Africa, Rhodesia
Aluminum (bauxite and metal)	%	Jamaica, Surinam, Canada, Australia
Manganese	95	Brazil, Gabon, South Africa, Zaire
Tin	77	Malaysia, Thailand, Bolivia
Nickel	74	Canada, Norway
Zinc	52	Canada, Mexico, Peru
Tungsten	44	Canada, Bolivia, Peru, South Korea
Vanadium	32	South Africa, Chile, USSR
Iron	28	Canada, Venezuela, Japan European Economic Community (EEC)
Lead	26	Canada, Australia, Peru, Mexico
Copper	18	Canada, Peru, Chile, Zambia, Zaire
Polymers		
Rubber (natural)	100	Malaysia
Petrochemicals (plastics and synthetic rubber)	29	Central and South America, Canada, Middle East

Source: Final report of the National Commission on Materials Policy (1973).

TABLE 4. U.S. RESERVES AND RESOURCES OF *AUTOMOTIVE MINERALS**

	Reserves (at 1971 prices) as % of probable cumulative demand, 1971-2000	Resources as % of minimum anticipated cumulative demand, 197 I-2000
Sufficient supply through 1980		
Iron	67	200-1,000
Copper Lead	87	70-200
	50	70-2(K)
Zinc	48	200-1,000
Vanadium	24	200-1,000
Insufficient supply through 1980		
Aluminum	3	200-1,000
Nickel	5	70-200
Tung Len	17	30-70
Manganese	0	70-200
Chromium		Insignificant
Tin	0	Insignificant
others		
Petroleum	14	70-200
Coal	Adequate	1 000,+
Natural Gas	25	30-70
Platinum	6	30-70

*Reserves are mineral deposits which can be exploited profitable under present economic conditions. Resources are reasonable known deposits, but requiring greater investment and additional technological developments.
Source: Final Report of the National Commission on Materials Policy (1973).

*TABLE 5. WORLD RESERVES AND RESOURCES OF AUTOMOTIVE MINERALS**

	Reserves Years of supply (Base: 1971 consumption)	Resources Estimated additional years of supply (Base: 1971 consumption)
Minimal world supply problem		
Iron	110	Large
Aluminum	185	Large
Nickel		Large
Vanadium	370	Large
Increasing world supply/cost problem		
Chromium		Large
Manganese	60	Large
Copper	45	
Tungsten	42	NA
Lead	23	100+
Zinc	23	100
Tin	17	30
Others		
Platinum	119	
Petroleum	35	200+ (shale oil and coal)

*Reserves are Mineral deposits which can be exploited profitably under present economic conditions. Resources are reasonably known deposits, but requiring greater investment and additional technological developments.
Source: Second and Third Annual Reports of the Secretary of the Interior (1973, 1974).

TABLE 6. U.S. AND WORLD MATERIALS REQUIREMENTS,

Commodity	Year	World requirements	Us. 70 of world
Aluminum (1000 metric tons)	1950	1,584	52
	1970	9,855	35
	2000	46,743	33
Copper (1000 metric tons)	1950	3,009	43
	1970	7,191	26
	2000	19,693	22
Iron ore [million tons)	1950	116	46
	1970	413	19
	2000		13
Zinc 1000 metric tons)	1950	2076	44
	1970	4,913	22
	2000	13,448	21
Liquid fuel (million metric tons, coal equiv.)	1950		58
	1970	2,328	35
	2000	8,498	25

and threats, with perhaps no long term sustained impact, but certainly capable of causing local difficulties.

Accordingly, a four-part strategy is proposed:

(e) 1. Alert, as early as possible, the outside market to any major upward shift in specific materials usage. We clearly recognize that two to three year lead time or more may be required for materials producers to effect significant capacity expansion.

2. The extended lead time emphasizes the need for establishing early-on, continuous liaison and communication among product planning/engineering, manufacturing and supply activities concerning product assumptions and materials requirements to ensure availability of required materials to support our future vehicle programs.

3. Maintain periodic updates of availability, supply and economic projections to establish a monitoring and early warning system.

4. Explore feasibility of alternate materials to provide flexibility to compete in shifting materials supply markets.

The auto industry's response to these challenges requires a strong R&D effort, directed toward (f) "materials substitution, recycling, solid waste disposal and materials processing to provide new sources of materials, reduce scrap generation and increase productive utilization

TABLE 7. MATERIALS PRICE INCREASES, SEPTEMBER 1973-SEPTEMBER 1974.

Material	Increase since October 1973, %
Steel	36
Aluminum (primary)	56
Aluminum (secondary)	76
Copper	43
Zinc	[illegible]
Magnesium	[illegible]

of available materials to offset tight supply and increasing costs of materials'

But materials shortages are only one aspect of concern for materials in the auto industry. Materials are a "key common feature" underlying efforts to deal with such other issues as:

(g) Materials Shortages
Energy Crisis
Exhaust Emission Control
Manufacturing Environmental Control
Safety, Damageability and Crashworthiness
Fuel Economy and Weight Reduction
Noise
Recycling and Solid Waste Disposal
Guaranteed Minimum Product Durability

Policies of R&D in materials for use in auto manufacture are extensively influenced by the diminishing availability of petroleum. On the subject of materials substitution, Dr. Harwood had this to say:

(h) The energy crunch has made weight reduction, in particular, a new way of life for the automotive industry. Lighter weight/higher strength materials, lighter designs and structures and new vehicle size and weight concepts are being intensively pursued. Starting with about 1971, increasing vehicle weight as a consequence of product improvements and the added requirements of safety, damageability and emission control systems became a problem of concern with reference to deteriorating fuel economy.

High strength-low alloy steels, aluminum alloys and plastics are the prime candidate materials being considered for weight-reduction opportunities. All three sometimes are in direct competition as substitutes for conventional low carbon steels so widely used in vehicle bodies and structures. Magnesium is also receiving more limited consideration and in the long term future the potential of high modulus/high strength composites may become practical.

A simplified analysis showing the thickness and weight reduction and cost savings possible through the use of HSLA steels is illustrated in Figure 1. This potential has led to detailed design studies which indicate that substitution of HSLA steels for some 300 lbs. of hot rolled low carbon steels can achieve some 50 to 75 pounds of weight saving.

Aluminum with a three-fold weight advantage over steel, obviously offers significant potential for weight reduction. Up to 75 pounds of aluminum are being used in current U.S. car models. The die-cast aluminum intake manifold for the 2.3 liter Pinto engine represents a 20-pound weight savings over cast iron at no cost penalty. In our Ford heavy truck W series, aluminum cabs weigh only 75% as much as steel cabs with a 460-pound weight saving,

As with HSLA steels, intensive development and application

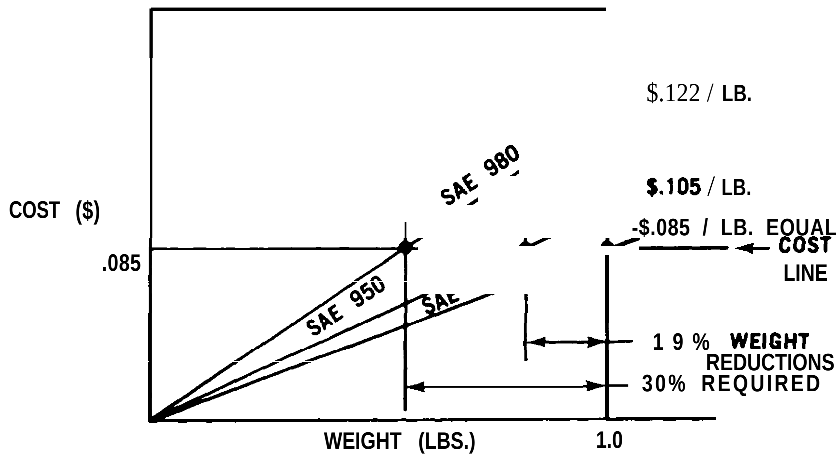

Figure 1.

evaluation programs are underway for the substitution of aluminum. These cover four main areas of application:

a. Wrought structural shapes—hoods, deck lids, tailgates, doors to replace sheet steel
b. Cast engine and powertrain components—engines, cylinder heads, transmission housings to replace cast iron
c. Radiators and heat exchangers to replace copper and brass
d. Wiring harnesses to replace copper,

HSLA steels are utilized extensively as bumper reinforcement bars in 1974 Ford vehicles. Brackets, frames, cross members, body structure components and the like are under prototype engineering evaluation for the weight saving potential of HSLA steels.

The combined utilization of HSLA steels and aluminum can achieve weight savings of hundreds of pounds in future car designs. There still are open technical issues to be completely resolved and there may be significant cost penalties involved with the use of aluminum sheet stampings, But the overall systems advantages from major integrated weight reduction might reduce the cost disadvantages to acceptable levels. Design studies and prototype programs to delineate and validate cost effective applications are being intensively pursued.

Among the new parameters in the future substitution of aluminum are the cost uncertainty and supply assurance. The aluminum industry is already performing at practically full capacity and increased automotive utilization of even 100 pounds per car will require major industrial expansion from the initial raw materials to foundry capacity and other fabricating facilities. In the new tight market place of materials any major shift in specific automotive materials usage or substitutions will require meshing with capacity plans of material producers.

This may be particularly true for plastics, which are so sensitive to the petrochemical feedstock supply situation. Petrochemical feedstocks currently consume about 5% of the supply of petroleum. By far the most dramatic growth of all of the automotive materials has been in plastics. The average 1973 car contained approximately 130 pounds of plastics (Table 8); conservative projections prior to the energy crisis indicated a 100%o increase in vehicle plastic usage by 1980. The stakes have become very high with new fabrication methods and new polymeric formulations opening up the vehicle market to exterior body use and structural applications. Sheet molding compound (SMC) practice is a notable example of this.

TABLE 8. PLASTICS USAGE PER CAR, INDUSTRY AVERAGE.

Model year	Pounds per car
1940	3
1945	5
1950	9
1955	15
1%0	20
1%5	32
1%8	50
1%9	65
1970	90
1971	110
1972	120
1973	130

But perhaps the real kick-off was the demonstrated experience that redesign in plastics would provide improved productivity and cost benefits, despite the often higher unit materials costs. Reduction in number of parts, assembly operations and labor all combined to produce a net cost savings. This is particularly true for front end assemblies. The 1974 Mustang II represents our first high volume car programmed with a one-piece plastic front end. Body panels, energy absorbing bumpers, deck lids, hoods, etc. are other application possibilities receiving much attention.

Continued development of plastic fabrication techniques, amenable to large volume production and higher forming rates, approaching metal stamping operations, will further accelerate exterior application developments.

It would appear that the competitive usage positions of steel, aluminum, plastics and other related materials, will depend markedly upon the relative price and capacity trends during the next few years. For some applications, relatively modest shift in prices can change the cost effectiveness and shift competitive aspects of substitution possibilities.

Before leaving the field of R&D opportunities in materials substitutions, let me mention briefly the exciting challenges offered in the development of an all ceramic gas turbine. At Ford Motor Company, a major program has been underway for several years to develop a high temperature (2500° F inlet gas temperature) small gas turbine. The key feature of this program is the focus on the design and application of ceramic materials and components of the hot end of the turbine. The compressor, combustion chamber, regenerator, stator, nose cone and turbine rotor are major ceramic components under development. Silicon nitride and silicon carbide are the most promising candidates for high temperature and high stress conditions associated with turbine stators and rotors.

One of the more intriguing features of these ceramic developments has been the use of polymeric materials and polymeric fabrication techniques to produce shapes which are later converted to ceramic forms by appropriate conversion techniques.

Obvious] y the successful development of this all-ceramic power plant and its introduction into commercial production would be a major step in altering the materials resource requirements of automotive power plants.

Attention is also being given to manufacturing processes as a means of reducing requirements for materials. "One R&D response . . . is to develop opportunities for reduction in amount of original starting materials, processing steps, machining operations, scrap and offal content, and overall manufacturing costs". Examples cited of R&D in this area involved powder metallurgy forgings, various pressure-

LASER WELDING

- **WELDING SPEEDS COMPARABLE TO CONVENTIONAL TECHNIQUES**
- **SMALL HEAT AFFECTED ZONE**
- **LARGE PENETRATION / WIDTH RATIO**
- **NO CONTACT WITH WORK REQUIRED**
  GAP SIZE OF .010 IN. CAN BE TOLERATED ON BURN-THROUGH WELDS
- **EASY MANIPULATION OF LASER BEAM**

Figure 2.

forming methods, and laser technology. (The advantages of laser welding are enumerated in Figure 2; other potential uses are laser cutting, machining, and heat-treatment.)

Efficiency of materials use cannot be permitted to stop with the shipment of automobiles from the factory, The automobile, Harwood observes, “represents the country’s greatest single source of recyclable materials’. Rate of recovery is high: between 80 and 90 percent of junked cars are now being recycled. As a major consumer of materials and as a major generator of “obsolescent’ ’scrap, the automobile industry occupies a dominant position in the total materials cycle. Accordingly, says Harwood:

(i) We may anticipate that our industry will be subjected to a variety of pressures with respect to both recovery and utilization of materials from the recycling of its products and to product design to enhance recyclability.

He goes on to discuss at some length the role of the industry in relation to secondary recovery of materials:

(j) A considerable amount of recycled materials is already used by the automotive industry, as shown in Figure 3. Unlike metals, little attention has been paid in the past to the recovery of scrap plastics and polymeric materials.

However, Figure 4 indicates the average weight of plastic materials which will be generated as waste from junked cars. Since more than half of the eight million cars scrapped each year in the U.S. are processed by about 100 auto shredders, these can be concentration sites for plastic scrap. A shredder is a giant hammer mill machine which shreds entire automobiles into fist size fragments. The process produces three fractions: (a) A magnetic or ferrous fraction which is transported to steel mills and foundries for reuse, (b) A non-magnetic fraction which

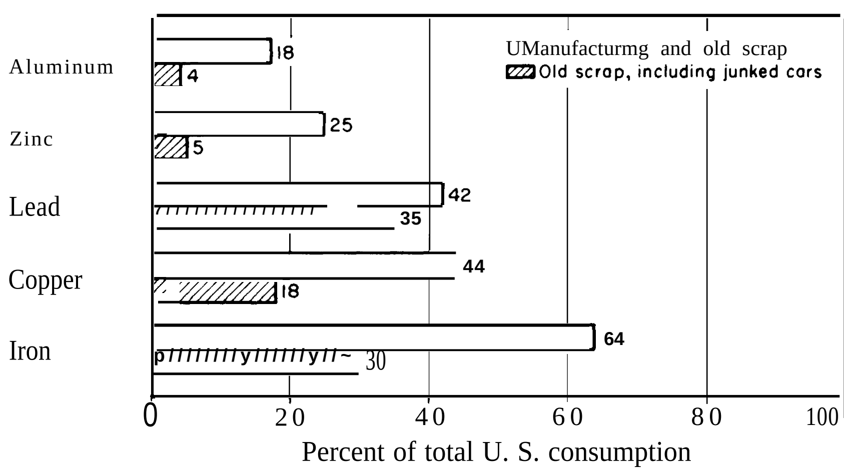

Figure 3. Nationwide recycled materials (1971).

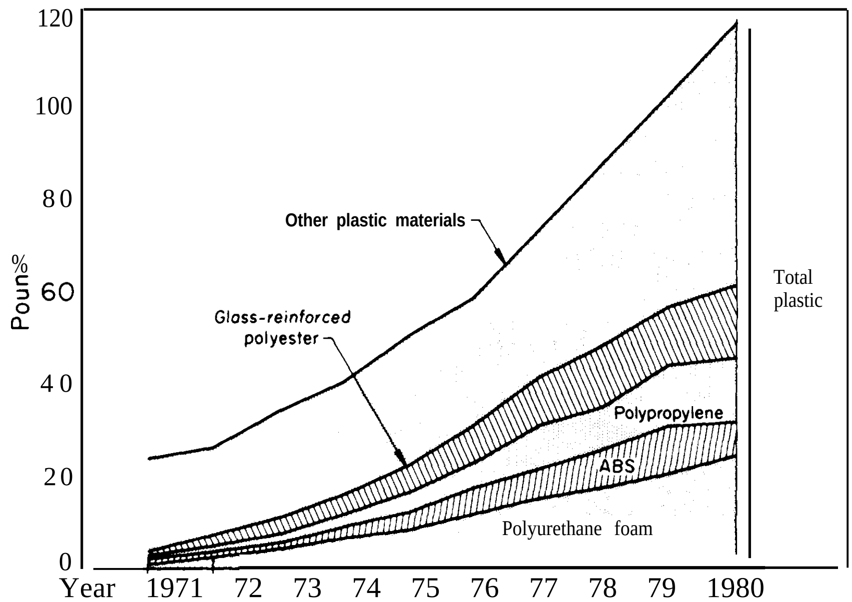

Figure 4. Average weight of plastic waste per junk car.

is shipped from many shredders to a few nonferrous metal recovery plants, and (c) An air fraction consisting of low density materials, used in the past for landfill. (Figure 5.)

After about 1975, million-pound quantities of ABS, polypropylene and polyurethane foam will be generated from an auto shredder processing 100,000 units per year, Since polyurethane

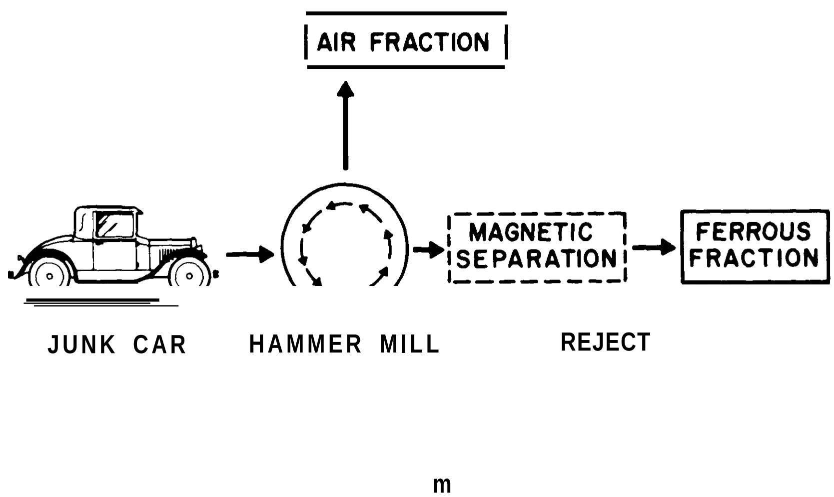

Figure 5.

foam is not a desirable landfill material, it can present a serious disposal problem by the late 1970's.

These considerations led to a cooperative Ford-Bureau of Mines program to explore methods for the recovery or disposal of these large quantities of plastic materials. Early results indicated that the recovery of plastics from shredded junk cars is technically feasible.

In our own laboratory, we have developed a relatively simple hydrolysis method which converts waste polyurethane foam into a liquid residue with a striking reduction in volume. The liquid itself, it is believed, can be used as a refoaming agent or for other chemical by-products. Engineering scale-up of this process is now underway. The process, of course, is adaptable to the reclamation of polyurethane waste generated during the manufacture of virgin foam products in our own plants.

The non-ferrous fraction from the shredders can be treated by dense media techniques for additional separation of materials. Table 9 presents the results of the density separation of plastics from the nonferrous fraction of a shredded 1972 Montego. Injection remolding of a fraction rich in unfilled ABS indicates that the remolded material has physical properties comparable with virgin reground ABS, (Figure 6). Work is underway to improve the impact properties of the remolded scrap through the use of blending agents. Recycling methods are also being explored for polypropylene, acrylics and PVC. One of the interesting questions to be answered is the possible degradation effects of long term aging, in service, on the properties of the reclaimed scrap.

The utilization of polymeric wastes as an energy (heat) source or for direct conversion into crude oil, is believed by many to be more attractive and feasible for the reclamation and reutilization of plastic scrap.

The automotive industry is one of the largest machine scrap generators in the world. Processes to convert such scrap to powder by crushing of the swarf have been recently developed and are potential new supply sources for iron powders. The iron powder

TABLE 9. ANALYSIS OF PRODUCTS FROM THE DENSITY SEPARATION OF THE NONMAGNETIC FRACTION (1972 MONTEGO TWO-DOOR G.T. HARDTOP SEDAN).

Product	1.075> d > 1.0 (lb)	1.16> d > 1.075 (lb)	1.20> d > 1.16 (- 1 inch)	(+ 1 inch)
PMMA		0.04	2.57	
ABS (filled)		2.84		
ABS (unfilled)	15.3			
Polyvinyl butyral		0.87		
PVC-coated fabric		0.06	0.16	3.33
Rubber	0.4	3.63	0.66	1.66

INJECTION MOLDED ABS	RECLAIMED SHREDDER SCRAP	VIRGIN GRADE	VIRGIN REGROUND	VIRGIN REGROUND & BLENDED
TENSILE STRENGTH – (PSI)	6300	5500 MIN.	5500	5500
FLEXURAL YIELD STRENGTH – (Psi)	8500	9000	9000	
IZOD IMPACT STRENGTH (FT.-LB. / IN. OF NOTCH)	1.5	2.0-2.5	2,0	3.0

Figure 6.

obtained is useful for both conventional sintering practice and for the P/M forged preforms previously discussed, Cost estimates indicate economic feasibility for a facility to handle scrap produced by a typical, large automotive plant to produce powder of high commercial value from a low cost, contaminated, bulky scrap product. The General Motors Macro Mesh Process has been announced as being scheduled for production, to reclaim such machine scrap.

These are but a few examples of R&D approaches to recycling of scrap and wastes. We are convinced that this will be an increasingly important area to alleviate future materials shortages, offset rising prices and to optimize our utilization of resources.

By way of summary, Dr. Harwood observes that “Materials no longer can be treated as an independent variable in the materials/product transfer process. ” Noting the interdependent relationship among materials, energy, and environment, he calls for “integration of materials, design, and processing into a materials systems approach”. He continues:

(k) Realistic trade-off analyses and optimization of solutions to materials problems require the early integration and simultaneous satisfaction of all three factors in a materials systems way of life.

I would suggest that this not only has implications to industrial organizational and institutional arrangements for utilization and management of materials, but equally so for the education of materials graduates and perhaps more importantly for the entire engineering curricula as well. ”

In summary, “the recent problems of materials availability, supply and costs have put a new focus on the role of materials in industrial operations and in national affairs. Perhaps, in a peacetime situation, it proved to be a needed catalyst for the proper recognition of the pervasive force of materials technology throughout our world. For the automotive industry in particular, future trends in materials supply and cost will certainly be an additional pressure and intensify other pressures. R&D programs in substitution, conservation, reclamation and management of materials can provide responsive opportunities to offset some of these pressures and problems. Materials processing and manufacturing research, recycling and a materials systems approach are key elements in the R&D response of the automotive industry in meeting materials resources challenges.

II. TUTORIAL PAPERS

This section of the Proceedings contains five lectures on the five major policy areas addressed by the conference. The paper by Mr. Promisel was not delivered at the conference but was supplied later; in its place, the conferees heard a series of short presentations on various international aspects of materials policy.

The five major areas dealt with in these papers are: the current state of materials information management in the United States; the present condition of U.S. supply of materials; the opportunities for materials conservation through engineering design; the current state of recycling and re-use of materials recovered from municipal solid waste; and the potential contributions of the technical societies in materials fields to national and international goals of society.

Materials Information: An Examination of the Adequacy of Existing Systems

J. H. Westbrook
General Electric Company

Introduction

It has been said that the possession of materials, the understanding of materials and the ability to use materials have been the determinants of every civilization the earth has ever known. If this be granted, then *information* on materials is an even more basic building block in a flourishing society. We need to know the amounts and the qualities of the material resources we possess (or lack), we must record, catalog and retrieve the myriad facts, theories and observations that constitute our understanding of materials, and we must have sufficient handbooks, manuals, texts and tutorial works to guide our citizens in their use. Despite this basic and critical position of materials information, we have become all too familiar with what may be called the materials information syndrome among the users of this information. This syndrome comprises bewilderment, apprehension, dismay, frustration, and outrage: *Bewilderment* with respect to the enormous volume and diversity of needed sources of information; *Apprehension* as to the quality and reliability of those facts; *Dismay* at the redundancy, gaps, and lack of coordination between information sources and systems; *Frustration* with the mechanics of search, retrieval and manipulation of information from the general store; and *Outrage* at the cost of seeking and locating needed information.

There appears to have been adequate prior recognition of the importance of this problem and the urgency to do something about it on a comprehensive, coordinated national scale. Looking only at reports and conferences of the several recent national ad hoc commissions addressed to questions of materials policy, we find that the two earlier Henniker Conferences of 1970 and 1972, the 1973 NCMP report, "Materials Needs and the Environment", the 1973 FMS report, "Conservation in Materials Utilization", and the 1974 COSMAT report, "Materials and Man's Needs", all placed this question high on the list of priorities. Unfortunately, these reports offer few specifics in proposals for alleviating the problems alluded to above. Further recognition of the high importance of the problem of materials information was the action by the recently formed Federation of Materials Societies in establishing a standing Materials Information Committee. This Committee was in the early stages of planning and implementing its program of activities when a request came to it from the Office of Technology Assessment to conduct a quick but comprehensive survey of the breadth and intensity of the materials information problem. Such a survey was mounted and this paper is an interim report of some of its preliminary results although the survey is still in progress.

Methodology of the Survey

A four-page questionnaire was designed* and circulated to about 4000 addressees. These were selected from conference registration lists of persons previously evincing an interest in materials information, from nominations by the constituent societies of FMS, from special interest groups such as the Special Libraries Association and from the discipline indices of the 12th edition of *American Men and Women of Science.* This multifaceted approach was taken to ensure reasonable coverage of all elements of a large materials-information matrix embracing all kinds of materials and all types of information. The questionnaire posed both general questions as to the nature and importance of the materials information problem and specific questions about the attributes of certain information sources frequently used and highly valued by the respondent. At the time of preparation of the present paper, about 700 replies had been received, the quantifiable data key-punched and

*Although the membership of the Materials Information Committee of FMS is broader still, those members of the Committee who participated in the design, circulation and analysis of this questionnaire were: J. H. Westbrook (General Electric Company) Chairman; Felice Celli (Chemical Abstracts); Edward Dugger (US Air Force); Franklin Huddle (Library of Congress); Morton Malin (Institute of Scientific Information); Robert Marvin (National Bureau of Standards); Dana Moran (Battelle Memorial Institute); and Theodore Rupprecht (Bendix Corporation).

computer-analyzed. This response was not as great as had been hoped. Many people apparently had difficulty with the questionnaire—some finding it excessively broad and open-ended; others viewing it as much too specific. Nonetheless, it appears that the volume of response is already sufficient and the pattern of replies to individual questions such as to give some useful insights to the general problem.

The Respondents

An early question on the form asked the respondent to characterize himself as to the nature of his disciplinary field, his institutional affiliation, and his function within his institution. The results are summarized in Figure 1. This result is satisfying in that it shows we had a diverse response in all of these respects. It might only have been hoped to have had a larger response from information specialists and design engineers although it is admittedly difficult to identify individuals from these disciplines who simultaneously have an interest in, and some familiarity with, materials and materials information sources.

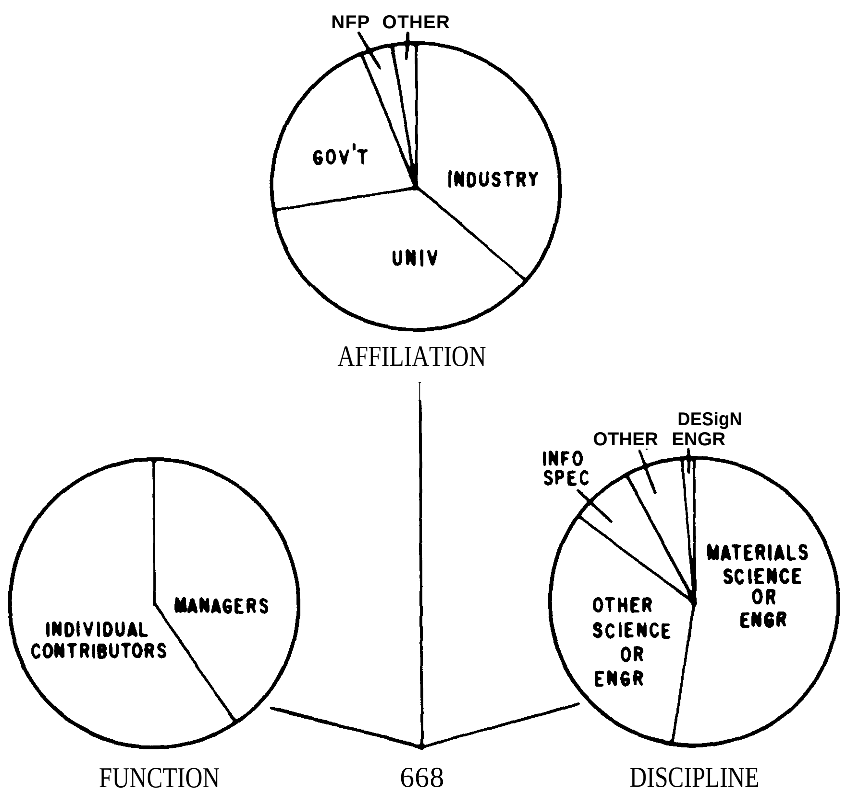

Figure 1. Respondents.

FIGURE 2. RESPONDENTS TO QUESTIONNAIRE.

University	Materials scientists/engineers	[illegible]	88
University	Other scientists/engineers	IC	84
Industry	Materials scientists/engineers	MGR	78
Industry	Materials scientists/engineers		60
Government	Materials scientists/engineers	MGR	40

FIGURE 3.668 USABLE RESPONSES TO QUESTIONNAIRE.

Materials	Engr prop	Sci data	Eval tech	Applic	S/D stat	Supp	Totals
Metals and ores	68	71	15	22	31	29	236
Minerals	11			10	21	7	94
Forest products	13	38	4	10	20	8	93
Polymers	16	28	5	10	2	1	62
Ceramics and glass	16	41	2	12	1	1	73
Textiles and agricultural products	4	13	1	8	2	1	32
Chemicals, lubricants and finishes	4	26	0	6	5	2	44
Semiconductors	7					0	34
Totals	139	277	39	82	82	49	

Figure 2 shows the most heavily populated groupings of respondents when the various combinations of affiliation, discipline, and function are considered. Individual contributor materials scientists/engineers with university affiliation top the list. The distribution of respondents over the materials-information matrix is shown in Figure 3.** Here again the results showed that we had indeed cast our net quite broadly. There are few sparsely populated cells and this defect should be readily remedied in further extension of the survey.

Importance of Materials Information

Asked to assess the importance of improved materials information systems to the national interest, respondents replied as shown in Figure 4. Less than 15% find the present situation satisfactory and more than a third rate it highly critical. These responses were broken down by affiliation, discipline and function as shown in Figure 5 but no significant differences are revealed (too few designers replied to represent their percentage response). Broken down once again by the matrix categories of Figure 3, the replies are distributed according to intensity of need as shown in Figure 6. Better information on Supply/Demand Statistics and Evaluation Techniques on metals and their ores is most keenly felt followed by that for Applications, Engineering Properties and Scientific Data on a wide variety of materials.

***For the purposes of this interim report, some of the columns and rows of the original 9 x 15 matrix were melded together to yield the 6 x 8 form shown here.*

General Views *and Recommendations*

Respondents were asked to specify what they perceived as the greatest deficiency in materials information with respect to the national interest in a free-form response. These responses naturally varied widely in wording and specifics, but after grouping replies into a small number of categories, Figure 7 was compiled. It should be noted that the idealized system filling the greatest perceived need has three distinct attributes: it is comprehensive (at least from the standpoint of one user); it is machine readable, and it is continuously updated. It must be pointed out, as will be seen later, this does not imply a single, all-encompassing computer information bank of all materials information; but rather one which is comprehensive only as regards a single element (or a few closely related ones) of the matrix of Figure 3.

Another question asked for the favored broad objective in improvement of our national management of materials information with the result shown in Figure 8. Less than half the respondents seek an

FIGURE 4. IMPORTANCE OF IMPROVED MATERIALS INFORMATION SYSTEMS.

Assessment	70
Highly critical	36.5
Important	48.5
Satisfactory	11.6
Attention. selected area only	3.3

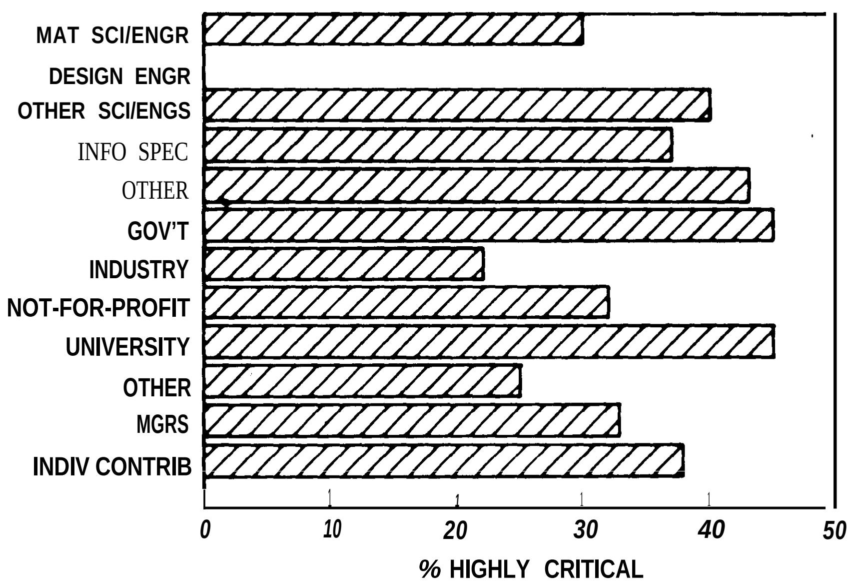

Figure 5. importance

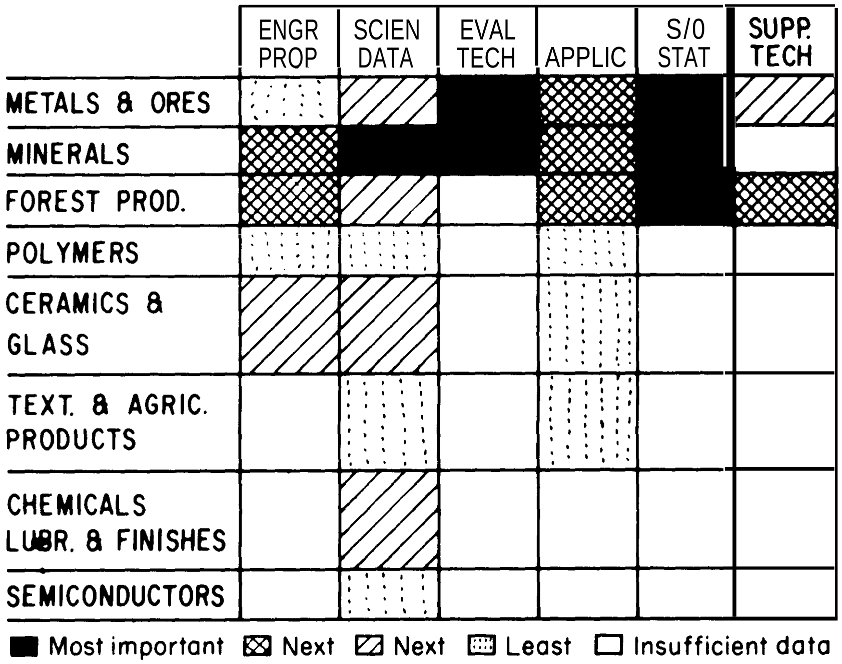

Figure 6. 668 **usable responses.**

integrated national system and even some of these may be looking at the question in the narrower sense discussed above. There is support for selected improvements to our present pluralistic system.

A common observation, particularly by information specialists, is that lack of awareness on the part of potential users of presently existing information sources inhibits their full utilization. The results of Figure 9 would indicate that while this may be true to a degree, it is spotty rather than general in occurrence. A closely related question sought to discover whether it was important to educate materials specialists in information sources and information handling techniques or correspondingly to educate information specialists in the vocabulary and information needs of materials specialists. Figure 10 shows that both these aspects are held to be important.

Figure 11 supports the widely held view that as far as technology is concerned, we are, indeed, "one world" and we in the U.S. cannot

FIGURE 7. PERCEIVED NEED.

Comprehensive, machine readable, continuously updated information system	111
Handbooks, reviews, compilations with critical evaluation and coordination	107
Lag in availability of information	47
Problem of proprietary information	
Better economic statistics, supply/demand, etc.	42
Problems of coping with foreign information	29

FIGURE 8. FAVORED OBJECTIVE.

Comprehensive, integrated, national system	44.0%
Improved present pluralistic system	43.2
No change	12.8

FIGURE 9, AWARENESS BY USERS.

Sufficiently aware	41 .6%
Some blind spots	44.4
Woefully ignorant	14.0

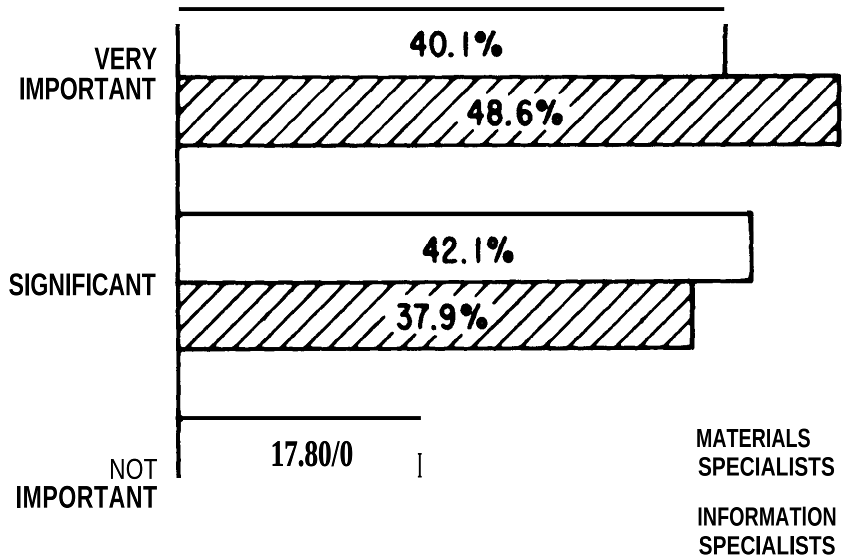

Figure 10. Education.

FIGURE 11. U.S./FOREIGN INFORMATION.

Well coupled	32.0%
Not well coupled	64.5
Not important	3.5

FIGURE 12. WHO SHOULD PAY COSTS?

Shared	54.2%
Government mission agency	22.8
	17.6
Professional societies	3.5
Other	I .9

ignore the materials information generated and organized by foreign sources. Two-thirds of the respondents believe we are not adequately coupled to these sources.

Various schemes for paying the costs of materials information management have been assayed in recent years. The findings of Figure

12 clearly reject the traditional approaches and opt for some form of cost sharing.

Attributes of Specific Information Sources or Systems

A major portion of the questionnaire dealt with this topic. The respondent was asked to cite the four most important specific, not generic, sources of systems of materials information in the materials-information matrix category with which he most readily identified himself. Then he was asked to evaluate each source cited with respect to 10 qualities or attributes. Space does not permit inclusion of all these results here, but some of the more interesting will be presented.

The most startling result was that the 668 responses to the questionnaire evoked the citation of 574 unique sources despite the fact that many ignored the direction and cited generic sources such as “the technical literature” or “my Company’s files”. This great diversity of important sources is one of the root causes of the materials information problem. Although the data scatter too widely to permit rank ordering of individual sources, the leading specific sources are listed in Figure 13 and the most important generic sources in Figure 14. Here again the strength of a diverse, pluralistic information base are illustrated both with respect to the form of information collection and to the sponsoring body (government or professional society).

The great number of specific sources cited by respondents precluded the collective assessment of individual sources. Consequently, all that has been possible to this point is to lump all these assessments together. This procedure at least permits an evaluation of the characteristics of materials information sources in general. Figure 15 shows that few sources are complete in the sense of containing all of known information while Figure 16 shows an analogous deficiency in serving the existent national needs for materials information. Quality of information is generally good to excellent with little that is imprecise, unreliable or obsolete (Figure 17). Under the rubric “accessibility” the barriers posed

FIGURE 13. MOST IMPORTANT SPECIFIC SOURCES.

Chemical Abstracts	US Bureau of Mines	ASTM
Journals, American Ceramic Society	US Geological Survey	MCIC
Journal, Polymer Science	US Forest Service	ASM Metals Handbook

FIGURE 14. MOST IMPORTANT GENERIC SOURCES.

Source	No. of citations
Primary literature	513
Abstracts, journals, indices, bibliographies	368
Information centers	358
Handbooks and data compilations	257
Professional societies	127
Review serials	32

FIGURE 15. COMPLETENESS.

100% (approx)	14.7%
75% (approx)	31.0
50% (approx)	27.1
Less than 20%	27.2

FIGURE 16. ADEQUACY.

Classification	
Serves all needs	8.2
Serves most needs	57.9
Many not served	33.9

FIGURE 17. QUALITY.

Excellent	29. 1%
Good, some deficiencies	63.8
Imprecise, unreliable or obsolete	7.1

FIGURE 18. ACCESSIBILITY.

Adequate	56.9%
Limited	32.1
Very limited	11.1

FIGURE 19. SYSTEMS INTERFACE.

Very well	46.9%
In part	42.4
Not at all	10.7

FIGURE 20. RESTRICTIONS

Non-English language	15.67.
Military classification	3.6
Company proprietary	22.4
Specialized terminology or orientation	48.5
Other	9.9

by cost, arrangement of information and time delay in search and retrieval were assembled. Figure 18 shows that less than half the respondents found this factor limiting the utility of the sources cited. Compatibility y of the source in interfacing with other information systems was not found to be a major problem (Figure 19); while user qualifications present barriers to utilization that are held to be of various degrees of importance (Figure 20). Of special significance is the finding that the specialized terminology or orientation of many information sources impedes their full utilization by all potentially interested persons.

Concluding Remarks

This preliminary survey conducted for the Office of Technology Assessment has produced many useful insights into the problems of the management of materials information. The more important of these can be summarized as follows:

1. The critical importance of the materials information problem is recognized broadly.
2. Attention is required for improved evaluation, condensation, presentation and mechanization of materials information.
3. There are special problems with proprietary information, foreign information, and supply/demand statistics.
4. There are educational problems acquainting information specialists with the needs of materials people, teaching materials technologists the tools and techniques of information specialists and in presenting design engineers with materials information in a form they can understand and use.

It is planned that this conference will operate in the mode of parallel task forces addressing themselves to each of the problems selected for study. With respect to the problem of the management of materials information, we would offer the following specific charges to the task forces:

1. Goals
   a) definition of *specific, attainable,* goals
   b) assignment of priorities to these goals
2. Means of implementation
   a) setting up alternative routes toward each goal
   b) choosing between these alternatives
   c) in-depth analysis of a specific plan toward each goal
3. Value of information
   a) how to fix the proper amount of money to be spent for information
   b) how to allocate costs of information
   c) how to demonstrate benefit/cost ratio for information

The success of the Conference with respect to the materials information problem will be measured in large part by the degree to which the task forces have grappled with these specifics.

THE CURRENT STATUS OF THE U.S. MINING INDUSTRY AND THE NEED FOR BOTH INCREASED PRODUCTION AND INCREASED PRODUCTIVITY

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Assistant Director—Mineral Position Analysis
Bureau of Mines, Department of the Interior

Abstract

The U.S. economy annually needs over 4 billion tons of new mineral supplies. The value of domestically produced energy and processed materials of mineral origin exceeds $175 billion annually, but domestic production of both raw and processed minerals is not keeping pace with demand.

Mining and agriculture are the primary sources of all new wealth and minerals are the lifeblood of any industrialized civilization. Annually, the economy of the United States now requires over 4 billion tons of new mineral supplies. Two decades ago that tonnage was only half as large, while projections indicate that demand could nearly triple from present levels by the year 2000.

In 1973 the U.S. economy reached a new annual high of $1,288 billion, increasing each quarter. However, there was a relative plateauing in the last quarter of the year, reflecting the impact of the “energy crisis” precipitated by the Arab oil embargo. The value of domestically produced energy and processed materials of mineral origin was estimated to be more than $175 billion in 1973, based largely on mineral raw materials of domestic origin valued at $35 billion, supplemented by imports of raw and processed mineral materials valued at $19 billion. Imports were, however, offset to some degree by exports of raw and processed minerals valued at $11 billion, leaving a net U.S. deficit of the order of $8 billion. This deficit, which has been increasing over the years, is a major factor pointing to the need for increased domestic productivity. As detailed in Figure 1, crude and refined petroleum and iron and steel were the major items contributing to the net deficit position. Imports of both those major materials have been rising steadily over the past two decades, as shown in Figures 2 and 3.

In 1973, domestic production of most major metals, led by a 14 percent rise in domestic raw steel production, was up somewhat and

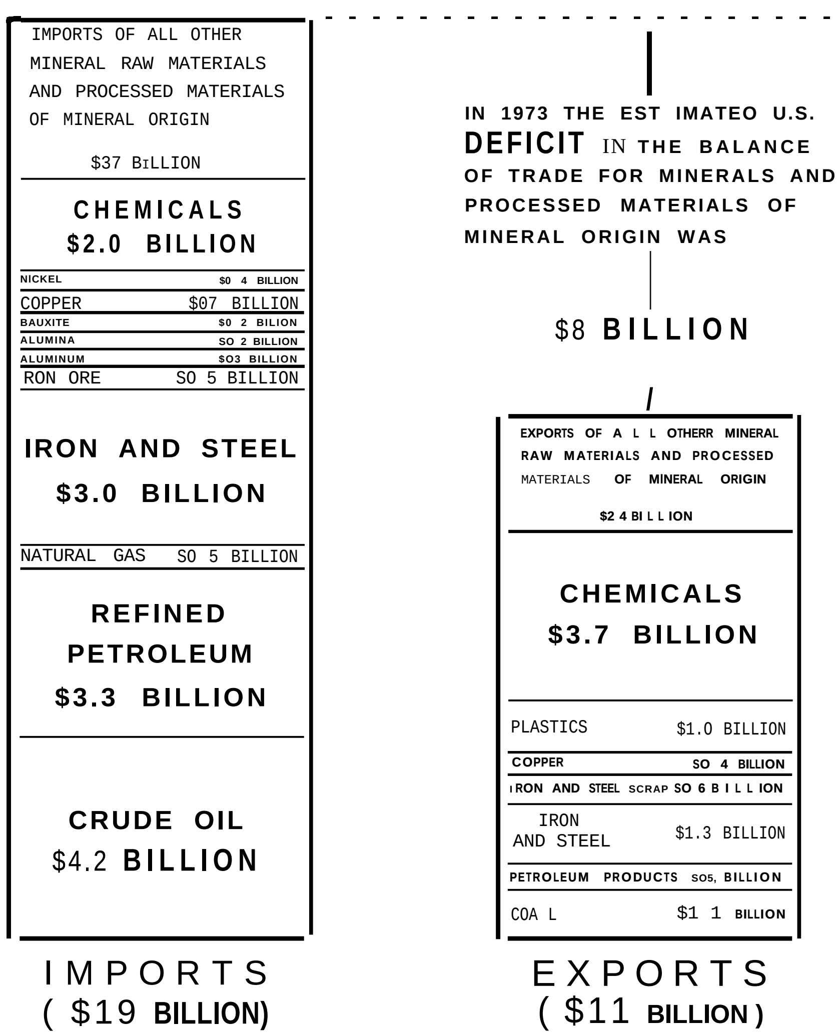

Figure I. U.S. mineral import deficit (1973).

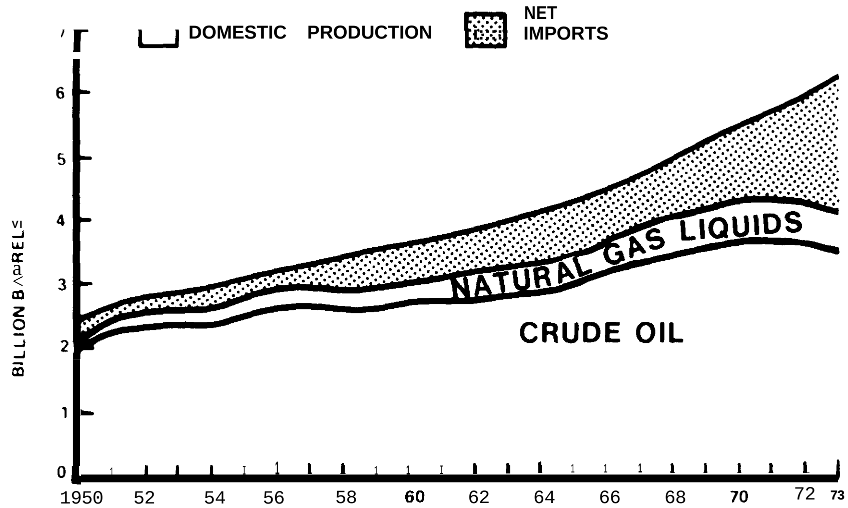

Figure 2. U.S. supplies of petroleum (1950 through 1973).

domestic production of most nonmetallic was also up. However, on an overall basis, domestic mineral production is *not* keeping pace with domestic demand. In 1973 demand for minerals was stimulated in part by business expenditures for new plant and equipment estimated at $100 billion, while the value of new construction put into place was valued at $135 billion. Demand for motor vehicles also stimulated demand for minerals because about one-fifth of our steel and proportional quantities of many other minerals are so used: 1973 production of

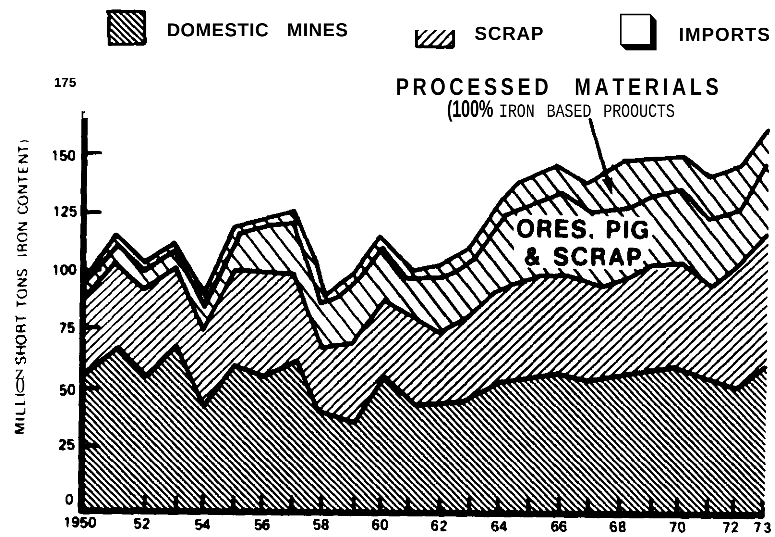

Figure 3. U.S. supplies of iron and steel (1950 through 1973).

new automobiles was up 9 percent to a total of 9,667,000 units and truck production was up 21 percent to a total of 3,014,000 units.

Despite a variety of price controls in effect in 1973 pursuant to the Economic Stabilization Act of 1971, as amended, the wholesale price indexes of major mineral commodity groups increased. The 1973 indexes, based on 1967 = 100, were as follows: metals and metal products, up 7.5% to 132.8; nonmetallic mineral products, up 3.3% to 130.2; chemicals and allied products, up ***5.670*** to 110.0; and fuels and related products and power, up 2370 to 145.5. These price increases are another major factor pointing to the need for increased productivity. Domestic price controls were alleged to have created a number of anomalies in the mineral industry in 1973, including such diverse impacts as creating domestic "shortages" of ammonium nitrate for fertilizers and explosives, of roof bolts for coal mine safety, and of domestic copper, lead, zinc, and other materials in instances where world prices rose significantly above domestic prices and where United States export controls were either not in effect or inadequate. The President, in his February 1, 1974, "Economic Report to the Congress" recognized the importance of free markets, stating:

> "In the past several years, under the pressure of emergency conditions, we have made great, but temporary, departures from reliance on free prices and free markets. In special circumstances and for short periods these departures have been helpful. But taken together, these experiences have confirmed the view that the free market is, in general, our most efficient system of economic organization. and that sustained and comprehensive suppression of it will not solve the inflation problem".

In line with this philosophy, price controls on all metals except steel, copper, and aluminum were lifted completely in December of 1973, and controlled rises in some of these product areas were permitted. All price controls expired on April 30, 1974, except those on petroleum.

In mid-1973, the Secretary of the Interior issued his "Second Annual Report Under the Mining and Minerals Policy Act of 1970. " Stating that "development of domestic mineral resources is not keeping pace with domestic demand, " he cited nine major problem areas confronting the mining, minerals, metal, mineral reclamation, and energy industries as follows:

(1) Mineral imports have an unfavorable impact upon the U.S. balance of trade and upon the U.S. balance of payments;

(2) Expropriations, confiscations, and forced modifications of agreements have severely modified the flow to the U.S. of some foreign mineral materials produced by U.S. firms operating abroad, and have made other materials more costly;

(3) U.S. industry is encountering greater competition from foreign nations and supranational groups in developing new foreign mineral supplies and in assuring the long-term flow of minerals to the United States;

(4) Development of the U.S. transportation net is not keeping pace with demand, thus seriously affecting the energy and minerals industries;

(5) Removal of billions of tons of minerals annually from the earth contributes to a variety of disturbances;

(6) The U.S. mining, minerals, metal, and mineral reclamation industries are encountering increasing difficulty in financing needed expansion of capacity and the introduction of new or improved technology;

(7) Management of the resources of the public lands, including the continental shelves, must be improved;

(8) The factual basis for the formulation and implementation of environmental regulations must be improved, so that man and nature are properly protected with minimum dislocation of important economic activities; and

(9) The U.S. Government information base for the conduct of its mineral responsibilities is grossly inadequate.

A number of corrective legislative recommendations were made, including creation of a Department of Energy and Natural Resources, provision of an organic act for the Bureau of Land Management, revision of the mineral leasing laws, regulation of surface mining activities, amendment of the Natural Gas Act, construction of deep-water ports, and modification of right-of-way limitations, but only the latter, as the Alaska Pipeline Bill, was enacted into law in 1973, and the other recommendations were carried forward into the considerations of the Congress in 1974. Also in mid-1973, the National Commission on Materials Policy issued its "Final Report" which made 177 detailed recommendations, those affecting minerals being in close agreement with the Mineral Policy Report. Perhaps, the most significant recommendation of the NCMP was that—

> "it should be the policy of the United States to rely on market forces as a prime determinant of the mix of imports and domestic production in the field of materials but at the same time decrease and prevent wherever necessary a dangerous or costly dependence on imports".

While our economy has grown over the years, that of the world has increased even more, so that today we are finding ever increasing competition when it comes to acquiring needed raw materials, while, at the same time, we are also finding it increasingly difficult to sell many manufactured articles in world markets to pay for imported raw materials. Two decades ago, the United States produced about one-half of the world's steel as shown by Figure 4, whereas today, despite growth, we now only produce one-fifth. Similarly, as shown by Figure 5, where we once produced larger fractions, today we produce only one-fourth of the world's refined petroleum, and one-third of the world's aluminum metal. And, as shown by Figure 6, we are dependent upon imports for substantial portions of a number of important mineral materials. Lessening such dependence by increasing domestic production and/or productivity would be highly desirable.

The natural resources of the United States are vast, but to be useful to man natural resources must be found, developed, and processed. The natural resources of any nation are related to its size, its geology, and its location on the earth. Only one nation—the Union of Soviet

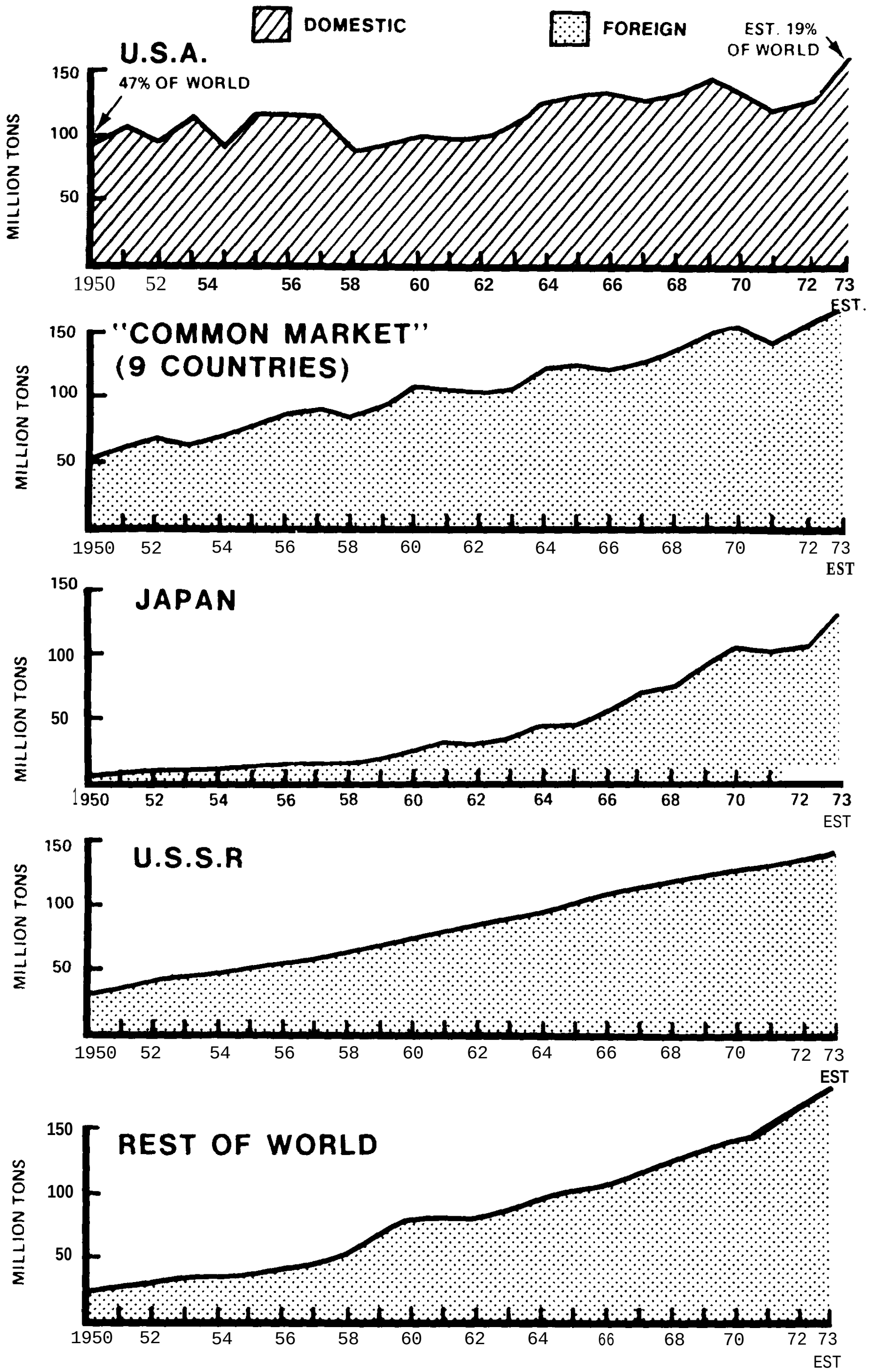

Figure 4. World steel production (1950 through 1973).

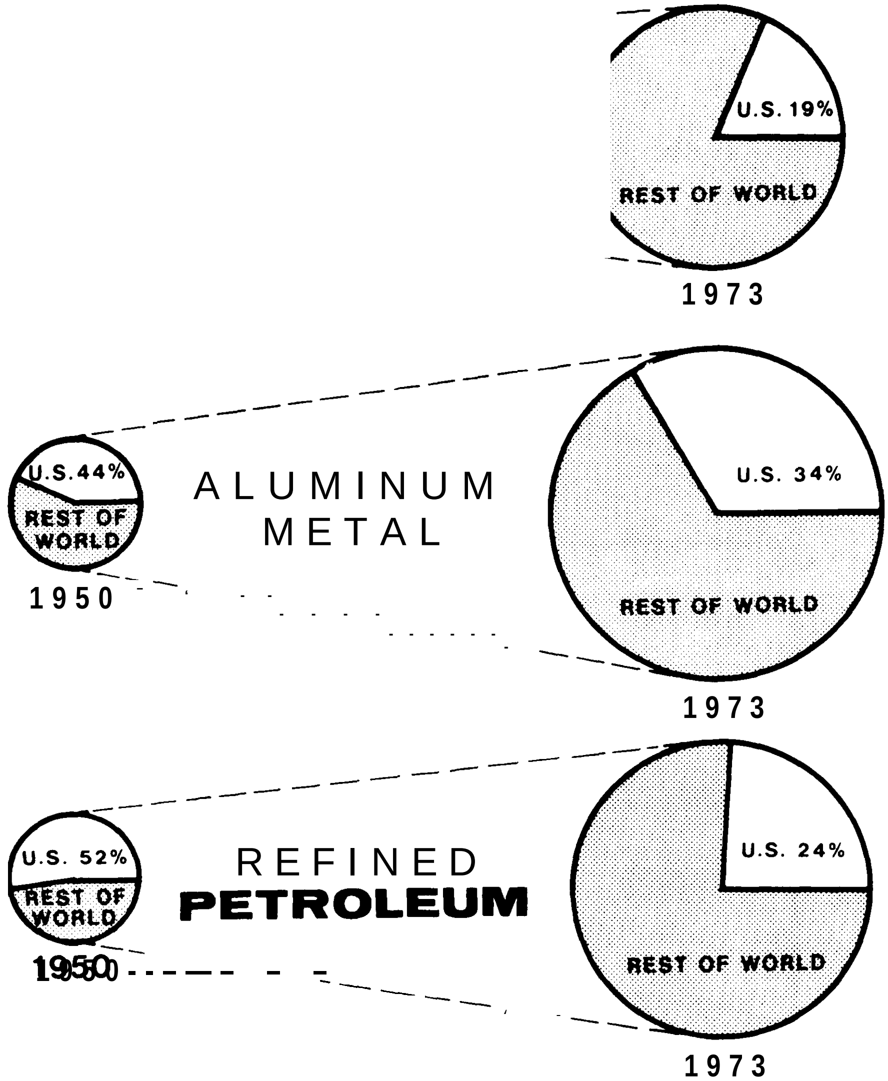

Figure 5. U.S./world production (1950 and 1973).

Socialist Republics—substantially exceeds the United States in land area, and only four other nations—the People's Republic of China, Canada, Brazil, and Australia—have land areas about the size of the United States. In addition to its land area, the United States has extensive continental shelves and direct access to the seas and the seabeds of the world. The United States has almost every type of geologic formation within its borders. As a consequence of its size, geology, and geography, the United States has vast resources of rocks and minerals, soils, subsurface fluids (including oil and gas), waters, and air.

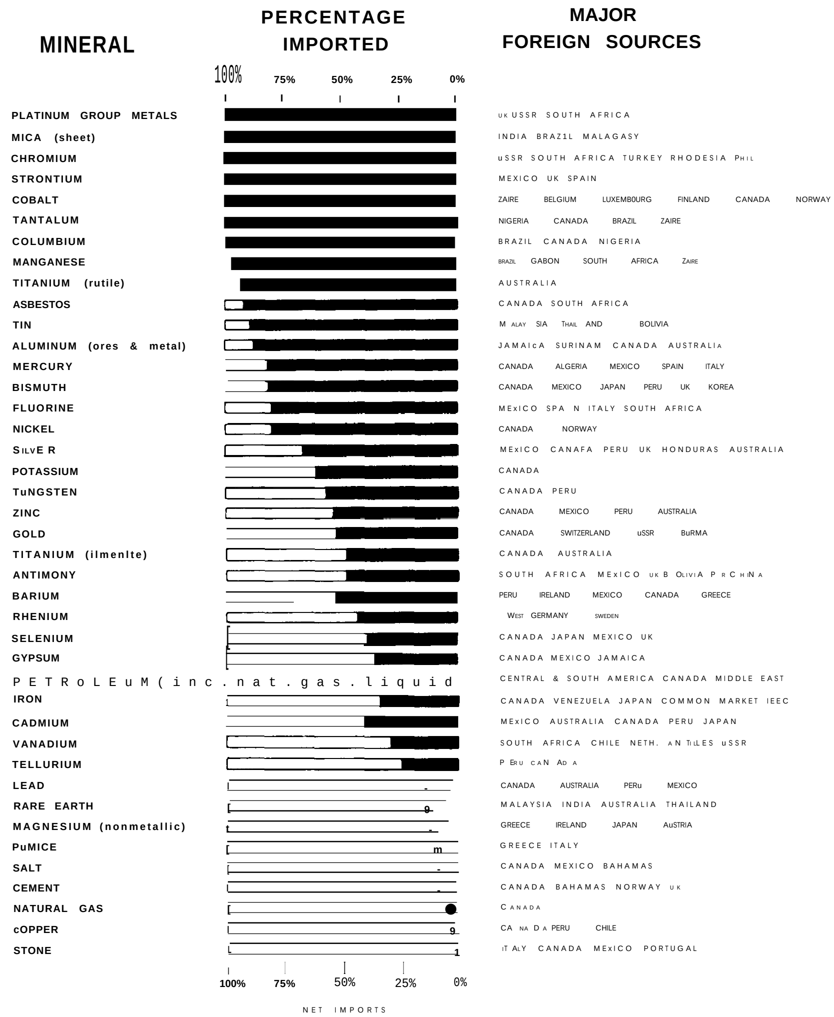

Figure 6. U.S. dependence **upon imports (1973)**

However, to convert natural resources into useful materials technology must be continuously improved; the technology must be workable at reasonable prices; the processes must be compatible with environmental regulations and industrial health and safety standards; and the business must yield profits comparable with other economic activities. Examination of Figure 7 covering debt/equity ratios and of Figure 8 covering profits as a percent of stockholders' equity indicates that some major segments of the mineral industry are not in as satisfactory position as ''all manufacturing' as a whole. Consequently, improvement of productivity is essential.

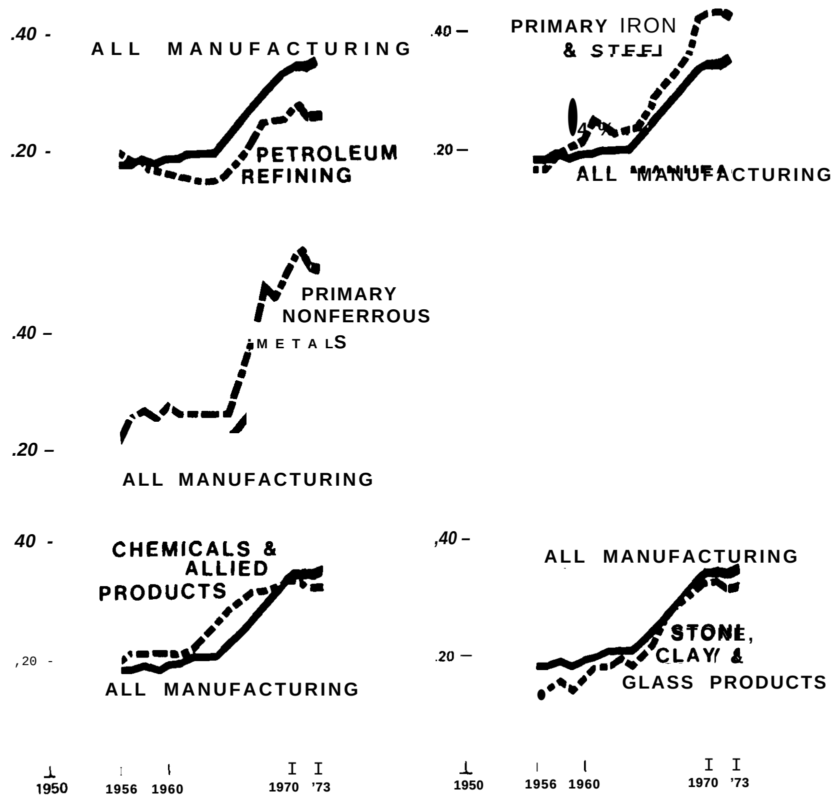

Figure 7. **Debt/equity ratios (1956 through 1973). Numbers are ratios** of dollars involved.

Mineral deposits generally are harder to find and assess than agricultural resources, because most mineral deposits are located out of sight below the earth's surface. Our deepest mines have penetrated only somewhat beyond a mile in a few places and our deepest wells only to about six miles in a few places. Our deepest dredges now operate in only a few hundred feet of water; yet it is nearly four thousand miles to the center of the earth. Through the study of geological maps and the making of complex geophysical and geochemical measurements skilled geologists can, in some cases, infer what lies below the surface. Obviously, in areas where the rock strata are relatively uniform and cover many square miles, inferences as to what may be found below are better than in areas of very complex geology where heat, pressure, and earth movements have greatly deformed the rocks. Mineral deposits that have been found, adequately drilled to determine their content of valuable minerals, and that can be mined, processed, and converted into useful materials with known technology at reasonable prices are commonly called "reserves. " (Example: the rocks of the earth's crust average 5% iron, the United States has vast "resources" of rocks

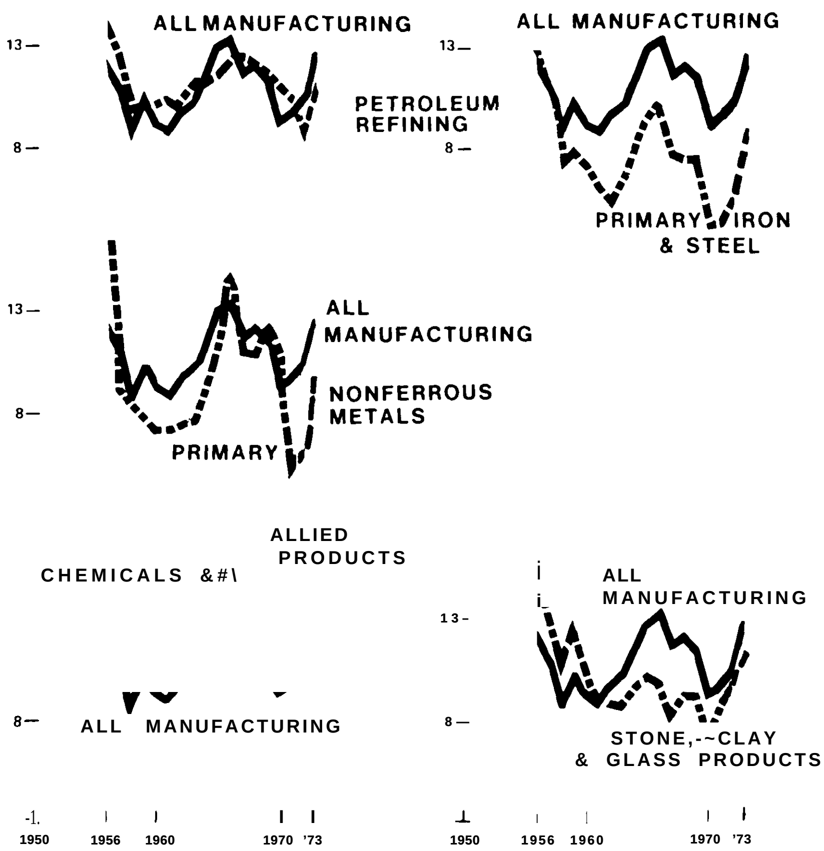

Figure 8. Profits as a percent of stockholders' equity (1956 through 1973). Numbers are percentages.

containing more than 5% iron; the iron ore "reserves" of the United States are 10,000,000,000 tons, which in turn contain 2,000,000,000 tons of recoverable iron metal, compared to U.S. steel production of 151,000,000 tons in 1973). Agricultural materials are generally renewable in relatively short time spans, in that some crops can be raised four or five times a year, annual cycles are common, and softwood trees can be raised on fifteen to twenty year cycles. Mineral deposits, however, normally are formed only over much longer periods of time—usually tens of millions or hundreds of millions of years. Consequently, the total supply of all minerals accessible to man in the earth's crust is, to all practical purposes, relatively fixed; consequently, mineral materials are generally of greater concern to nations with heavy industry.

Other than in nuclear processes, elements are neither created nor destroyed—man's processing merely combines them in certain ways, recombines them, or reduces combinations into elemental form. Thus, the materials industries are engaged in extracting elements from natural materials, and/or combining or recombining them into forms useful to man. Nature itself is constantly engaged in vast processing activities, in which the ‘‘carbon-oxygen” and “nitrogen” and “hydrologic” cycles are major examples.

For many purposes interchangeabilities in materials are possible. (For example: rubber can be made from: natural latex from rubber trees, carbon and hydrogen from alcohol from grain or other agricultural materials, carbon and hydrogen from hydrocarbons from petroleum, natural gas, coal, etc.; and buildings can be constructed from: steel, aluminum, copper, glass, stone, slate, concrete, tile, wood, plastics, plywood and many, many other materials.)

However, in specialized technological applications in which a multiplicity of properties are required, (for example: a combination of strength, electrical conductivity, temperature resistance, corrosion resistance, and creep resistance) the available materials are much more limited. If we are to achieve substantial breakthroughs in metallurgy, chemical processing, and energy generation, we must have greatly improved temperature-resistant materials, yet Figure 9 shows that there are only a very limited number of elements which possess such properties. Here, too, the “productivity” of our alloys and refractories must be improved.

Today improvement of productivity in the mining, minerals, metal, mineral reclamation, and energy industries requires accelerated development of new and improved technology and rapid introduction thereof into all stages including:

Exploration
Mining and petroleum and natural gas production
Processing
Use
Recovery and Recycling

In all of the above appropriate provision must be made for the health and safety of workers and for environmental enhancement through: minimizing air, water, and land pollution; land restoration; and esthetic improvement.

Further, because many important minerals are initially large bulk items, mineral production is heavily dependent on the United States transportation infrastructure. Minerals account for:

90% of all U.S. waterborne imports
50% of all U.S. waterborne exports
85% of all domestic waterborne commerce
70% of all railroad traffic
1OO% of all pipeline traffic

Consequently, improvements in rail and water transportation are of direct concern to major segments of the domestic mineral industry.

The resources of industry, government, and of academia, must be brought to bear on current major problems, including:

Discovery and assessment of resources presently untouched by our deepest mines and wells.

Development of safe and efficient coal mining systems to significantly

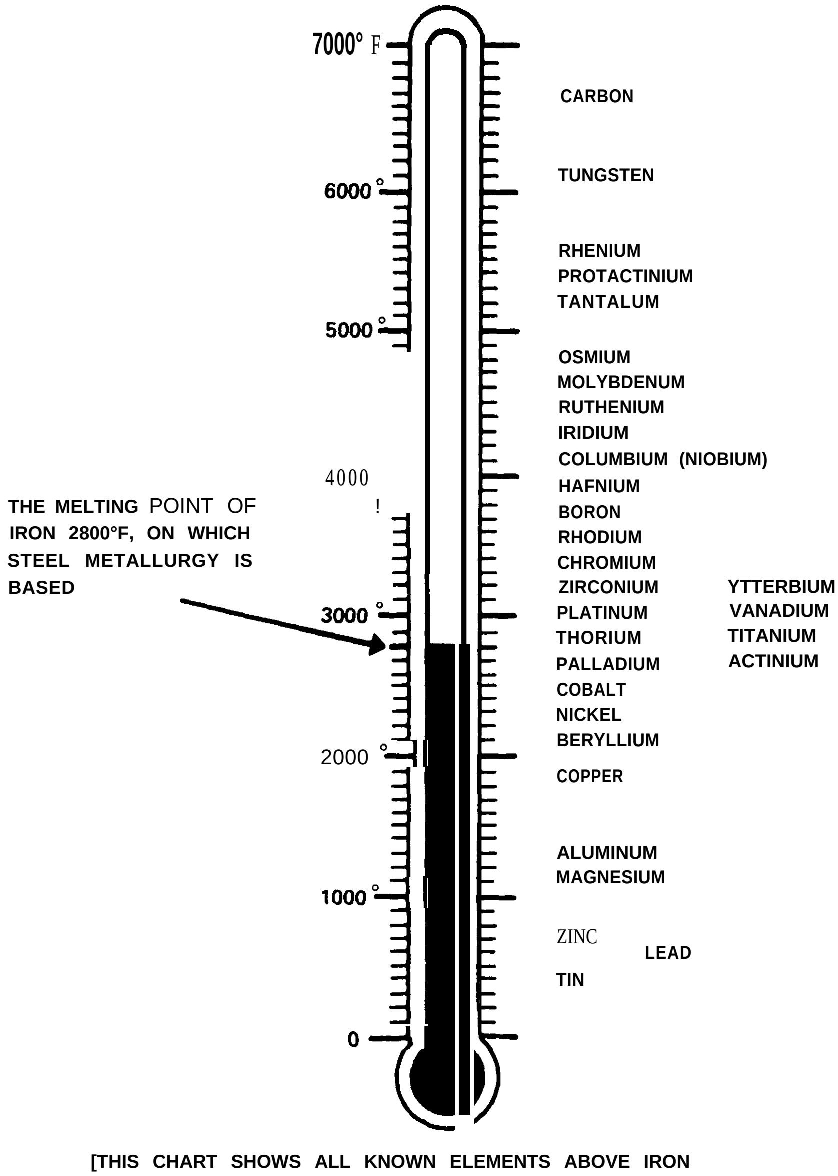

Figure 9. Melting points of selected elements.

increase underground extraction ratios from the present level of about one-half.

Development of improved petroleum recovery methods to significantly increase extraction ratios above the present level of about one-third.

Development of underground and surface mining methods to minimize degradation of the land surface, subsidence, and harm to surface and subsurface waters.

Development of clean burning solid, liquid, and gaseous fuels from coal, petroleum, and other energy materials.

Improvement of combustion processes to increase efficiency and to reduce emissions of fumes and particulate.

Improvement of electricity generation, transmission, and conversion methods.

Development of new energy sources including geothermal and solar.

Development of stronger, lighter, corrosion-resistant and temperature-resistant materials.

Improvement of recycling techniques to conserve natural materials and energy, and to promote environmental enhancement.

Stimulation of measures to conserve energy and materials in actual or potential short supply.

In the Department of the Interior, the Geological Survey, the Office of Coal Research, and the Bureau of Mines, under the immediate direction of the Assistant Secretary—Energy and Minerals, and the Secretary, are working closely together in furtherance of the above objectives to improve our domestic minerals position.

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Sponsored by the Mining Departments of the following:
University of Missouri--Rolla,
Pennsylvaniu **State University,**
University of *Arizona).*

THE DESIGNER AND MATERIALS CONSERVATION

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Introduction

One cannot help but be in complete accord with the intent of this conference and with the growing awareness of impending materials scarcity in our society. I certainly do not have to reiterate for this audience the need for laying in the proper course for our materials future. Nor must I acquaint you with the complexity and breadth of the issues which surround that task. We in the United States are just beginning to realize that the proper use of our materials heritage, and the preservation of that heritage for future generations, are issues that require a more farsighted and objective treatment than they can get through the raw instincts of supply and demand. These issues are also highly dependent on such unpredictable forces as national and international politics, cultural and esthetic factors, and society's attitudes and values. Their proper resolution will require the continuing effort of a lot of very capable and knowledgeable people. But the raw materials issues are so vital to man's future, and the proper course so difficult to define, that it is imperative for us to begin serious efforts to formulate practical policies,

My remarks today deal with the potential for improved materials conservation in product design. The growing prospects of shortages in resources vital to our society's needs has led to closer scrutiny of our design use of materials. The opportunities and basic principles for resource conservation through more effective utilization of materials in product design and manufacture are documented in a number of papers and committee proceedings. Perhaps the best summary statement of these principles is to be found in the definition of "materials effectiveness" introduced in the report of the Federation of Materials Societies to the National Commission on Materials Policy:

> "In the most general sense and in relation to materials use and conservation, it means that in a given application or product, our aims are:

1. To develop, select and design into products materials that most efficiently meet application requirements, that have optimum durability and life, and that are recyclable.

2. To process and fabricate materials so as to consume, waste, or disperse the least amount of materials for equivalent performance.

Now these principles are well considered and hardly subject to dispute. Accordingly, I don't feel it would be useful for me today to reintroduce, or rephrase, or rederive them. Instead, I will address two issues which appear tome to be critical to the ultimate exploitation of the opportunities for improved materials conservation through design. They are:

1. What must we do to provide the individual product designer with the tools, the training and motivation to implement this shift in design philosophy towards materials conservation?

2. As new materials and processes emerge from our research and development laboratories which might better serve materials conservation, what must we do to overcome the traditional reluctance to apply new materials and manufacturing techniques?

I must draw most of my basic examples from the aerospace industry since that is the turf I have played on for the past thirty years and is where I feel most at home. To put the aerospace industry into perspective as to its raw materials use, Figure 1 identifies three primary materials most widely used in our industry. It includes the total national consumption, the amount consumed by the total aerospace industry, both military and commercial, and the percentage that the aerospace use is of the total.

In general, the aerospace industry is not a materials "intensive" industry. It is, however, extremely materials "sensitive, " since, after all, the construction of a flying machine depends on the application of high-performance, light-weight materials.

Let's consider the first issue, shifting the design philosophy. In the end, the actual implementation of a design philosophy depends on the individual designer—the man sitting before a clean sheet of paper with a pencil in his hand, attempting to lend shape and function to his concepts. His world is complex and demanding. He must balance conflicting requirements of product performance and cost, risk and benefit, innovation and experience, often within a compressed time schedule. In order that he may effectively perform his function, he

FIGURE 1. AEROSPACE MATERIALS CONSUMPTION, 1973.

Materials	National use	Aerospace use	%
Aluminum (Million tons)	7.3	0.440	6,000
Steel (Million tons)	111.4	0.069	0.062
Titanium (Thousand tons)	14.5	12,500	86.000

relies on extensive libraries of design data and codes which serve to augment his experience and lend quantitative discipline to his creative imagination. One needs only to flip through a Marks' Mechanical Engineering Handbook or the civil engineer's steel code or concrete code to gain some feeling for the massive body of detailed technical and economic information from which the designer draws.

How might we characterize the designer's current environment? Our system is set up to motivate the designer to produce an item which reflects a given customer appeal and which can sell at the lowest price. The product's customer appeal is derived from the characteristics of its life cycle—appearance, performance, reliability, maintainability, durability and life. The product cost is the sum of a number of elements, including development, overhead, direct labor, marketing and, of course, the cost of the raw materials.

Where elements of the current design philosophy of maximum customer appeal and minimum price are consistent with materials conservation, we need not be concerned. Such correspondence exists in principle. For example, given all else equal, the designer will choose a material or process which inherently provides for a greater ''materials utilization factor:—or the ratio of the amount of raw materials purchased to the amount used in the product. Also, there frequently is some correlation between the cost of a raw material and its scarcity. However, raw material costs may comprise such a small portion of the total product cost that they will not have sufficient "punch" to drive the design economics towards cheaper or more abundant materials.

Where the "Dollar Economy" design philosophy is *not* consistent with materials conservation, we have a problem. We can identify some mechanisms which can help promote more materials conservative designs. They include:

1. A shift in customer appeal. Simply, this is getting the customer to choose products because they conserve materials, This could be quite a chore with the private and commercial customer.
2. A reordering of the "Dollar Economy". The introduction of a carefully considered system for assessing the true value of a material to our society such that the price of a product would better reflect its total materials impact.
3. The application of artificial constraints and controls such that the traditional principles of maximum appeal at minimum cost are forcefully "overridden" in favor of resource conservation.

Each of these alternative implies that our designers (our front line soldiers, so to speak) must be equipped with new tools, training and motivation.

The designer's motivation to use any given set of design principles is derived from the consumer—either directly, or indirectly. There's little reward in designing an automobile that can last 500,000 miles if it is known that most consumers will discard it after 40,000 miles because of styling or what. Thus, while it must be acknowledged that there are isolated examples of trend setting design, in general the designer's motivations are a reflection of the consumer's values. It's apparent, then, that a prerequisite to a shift in design philosophy towards materials conservation is the reorientation of the customer's attitudes. Such a reorientation implies, at the least, a massive public education program. Whether or not the attitudes of the private or commercial consumer could be changed in the near term to the point that a designer could count on "conservation of materials" for sales appeal is a dubious supposition. It's certainly a goal worth striving for, but since time is so important, we should also seek out other and more immediate solutions.

Now, on the other hand, the Federal Government—and it is the single largest customer—could elect to follow a procurement policy which includes materials conservation requirements.

Also, Federal and local governments could implement materials conservation through product design codes or requirements in the same vein as current environmental legislation. Personally, this last proposal makes me, as a producer, very nervous. One has only to look at the rather qualified success of environmental legislation to gain some appreciation for the complexity and scope of the task.

Motivation, as important as it is, is only part of the job. Exhorting the designer to be more materials conservative is useless unless he has the necessary tools. What is the nature of the tools he uses now? In general, extensive libraries of design data and codes provide performance and cost information at the fundamental level for different structural configurations, materials, and manufacturing processes.

Let's take an example. Several years ago, the Department of Defense initiated a program called "design-to-cost". We in the aerospace industry

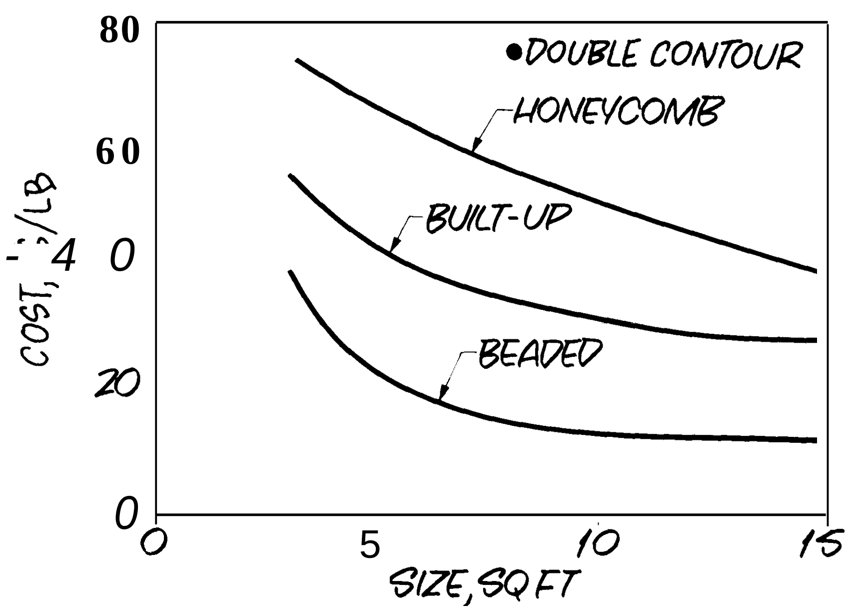


Figure 2. Equipment access doors, structural cost per lb.

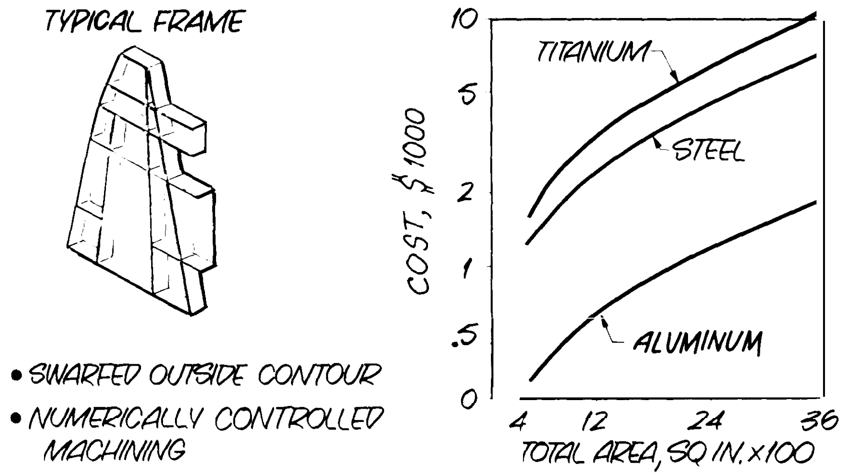
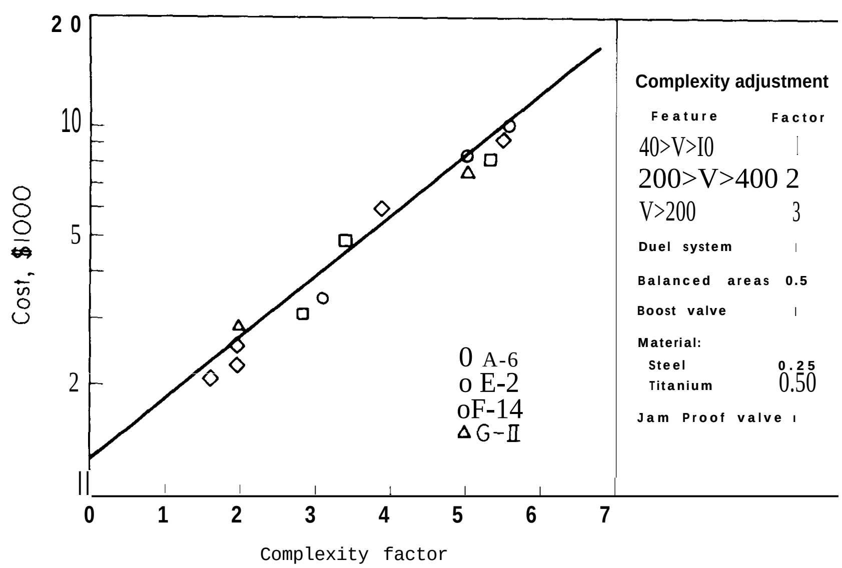


Figure 3. **Frame/bulkhead costs.**

have never been insensitive to cost. However. for obvious reasons, our heaviest emphasis has been on achieving maximum performance: cost was a result, not a totally integrated design parameter. With the growing concern over cost overruns in weapon systems procurement, the DOD felt it necessary to introduce a policy to provide more rigid control over costs right down to the subcomponent level. Design-to-cost does not mean better cost estimates, but rather how best to integrate cost into the design process so that the end product meets pre-defined



Figurc 4. Cost **of flight actuators.**

cost goals with the least degradation in performance. Supporting this program has not been a trivial chore. Grumman has already invested over $2 million in providing the training and tools to our designers in order to implement this policy.

Figures 2, 3, 4 and 5 are some examples typical of the sort of design data we've prepared for our design engineers to support the DOD shift to a design-to-cost philosophy. Note that the format is one of dollars plotted or tabulated against a material, a process, or a subassembly configuration. Other parts of the "designer's notebook" provide the performance counterparts—such as strength, reliability, durability and so on. What is the significance of these design tools, the data and codes, to the designer? *They provide him with a way to keep score.* They quantify at the very basic design level the costs and the performance of the building blocks which will eventually comprise his completed design. They provide a matrix, a framework within which the designer can best direct his judgment and experience in the creative process. Our current method of keeping score, of course, reflects the "Dollar Economy".

Here, then is our first challenge in providing our designers with the tools they need to implement a shift in design towards materials conservation. We must establish the ground rules, the scorekeeping methods, which permit the designer to make intelligent decisions

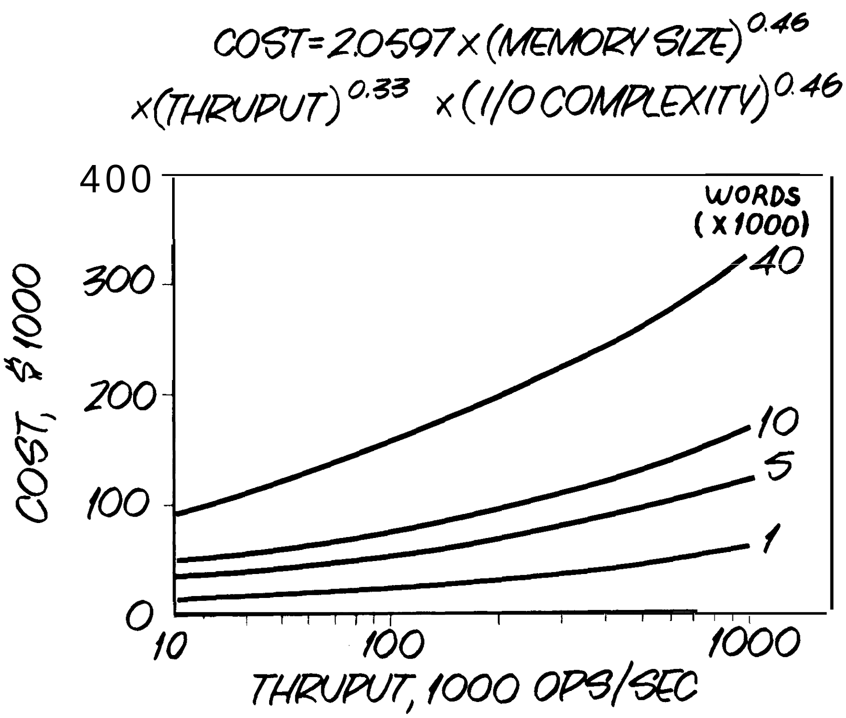


Figure 5. Avionics computer costs vs performance.

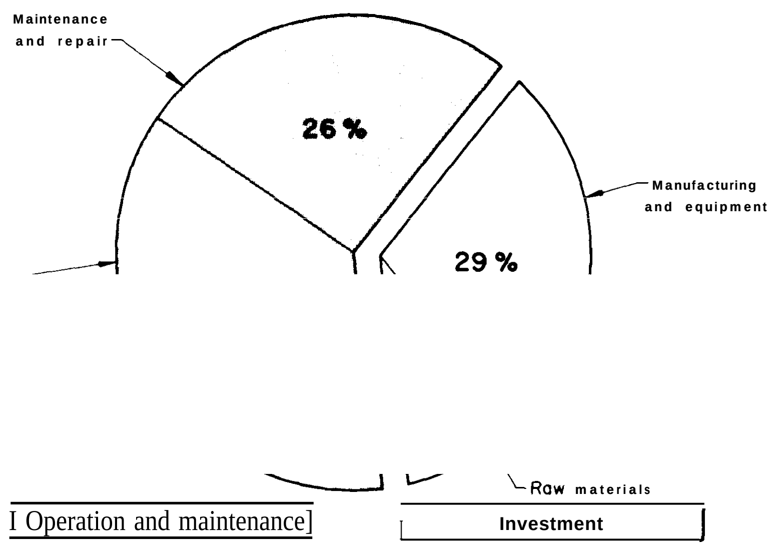


Figure 6. Automobile life-cycle costs (10 yr/ 100,000 miles).

concerning competing concepts, materials and processes.

One possible means of providing such a "score-keeping" system is to expand the concept of life cycle costs to include a measure of the product life cycle impact on broader materials and environmental issues. The distribution of life cycle costs for a typical automobile might provide some of the flavor of this concept. It's based largely on the results of a survey made by the Federal Highway Administration in 1972. Figure 6 shows that over a 10-year, 100,000-mile life cycle, the cost to produce the automobile, less profit, constitutes roughly one-third of the total—the balance going to fuel, maintenance and repairs. This fraction would be still less had I included other owner-incurred costs such as depreciation, taxes, tolls and insurance; these costs, however, are less liable to the product design than those I did include.

While far short of the comprehensive life-cycle costs model we'll need in order to implement an effective "design-to-conserve' philosophy, it does indicate the trend of thinking required: the cost of providing the customer with 10 years and 100,000 miles of transportation is not limited to the raw materials which comprise the vehicle. There are additional inherent materials costs. In this case, for example, there is an inherent cost of more than 7000 gallons of gasoline—a resource whose limits were all too apparent earlier this year. Note that the actual vehicle raw materials cost comprises some 8 to 10% of the total,

Figure 7 shows a corresponding life cycle cost distribution for a modern fighter aircraft. As with the automobile, the vehicle's raw materials costs are a small fraction of the total—about 5%. However.

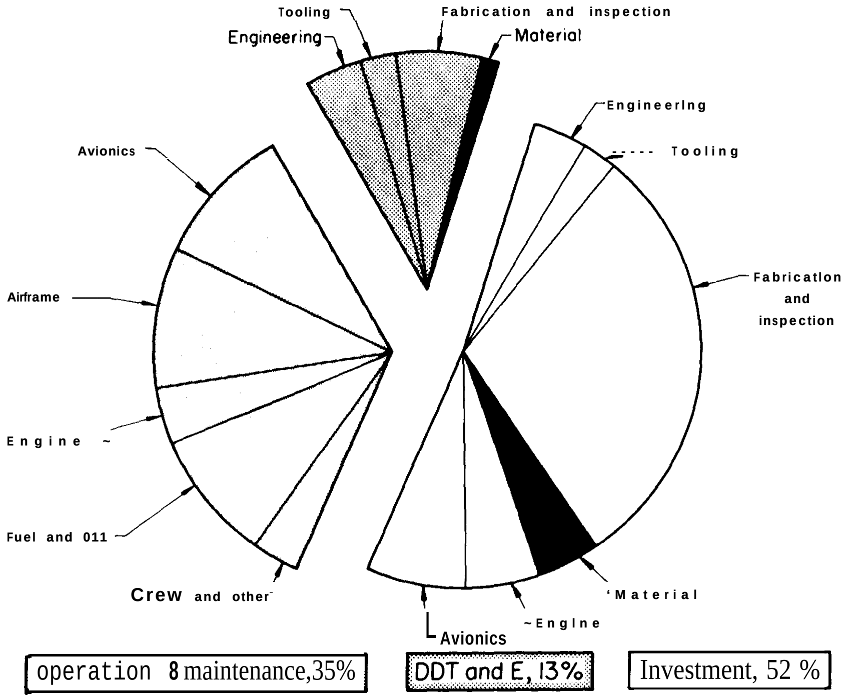


Figure 7. Fighter life-cycle costs.

as indicated by the lightly shaded areas, the materials choice made during design impacts elements responsible for an overwhelming 75% of the life cycle costs. The materials chosen affect the size of the aircraft and engines, what it will cost to produce it, how much fuel it will burn in its lifetime, what it will cost to maintain and repair it, and so on.

Obviously, raw materials costs do not provide an effective measure of the life cycle costs, much less the broader implied materials and environmental costs.

Whatever the scoring method devised, our next step is to introduce the technique into the “designer’s notebook”. This might best be accomplished by generating data analogous to the cost-oriented information discussed earlier, that is, derive and assign incremental materials impact costs to the designer’s basic building blocks of subassembly structural concepts, materials and processing choices. The qualitative materials conservation benefits and costs of many individual design and manufacturing techniques have already been defined in the literature. *Quantitative* definition is required to permit the designer to prepare a total materials, environment and product cost statement and to provide for the reasoned application of materials conservative design philosophies.

The know-how and technology for such a comprehensive cost versus benefit analysis are available, though admittedly never applied on perhaps such a large scale. Construction and implementation of this ‘‘score-keeping’ system, and the provision of the associated design tools, requires the long-range continuing efforts of a permanent materials policy body with the support of all concerned groups from industry, the government and the academic world.

Let’s turn now to the second issue critical to materials conservation through design, accelerating the utilization of new materials and processes. Many new and advanced materials and processes offer significant opportunities for materials conservation through improved “materials effectiveness. The new high strength metal alloys and advanced fiber composites can provide for less materials intensive products at equivalent performance. Their improved corrosion resistance and fracture strength imply increased product life. The composites in particular appear to offer the potential for less waste in manufacture. Advances in high integrity casting and powder metallurgy can provide for net and near-net shapes, allowing for less materials consigned to the scrap barrel. These are but a few of the emerging technologies which, properly exploited, offer large potential materials savings.

Unfortunately, the time span involved in the progress of an advanced material or process from the stage of a laboratory curiosity to widespread product application has proven to be on the order of 10 to 15 years. Apart from the impacts on the evolutionary development of improved product performance and costs, this sort of delay has obvious implication to continued materials waste.

The continuing development of the advanced composites is an excellent example of the scope of the time and effort which attends the introduction of a new material. I think that composite materials should be of particular interest to us here today. For the structural designer, they represent a significant departure from the materials he’s used to working with, that is, the metals. Accordingly, their introduction to the designer or manufacturer, traditionally reluctant to apply new materials, represents a considerable challenge. Moreover, they have significant materials conservation potential. Again, I'll quote from the Federation of Materials Societies Report:

> “The concept of designing materials themselves to perform functions or to meet specific application requirements in principle leads to maximum materials effectiveness, Composites hold out great promise for the development of materials in this direction. They can be constructed by combinations of different materials and different constituent forms, such as fibers, particles or layers. The possible combinations are endless, and by proper choice of materials and constituents, property systems can be designed to meet specific requirements”.

In order to acquaint those who may not be familiar with this rather classic example of the forced development of a new material, I will briefly review our progress. The case history of the introduction of advanced, high strength/modulus composites to the aerospace industry began in 1959. It was then that Texaco Experiment, Inc. reported for the first time the high strength and stiffness of continuous boron

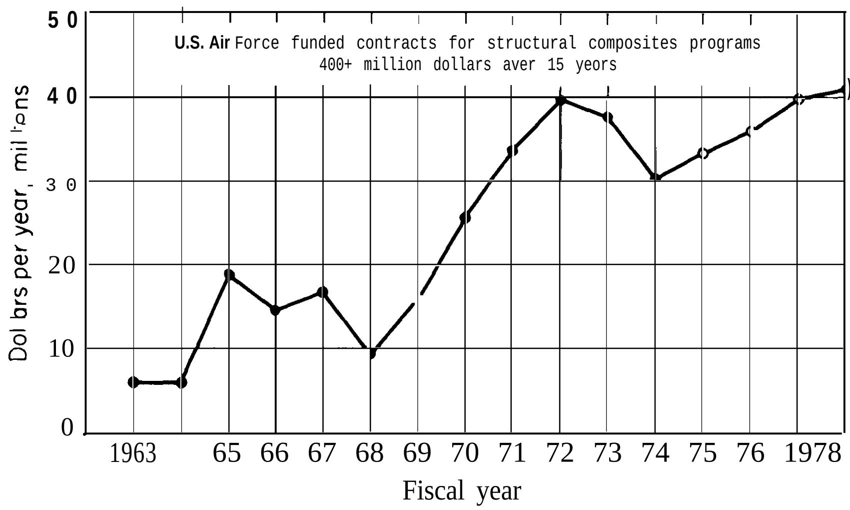


Figure 8. USAF funding for advanced composites.

filaments. Later experiments with boron fiber reinforced plastics suggested a latent potential for the development of structural materials with greatly increased strength-to-weight and stiffness modulus. Recognizing this potential and its value to advanced aircraft, the Air Force Materials Laboratory in 1960 initiated programs to characterize boron-epoxy composites. In the early 60's, the Air Force undertook a major commitment to accelerate the development and exploitation of these materials—a commitment which extends through the present and into the future.

Figure 8 attempts to give you some measure of that commitment—over $400 million in 15 years. The role of the Federal Government in the development of these remarkable materials has been vital. Their development to date is evidence that composites will fulfill their promise of 15 years ago. Cost and weight savings have been demonstrated in certain applications, and their broadened usage, attended by reduced costs, will come as a matter of course.

The message of this case history is both exciting and discouraging. It is a reaffirmation of man's ability to make significant strides in the development and application of the materials that serve him. At the same time, it is a discouraging comment on the overwhelming time and effort he must expend to do so.

Nor are composites unique in this respect. Some 719 government supported research contracts distributed over the 20-year period from 1945 to 1965 were devoted to the characterization and development of titanium—to say nothing of the substantial development effort expended by the titanium and aerospace industries.

In 1971, the National Materials Advisory Board undertook for the National Academy of Sciences and the National Academy of Engineering a study of the factors which promote or inhibit the introduction of new materials in national programs. They identified the major causes of delay as:

a) Technical: including uncertainties in performance and reliability in service and the limited initial availability of design and fabrication data and product forms.

b) Economic: including the high initial costs of the material due to limited volume and the high capital facilities investment.

c) Management and Organization: including innate conservatism and the reluctance to assume the additional management tasks associated with the use of new materials.

d) Contractual: including procurement specifications which limit the use of new materials and the unilateral risk which must be assumed by the contractor.

There is understandably a great reluctance on the part of the producer and the customer to accept a material or process that is new, that is, that has not seen service experience. This provides the designer another ‘‘the chicken or the egg” problem. A designer is often unwilling or unable to apply a new material or process because it lacks service experience; of course, it cannot gain service experience without first being applied.

The National Materials Advisory Board made a number of specific recommendations to relieve this situation and to provide for the accelerated utilization of new materials. These included the establishment of a continuing function under the auspices of an interagency government organization to assist in providing the necessary guidance, knowledge and funding for the development of materials and processes which show potential for wide application to national problems. The applicability of such a function to materials conservation through improved ‘‘materials effectiveness” is obvious.

Conclusion

Let’s take a moment to review the points I’ve made today. I have a deep, abiding respect for the creative ability of man. I sincerely believe that the product designer can achieve whatever reasonable goals we establish for him. More to the point, I believe that potentials for materials conservation in the product design process are significant enough that their realization should be established as a national goal.

But it is necessary, in order for our designers to attain these goals, that we provide them with the necessary *tools* and *motivation.* Moreover, it is critical that as resource conservative materials and processes emerge from our laboratories, we get them into the hands of the designers as rapidly as possible.

As I’ve attempted to convey to you today, these are not trivial tasks. We must provide the designer a new means of “keeping score” in the “materials economy”-a task requiring new libraries of design data and codes. We must devise a procedure for the accelerated selection, development, introduction and utilization of promising new materials and processing techniques.

The proper execution of these tasks clearly requires the guidance and support of a dedicated national materials body which draws from all the necessary concerned groups from Government, industry and the academic world.

Whatever course we choose for our materials future, our investment will be substantial. Accordingly, we must expend the time and effort, however great, to assure that the course we choose is the fundamentally correct one.

MATERIALS AND ENERGY CONSERVATION THROUGH RECYCLING

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The Mitre Corporation

Prologue

The Henniker Conferences on materials have always been designed to be working meetings. Any attempt to prepare a tutorial approach to areas in the broad area of my assignment must try to get at the issues and alternatives rapidly. An effort must be made to describe the problems, the issues and the alternatives in order to be able to discuss and develop policy. I will attempt to do this by using an example, the conversion of municipal solid waste to energy. It is recognized that the problem is much broader than municipal waste and the treatment of this broader problem will be handled in the working sessions. However, I hope to develop, in this presentation, methodologies for approach that can be **used** in the working session. Some of the methodologies are literally borrowed from the systems analysis approach. These are designed to help view the elements of the problem in context with the broader picture.

Introduction

There is a pervasive logic that at times often borders on religious intensity that is involved in recycling and reuse. Throughout history communities which were materials limited worked out natural strategies to conserve limited sources of supply. As affluence increased, there has been a tendency for the quantities of waste to increase. We are living in a complex society where it is very difficult to recognize materials as such. We see products, buy services, and only in times of stress is it recognized that materials are the building blocks of things we use and energy we need.

We are at such a time now where we must take stock of our supplies and demands and attempt to balance these. The balancing mechanisms are complex and involve many potential strategies.

Any option for technology policy must address the public concern of benefit to the total society and also the individual’s concern of

' 'what's it worth to me?' A problem often develops in how to present technological alternatives in a manner easily understood, in a fashion which minimizes all potential ambiguities. Various viewpoints are invariably involved and although it is desirous for these to complement each other, they are often disparate.

An area of concern in the materials field is that of resource use and recycling. Each of these has descriptive components that can be broadly characterized as technical, economic and institutional. Each of the characterizes of these components may not only have a different professional cultural background but also a different language.

Resource and waste management when properly planned should take into account all the factors involved, from the generation of waste to its utilization or destruction. One can look at the entire system to identify areas of most interest with various reference points of time, location and point of view to best place the problem in perspective.

Recycling, one option in solid waste management, has been practiced in various forms for a long time. Recycling as now practiced is oriented primarily towards the benefit of the individuals engaged in the business; that is, the rather straightforward buyer-seller relationship. Another component has been recently added to the recycling scene: community benefit. In the past we were able to work with resource recovery in a relatively simple fashion because the complex nature of the sometimes overwhelming concept of community benefit was not an integral part of the issue. The individual business response to the potential profit stimulus was the main determinant to the extent of recycling. But now a new dimension which is societal in nature must be coped with, and requires an understanding of the institutional factors.

Since community benefit requires inputs from a broad spectrum of interests, it is clear that some method of bringing these interests together is essential. A systems approach could be used and should be concerned with factors such as economics and human motivation as well as technology, and should recognize the influence of these factors on each recycling strategy. Problems which are in the national interest should be "priorozed", and the blockage points that prevent solutions should be identified and removed by formulating relevant national policies.

In chemical reactions, the rate of reaction is dependent upon the slowest acting substance; a similar phenomenon is true in the recycling area, the rate-controlling step may involve regulation or law, technology, market, economics, or institutional arrangements, to name a representative sampling. In other chemical reactions, the mere combination of reactants may not yield a product; often a catalyst is needed. Similarly, in this system context, a catalyst such as legislative incentive or revised federal policies which initiate technology transfer or induce capital investment in recycling, may be needed to implement recycling activity. By utilizing an analysis approach that concerns itself with a broader "system", problems, focuses on key issues, and then, hopefully, provides solutions so that the factors which currently inhibit recycling can be redirected. In this way, incremental growth in recycling can be planned, and all participants can recognize where their greatest opportunities lie in the area of technology, institutional factors, or economics.

A useful concept for the visualization of these three components (technology, institutional and economic or TIE factors) is as shown in Figure 1. This concept, borrowed from phase equilibria, uses a triangular representation. Each of the apices represents one hundred percent of that factor and a decreasing percentage going to zero as one moves away from the apex. For example the center of the shaded area shown in Figure 1 describes a problem in recycling that is 20% technology, 20% economic and 60% institutional. It is meant to be broadly quantitative and designed to give an approximate order of the barriers in the problem area using the TIE factors. The area shown represents an analysis of the factors involved in the use of municipal refuse as a fuel which is described later in this paper. The TIE factor concept is not limited to the subject being discussed in this paper, but is useful in recognizing the scope of many problem areas being faced today.

The options in solid waste management are many and the strategy used must fit the situation on hand. There is no ideal scenario to be used throughout the country but a series of options which can be tailored to the situation. Sometimes recycling makes sense, other times it doesn't. The same is true of the use of municipal waste as fuel. The example discussed in this paper is designed to show that there are a variety of choices, only one of which might fit the situation

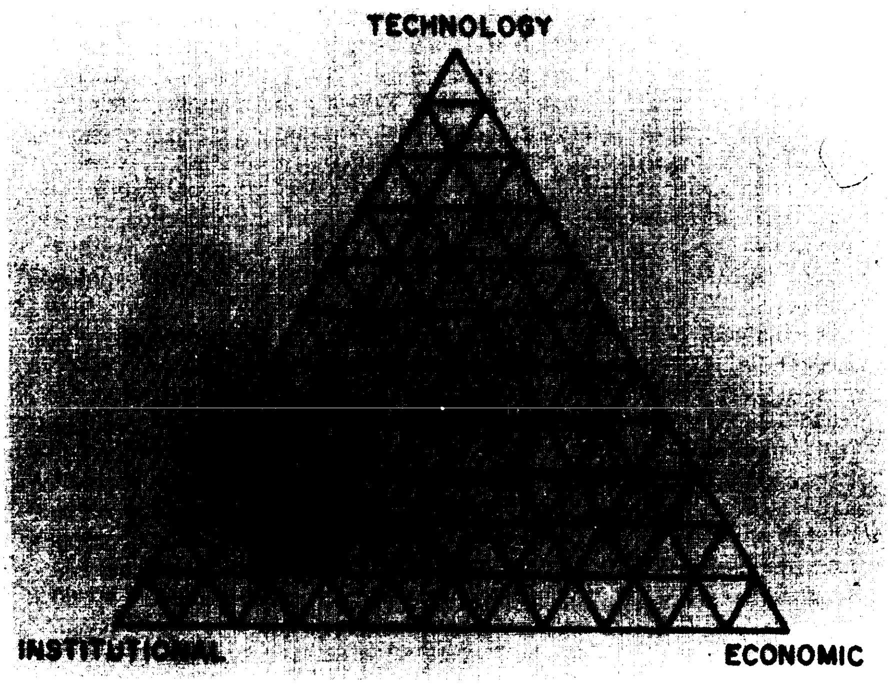


Figure 1. TIE factors.

on hand, and that its location on the TIE diagram, Figure 1, can help determine the priority of the problem area.

The Problem

At the last Henniker Conference the concept of life cycle of materials was discussed, (Figure 2). The area of interest for this discussion involves Reclamation, Recycling, Disposal and Factors Affecting the Public Sector (area shaded).

This area can be further described in Figure 3, Recycle Potential System. If we start in the middle of the diagram, Total Resource Needs, it is shown that a portion of this, actually the majority, is obtained from available reserves and imports. The solid waste stream can supply some portion of our needs and is in active operation now with lead, copper, iron and paper. The Solid Waste Stream can be related to the State of the Economy and Life Style. Life Style involves factors which are a result of our way of living, such as the use of convenience foods and the resulting packaging material and throw-away components. The Economic Parameters involve costs and scarcity of materials, for example. Each of these contribute to the quantity and quality of the Solid Waste Stream. Materials move from the Solid Waste Stream to Disposal. At this stage they are either recovered or exist as Residuals (scrap piles, dumps, water pollution, air pollution, etc.).

With certain motivating factors (shortages, costs) there may be an incentive to remine the Disposal piles and the line flows to Resource Recovery. In other cases the Residuals may give rise to pollution effects (water and air) and affect the Life Style by affecting factors such

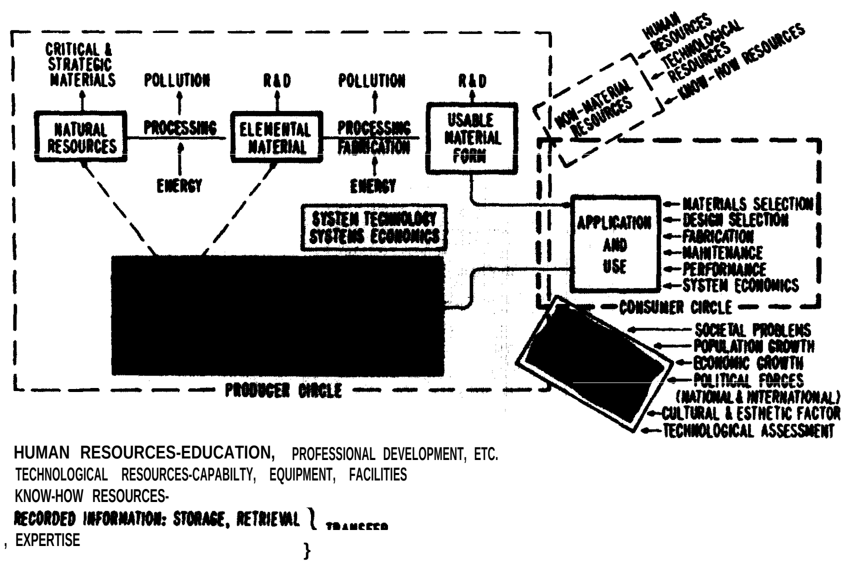


Figure 2. life cycle of materials.

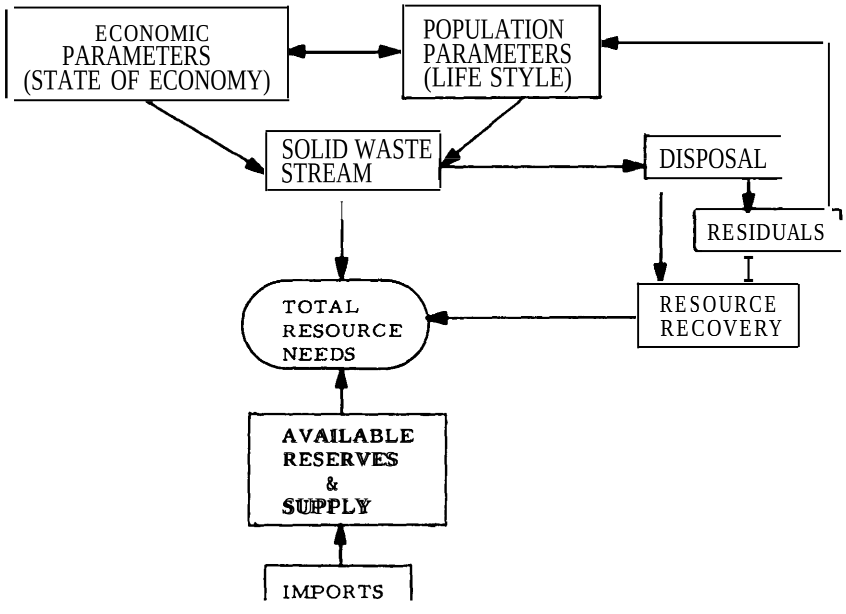


Figure 3. Recycle potential system.

as health, aesthetics and quantifiable factors such as the cost of repainting houses because of air pollution.

It may be possible to measure each of these connecting flow lines by econometric techniques to determine the magnitude of flow, to anticipate problems and to institute policies that will move the system in some desired fashion. If not easily quantifiable then they can offer an indication of magnitude and direction.

If we examine the specific problem of municipal waste, Figure 4,

- MUNICIPAL WASTE - 200M TONS PER YEAR
- INDUSTRIAL WASTE - 100M TONS PER YEAR IN URBAN AREAS
- LOCAL GOVERNMENTS SPENDING $6 BILLION/YEAR FOR COLLECTION AND DISPOSAL - COSTS RISING RAPIDLY
- 1/2 OF ALL CITIES RUNNING OUT OF CURRENT DISPOSAL CAPACITY IN 1 - 5 YEARS
- LAND FOR DISPOSAL BECOMING SCARCE - MUST USE NEW TECHNOLOGY
- FACING NEW CAPITAL COSTS, NEW TECHNOLOGY, NEW INSTITUTIONAL ARRANGEMENTS - TRADEOFFS DIFFICULT

Figure 4. The problem.

COMPONENT	COMPOSITION (% OF DRY WEIGHT)* RANGE	NOMINAL	
METALLICS	7 TO 10	9.0	
FERROUS	6 TO 8	7.5	
NONFERROUS	1 T0 2	1.5	
GLASS	6 TO 12	9.0	MECHANICAL RECOVERY
PAPER	37 TO 60	55.0	
NEWSPRINT	7 TO 15	12.0	
CARDBOARD	4 TO 18	11.0	
OTHER	26 To 37	32.0	
FOOD	12 TO 18	14.0	CONVERSION RECOVER Y
YARD	4 TO 10	5.0	
WOOD	1 TO 4	4.0	
PLASTIC	1 To 3	1.0	
MISCELLANEOUS	5	3.0	I

* MOISTURE CONTENT: RANGE, 20 TO 40 PERCENT: NOMINAL, 30 PERCENT.

Figure S. Expected ranges in mixed municipal refuse composition.

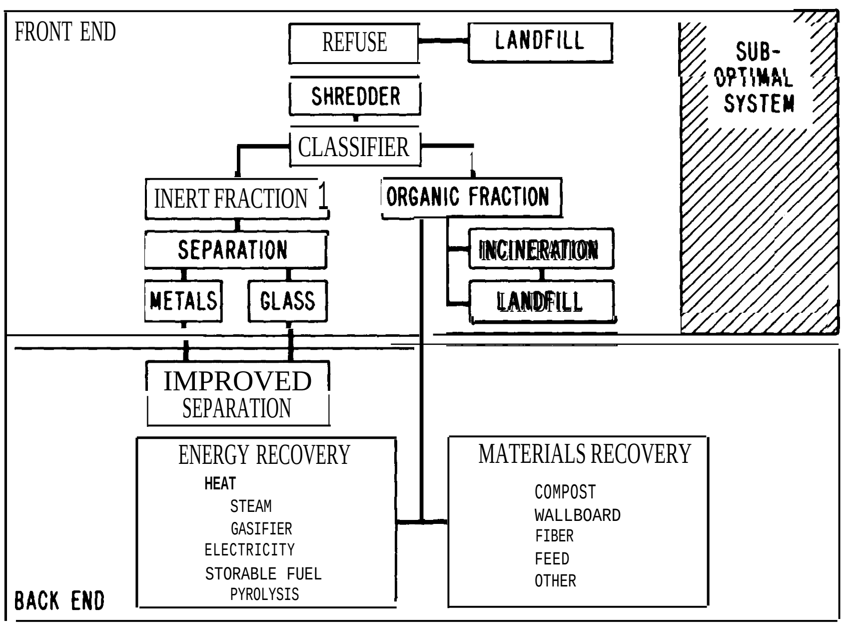


Figure 6. Modular approach to resource recovery.

we see increased quantities, an increase in disposal costs, a decrease in available land and new concern with: large capital costs, technologies not understood by the cities and new institutional problems such as setting up public utilities or combined private public utilities. In addition to discussing quantity we should also focus on quality.

Figure 5 describes the makeup of refuse in terms that a beneficiator would use. The greatest majority consists of paper products. Some of the components are recoverable by mechanical means, others by heating for conversion to energy.

Figure 6 shows a modular approach to recovery of metals and glass and the disposal of the organic fraction. The front end separation shown with this diagram is considered suboptimal in a total systems sense. The back end separation shown gives rise to less contaminated metals and glass and shows the organic portion converted to compost, fibers, etc., or energy.

Figure 7 depicts a detailed processing for separating materials from mixed refuse which was designed by Bureau of Mines, and is shown to give some idea of the process detail. We can describe the preparation of fuel by the diagram in Figure 8 and the firing operation in Figure 9, both of which involve the conversion of solid waste.

To this point we have described the problem facing cities with regard to solid waste and the techniques for processing the waste. These factors are important because we must examine the technology to see how adaptable it is. Several products can result from processing and include metals, glass, paper products and fuel. Figure 10 describes the relationship of various factors influencing the use of municipal refuse as a fuel for electrical energy generation. The prediction of municipal waste generation by year in tons per year (tpy) is given in column 1. The heat value, nominally figured as 5000 BTU/lb, at

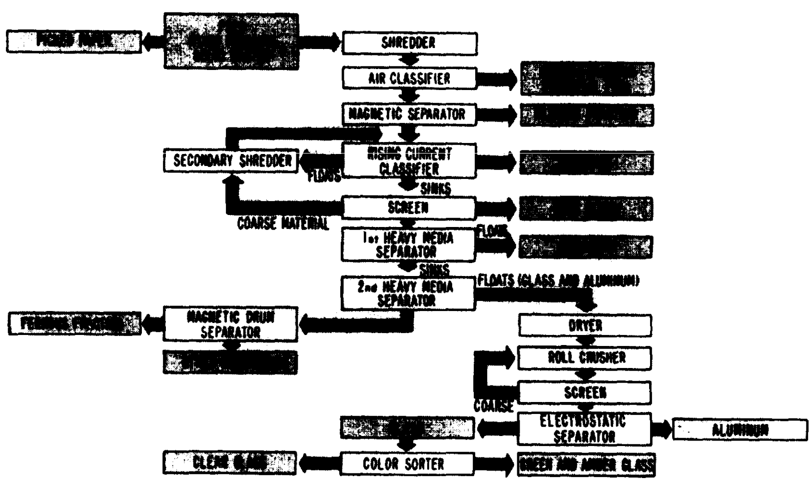


Figure 7. Processing scheme for separating materials from mixed refuse.

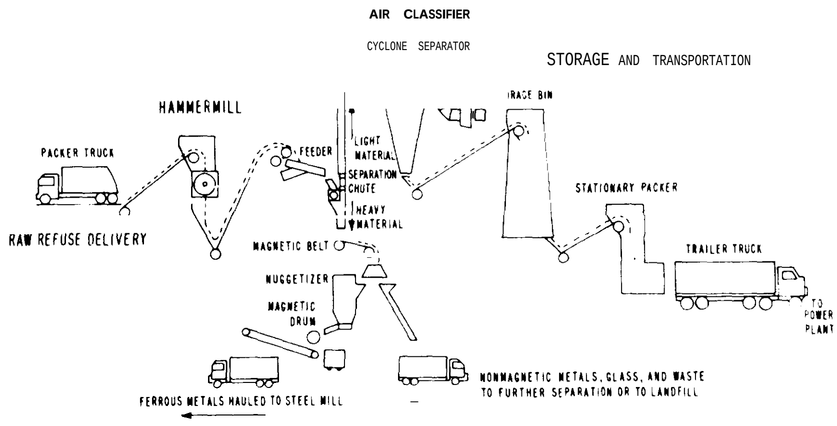


Figure 8. **Fuel preparation.**

the present time is expected to increase by about35% to 6700 BTU/lb a y m a t e r i a l s . These numbers are shown in column 2, Multiplication of the values in column 1 and 2 give rise to the data in column 3, the potential energy available from solid waste. This is of course a target for the maximum amount. It requires that all municipal waste be converted, which is next to impossible. The portion of the electrical energy demand to be met by oil and coal has been estimated in column 4. In this scenario we are only considering using the refuse as a fuel to be substituted for oil and coal. It has been demonstrated that coal burning boilers can be modified to burn up to 20% refuse before running into significant problems with bottom ash. However new techniques are under development which can treat the paper and plastic portion of

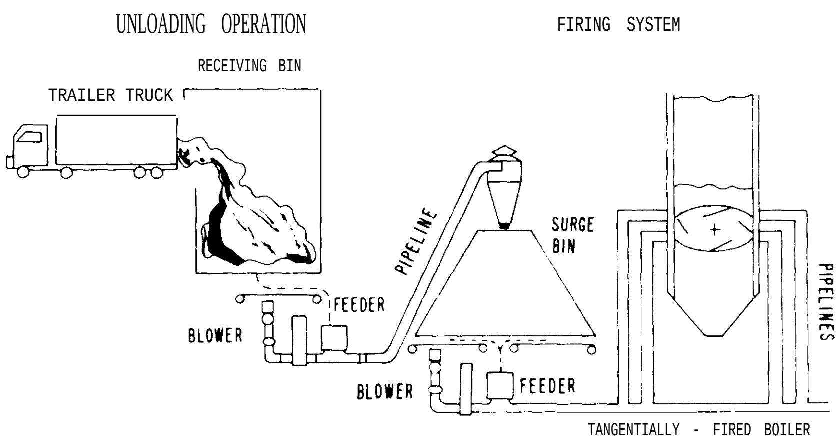


Figure 9. Firing operation.

1	2		4	5	6	7
YEAR	WASTE (1) GENERATION TPY x 10^6	(2) HEAT VALUE (BTU/TON) x 10	POTENTIAL ENERGY BTU/YR x 10^{15}	ESTIMATED U.S. ENERGY DEMAND (BTU/YR) x 10^{15} (3)	(4) %	% TOTAL ELECTRIC ENERGY
1970	181	10.0	1.8	9.6	18. e	10.8
1980	237	10.4	2.5	15. b	16.0	6.1
1990	322	11.6	3.7	21.1	17.5	4.8
2000	422	13.0	5.5	37.4	14.7	5.9

(1) ASSUMED 12%/YEAR GROWTH IN POPULATION AND INCREASE IN WASTE GENERATION (REFERENCE 5)

(2) HEAT VALUE INCREASE DUE TO EXPECTED CHANGE IN REFUSE MIX

(3) PORTION OF ELECTRICAL ENERGY DEMAND TO BE MET BY OIL AND COAL (REFERENCES 6 & 7)

(4) POTENTL4L ENERGY CONTRIBUTION OF SOLID WASTE AS A PERCENTAGE OF TOTAL FOSSIL FUEL DEMAND; I. E., COLUMN 4 DIVIDED BY COLUMN 5 TIMES 100

Figure 10. Relationships of factors influencing use of municipal refuse as a fuel for electrical energy generation.

refuse chemically to convert it to a dry powder with minimum ash content.

The data in column 5 are the percentage of the demand for energy that can be met by refuse assuming it can all be collected, transported and burned in boilers. The actual value may be much lower than this. As far as the total electrical energy is concerned, column 6, the projected increased use of nuclear reactors, indicates potential for using all the refuse but allows for a reduced percentage of the total electrical energy by the year 2000. It is estimated that about 2% of all energy requirements (electrical plus other) can be met by the energy value in municipal refuse.

This exercise was done to simply demonstrate that we may have

	CONCEPT	STATE OF ART	BARRIERS
TECHNOLOGY	PROVEN	• USED IN EUROPE • DEMONSTRATION PLANT	• CORROSION UNKNOWN
ECONOMIC	COST BENEFIT METHODOLOGY EXIST	• USED IN MANY OTHER AREAS • DATA BEING OBTAINED IN DEMONSTRATION OPERATION	• EXTRAPOLATION OF DATA TO OTHER LOCATIONS • EXTERNALITIES NEED QUANTIFICATION • PROFIT/LOSS NO CLEAR
1NSTITUTIONAL FACTORS	• TRIED BY FEDERAL GOV. & INDUSTRY (E. G., TVA) • MUNICIPALITY UNTRIED IN PRESENT FORM	• LIMITED EXPERIENCE	

Figure 11. Use of municipal refuse as a fuel source.

PARTICIPANTS	POTENTIAL BARRIERS	POSSIBLE REMEDIAL ACTIONS
Municipal officials	Capital expense Zoning Site selection Institutional complexity Lack of effective waste management progra	Solicit external funding Review future land resources Investigate site for co-located facilities Develop guidelines for wastes management
Utility managers	Economic risk Technological feasibility and effectiveness Limited interaction with community	Examining progress of existing systems Conduct specific technological and economic feasibility studies Promote public relations campaign
Citizens groups	Public attitudes Scenic impact (land use) Environmental impact	Educate the public Provide for citizen siting participation Develop compatible land use
Private industry	Ownership, control of refuse Conflicting interests (profit incentive	Provide incentives to private industry
State government	Incompatibility with regionalization efforts Desired uniformity of disposal methods	Develop waste management master plan
Regulatory and licensing agencies	Delay in separate siting and environmental impact approvals	Streamline approval procedures
Federal government	No direct contact with state and local governments	Provide assistance in formation of technological, economic guidelines

Figure 12. Potential barriers and remedial actions.

a reasonable goal in the conversion of refuse to fuel to meet the energy crisis (Figure 11).

What are the problems in using municipal refuse as a fuel? Earlier in this paper the concern of the three factors, technology, economics and institutional. were discussed. They are focused in the matrix in Figure 11 considering the use of the concept, the state of the art and the barriers as presently understood. The potential barriers and remedial actions are shown for demonstration purposes in Figure 12. The barriers and potential remedial actions are given for example of methodology on] y.

Many ideas have been advanced on the design of a total recovery system treating sewage and waste to generate steam and to provide recreational water. One such is shown schematically in Figure 13. The products here are considered to be secondary materials (metals, glass), heat and cooling water while getting rid of both sewage and refuse,

It might be worthwhile here prior to going further into the logic of waste to fuel that we look at our material needs in the U.S. to determine how this component, recycling of waste might fit our total material needs. Figure 14 shows the balance of trade (imports vs exports) with a deficit of six billion dollars in 1972. The detailed U.S. import dependence is shown in Figure 15. Our concern should be how to insure recycling as a viable component in material supply. I plan not to treat the area any further but to bring to attention the data in figures 14 and 15 which can be used in the working sessions.

Now going back to solid waste, what are the broad issues? I have listed four areas of importance in Figure 16 which need be treated.

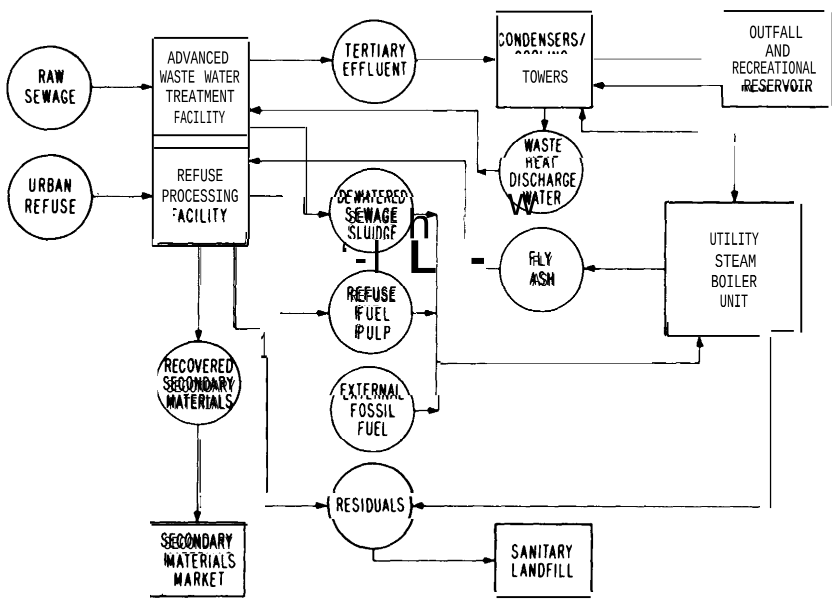
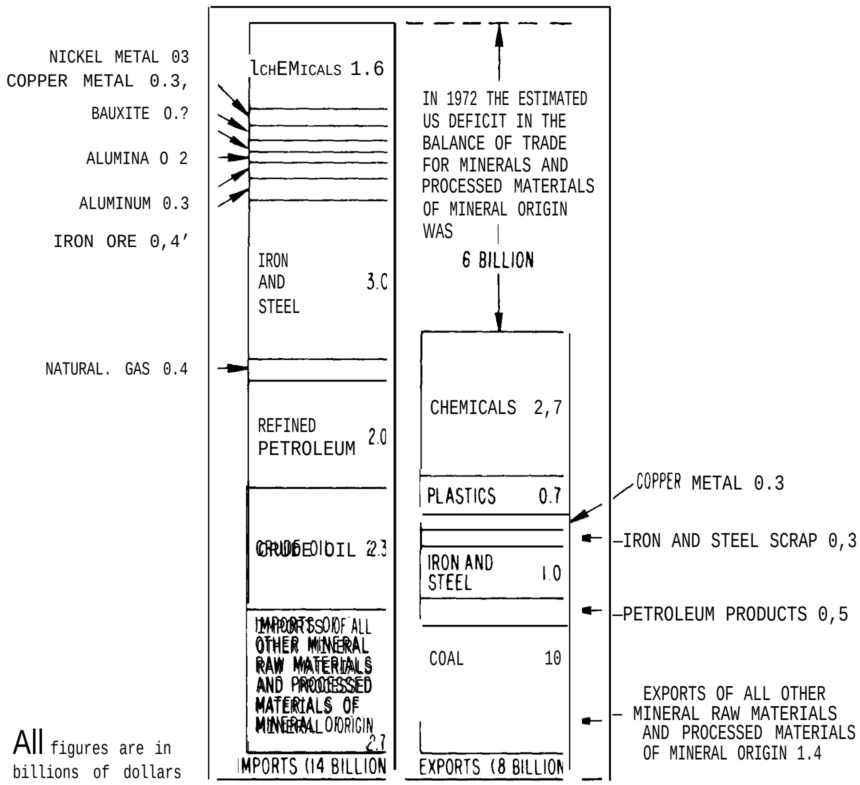


Figure 13. A joint community utility resource facility system diagram.



flgurc 14. BalANce of trade in materials.

National Policy is one of the most important of these issues. I don't believe that policy can be either easily established or easily instituted, but we certainly need a national direction. Without getting into the argument of the need for a national policy I have treated some inputs to such a policy in Figure 17 without much discussion. We can discourage residuals by developing product standards for increased life, use of taxes or the other factors shown. In like manner we can encourage recycling. We also have to consider the problems of conservation of resources, balance of trade, our economic health and materials security.

In the treatment of municipal refuse we have many alternatives.

FIGURE 15. U.S. IMPORT DEPENDENCE.

imports as percent of consumption, 1973

Bauxite	84%	Manganese	100%
Chromium	100	Mecury	82
Cobalt	100		92
Copper	8	Tin	100
Iron Ore	29	Tungsten	56
Lead	19	Zinc	50

FIGURE 16. BROAD ISSUES.

Issues in a solid waste research program (Municipal refuse)
1. National policy
2. Evaluation of alternatives
3. State of art data evaluation
4. Action for enforcement (decision support)

FIGURE 17. NATIONAL POLICY.

Issues in a solid waste research program (Municipal refuse)
Discourage residuals
- Product standards for increased life
- Residuals tax
- Design product for recycle
- Packaging regulation

Encourage recycling
- Incentive tax or bonus
- Federal procurement thrust
- Preference for secondary materials
  - Image
  - Shipping rates
  - Tax benefit

Conservation of resources
Environmental protection
Balance of trade
Economic health
Security

Some of these are shown in Figure 18. Concomitant with the consideration of these alternatives is the validation of the "state of art" in order to know, in a pragmatic sense, what we can depend on. Finally once we have explored each of these previous factors the question is how do we take action. An outline of the issues is shown in Figure 19. Many of these are institutional in nature and may require new arrangements or extrapolation of existing arrangements to join the public and private sectors together in areas which will benefit and motivate both. Again, no intensive treatment is intended here, but rather the recognition of some of the issues, and some of the actions necessary for enforcement are shown in Figure 20.

Many of the issues discussed so far are interrelated. Action in one area can cause reaction in another area. Developments in technology may give use to new economic or institutional problems. In an attempt to relate these various factors I have borrowed a concept in systems analysis shown in Figure 21. This sort of diagram attempts to put many, apparently disparate factors together to help in planning and

FIGURE 18. EVALUATION OF ALTERNATIVES.

Resource recovery technology
- Front end separation
- Incineration
- Comporting

Energy recovery steam
- Oil pyrolysis
- Gas pyrolysis
- Direct firing

Disposal/technology
- Incineration

Collection procedures
Transport procedures
Storage procedures
Separation economic

FIGURE 19. STATE OF ART DATA VALIDATION.

Existing resource recovery systems

Projected resource recovery systems

Has recycling worked?

Over-all system

Manufacturing practices

Institutional factors
- Federal
- Municipalities
- States
- Regions
- Industry

FIGURE 20. ACTION FOR ENFORCEMENT,

Laws, ordinances and standards
Manufacturing systems concepts
- Financing
- Ownership
- Long-term relationship
- Integrated utility
- Bid process
- Controls

Technology selection
- Readiness
- Environmental impact
- System costs

Markets
- Raw materials
- Products
- Energy

decision making. The diagram is not as complex as it initially appears and in general use one starts with Needs Assessment and Problem Identification. The factors involved on the left of the diagram, National Needs and Problem Identification help define the dimensions of Needs Assessment and Problem Identification. Once Goals are established they feed into helping define Policy. Since we must also examine our ability to set up attainable goals we have to factor into the process our existing Capabilities. We may then modify our Requirements and Goals to alternative Solutions. From these we can Target Program Areas and Develop a Program always being aware of Constraints. The final step is the Action Programs which might involve all of the components of Technology, Economics and Institutional factors. One

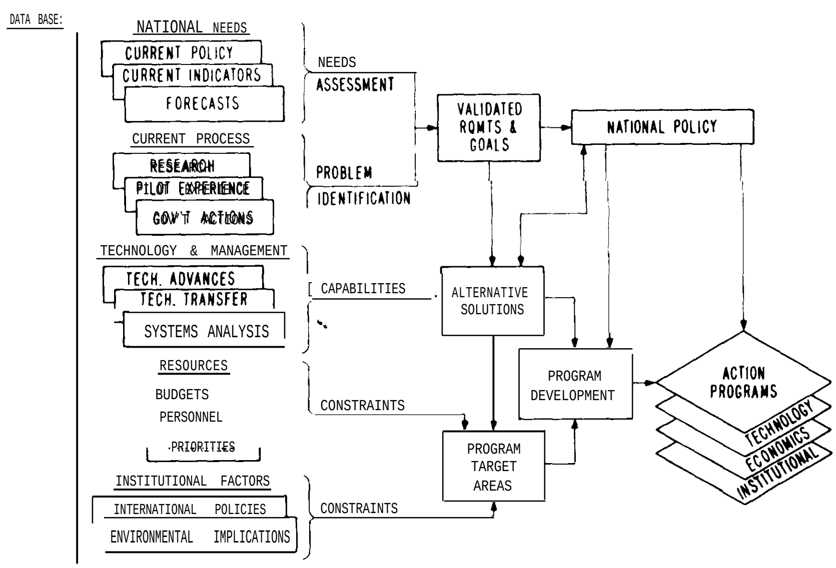


Figure 21. Recovery and reuse system.

must consider National Policy in this diagram as either a goal or an input. It can either direct the entire process or can be a resultant of the process.

This methodology of planning might be usable in our work sessions and perhaps to further imprint it I will go through an example for which I have already developed most of the data in the early part of this presentation, namely the use of municipal refuse as a fuel substitute for oil and coal in the generation of electricity.

A Needs Assessment and Problem Identification might give rise to a goal of burning refuse as a fuel substitute up to 20% of the BTU value of coal or oil in electrical generation. This scenario could come about by the forecast of energy needs, the indication that pilot trials of refuse to fuel have been made in St. Louis and the EPA has been funding some of the effort. We could from this develop validated Goals and Requirements which might indicate that energy should be generated from municipal refuse and the amount set at 20% of the BTU value of coal and oil presently being burned for the generation of electricity by utilities. However, if we look at our present capabilities, we recognize some problem with the 20% because of bottom ash and a question of whether this can be done in oil burning boilers. This might modify our goals to perhaps be: burn refuse up ‘to 2070 of coal in electrical generation. In this case we have not mentioned oil and put the 2070 as a maximum. We can then target specific program areas to determine whether oil burners can be used and examine the 20% by determining factors such as grate design, pretreating the paper to reduce ash, etc. A series of these target areas (technology, economic and institutional) are then broadly defined as Program Development in which Action Programs are to be started in these areas.

We might now question National Policy to determine what it may be. One ‘may start out broadly and describe National Policy in this area as the desire to be fuel independent (Project Independence) by 1980. Therefore the scenario we described on waste to fuel would fit in this policy. There may be other levels of policy that treat the incentives for joint government-private activity in setting up utilities (institutional) and attempt to motivate by tax treatment for example. There could be another ‘sub-policy which treats the economic portion of the waste to fuel area by setting up a stock pile of waste fuel and subsidize its sale. Other policies under consideration might include:

- Need to conserve energy
- Need to find a viable way to dispose of refuse
- Quantitative goals (time, amount) for conversion of waste to fuel
- Develop incentives for industry to work in waste to fuel area
  - Financial
  - Legal
  - Taxes

In the analysis given here we discussed Quantitative Goals for using 20% of the BTU value of coal and oil in electrical power generation. For example, if cities and states felt that construction grants to help them get started in this area was the proper way to proceed, then this could be examined as an input to Policy. It might be felt by those who are involved in policy making that construction grants might slow up the time scale for action by having cities and states wait for funding prior to taking action. Or it might give rise to the development of a policy which helps solve some of the institutional problems of raising capital and costs by developing a system of bonding or guaranteed loans. In like manner areas of a technical nature that were developing might develop a need for trial environmental relaxation for a limited time. The effect of this can be better understood by using a process of planning that would take in all the TIE factors (Technology, Institutional, Economic) and describe them in a fashion that would make the planner aware of the total system.

The need for an overview of the entire system is clear to the decision maker. However, the definition and detailing of the system is not always easy to do. In practice one starts with the specification of a desired system then a process of evaluation of the ongoing and planned programs and then the definition of an attainable system and finally a revised system specification and planned action. These modifications are real time based and require updating which tends to be event centered. In the area of recycling we are just in the process of understanding the system components and at this stage I think the problem is moderately well defined technically, the economics appear viable in some cases, but the majority of the problems are institutional in nature.

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INTERNATIONAL PROBLEMS AND OPPORTUNITIES; A ROLE FOR THE TECHNICAL SOCIETIES AND MANY OTHERS

N. E. Promisel

The petroleum embargo of 1973, aimed at a relatively small number of countries, continues to have ever-expanding, major, economic and political impact on a global scale, even on those countries on the sidelines that basically were unconcerned with the Mideast and its crisis.

This is only one dramatic example—and note that it is in the field of materials—of the unassailable fact that no country can stand aloof and avoid involvement on an international scale in many situations and problems regardless of their origin. Obviously, the degree of involvement will vary greatly, depending on the particular country and the particular problem. Obviously also, the United States, in the field of materials alone, will continue to be heavily involved internationally in most of the major issues, when we consider energy, resources, supply and demand, environment and related areas and technology, and the significant, if not controlling, role that materials play in all of these. And yet, with all these global materials problems, there is no established or recognized international organization whose major thesis, precept, or focus is founded on materials and processes. There is no such organization able to serve as a knowledgeable and adequate forum or mechanism for discussion, information exchange, mutual planning, international cooperation, integrated action, or even integrated response to materials problems and needs generated either nationally or in other international groups.

In 1972, there was formed an International Institute of Applied Systems Analysis, consisting of the U. S., U. S. S. R., U.K. and nine other Eastern and Western European countries. High on their priority list of projects were energy and materials resources, with additional proposed subjects being recycling of materials and the environment, among others. Yet—to repeat—there is no adequate international materials body to provide the necessary input to these materials-oriented projects. There is no adequate group in the U. N., nor in NATO, nor in OECD, nor in the International Council of Scientific Unions (ICSU) (which covers unions in other disciplines), nor in the World Federation of Engineering Organizations, etc., etc. At the second Henniker Conference on Materials Policy in 1972, this writer described the extant international organizations that dealt with certain facets of materials and processes and pointed out their scopes and deficiencies in terms of dealing comprehensively with this important field.

It is more regrettable that an appropriate world materials organization or union of materials science and engineering does not exist. The world can no longer afford random, incidental, casual, or limited international cooperation. There has been a need for such a major union for many years but the present climate throughout the world makes it almost imperative that action be initiated to fill this global gap. The timely reasons, as well as the ever-present ones, are quite obvious:

(1) As indicated above, the current long-range problems of energy, materials supply, and environment (for example, as it affects the economics of production and trade) are certainly global in scope and interdependency and need not be belabored here. Materials science and engineering are basic in these areas.

(2) The increasing social concern for the developing nations, with the correlative issues of economic improvement and, in most cases, industrialization, provides the more advanced countries with special opportunities for materials and processes technology transfer with obvious mutual rewards resulting therefrom. While bilateral efforts can be effective to a degree, a multilateral effort would be more effective and efficient and of great benefit—perhaps eventually essential to all concerned.

(3) Certain sectors of materials engineering require international cooperation; for example, materials exposure for corrosion study in world waters, atmospheric and oceanographic characterization data, exploitation of mineral resources in the international seabeds, etc.

(4) Since no country has a monopoly on talent and unique equipment, and with research and development becoming increasingly costly, it is important that there be a good mechanism for exchange of scientific and technical information, and for cooperative programs.

(5) Related to the preceding item is the opportunity to exchange scientific and technical personnel, with the evident benefits of such exchanges. These benefits are in addition to the opportunity for promoting familiarity and friendships among scientists and engineers on a broad international scale and the mutual education that such exchanges provide.

(6) Just as national materials policy is evolving in the United States through intensive studies and through symposia such as the Henniker series, so other countries are interested in or engaged in generating their own national policies. It is of value to be able to exchange such information and, perhaps to make policies with international implications internationally compatible. Similarly, it is useful to understand the organization and administration of research and development and other aspects of materials science and engineering in many countries. The last time this was done was in 1961 through the limited medium of a NATO symposium.

(7) There is need for a *mechanism* for optimizing the exchange of information on an international basis, for optimizing cross-fertilization in the many fields of materials science and engineering, and for generating global data necessary for intelligent national decisions and planning (as with resources). Among other results, there could ensue a rational basis for selective international conferences and symposia on critical, timely topics, as well as the generation of valuable, cooperative research and development programs that now are practical mainly on a bilateral basis (except in the field of aerospace in NATO).

(8) There is a need for a mechanism to define important world problems to which materials science and engineering can make significant contributions for their solution and easement.

(9) There is an opportunity to focus the world materials community and apply its collective talents to the betterment of mankind, especially those less fortunate.

Undoubtedly, there are additional good reasons for establishing an international organization for materials and processes but the above are sufficient for the time being. From these, the functions of such an organization derive easily; some important ones may be summarized as follows:

(1) To provide a forum for international discussion and debate of critical issues, followed by joint planning for action.

(2) To provide a recognized mechanism for cooperative programs in research and development and other sectors of materials and processes technology.

(3) To provide an adequate and rapid means for information and technology transfer, for mutual education, and for exchange of materials scientists and engineers. Included would be international publications and jointly planned conferences and symposia.

(4) To stimulate the advancement of materials science and engineering on a global basis and promote professional growth in this field.

(5) To promote a better understanding and appreciation of materials science and engineering and its importance by key executives and administrators in many countries.

(6) To insure a mechanism for proper inputs and response to the many other international bodies in other fields and thus to insure adequate consideration (now mostly lacking) of materials science and engineering in many global, critical issues.

(7) The organization would not deal with proprietary industrial technology or the market place per se although the impact of materials science and engineering on economics would be included.

The scope of an appropriate organization must embrace three basic tenets, even though, from a practical point of view, only selective portions of these could be encompassed and implemented at the beginning:

(1) The whole spectrum of materials and related processes and techniques must be included.

(2) Science and engineering and the whole life cycle of materials must be included.

(3) The organization must be worldwide.

The establishment of needs, potential achievements, scope, etc. is relatively simple but the best approach (simplest, fastest, most practical) is open to considerable discussion. As stated above, the author discussed existing institutions that might serve as nuclei, and their limitations, at the 1972 Henniker Conference and some (NATO, OECD, U. N.) have been mentioned again above. None of these are truly worldwide although the U.N. could conceivably be. It is suspected, however, that it would be extremely cumbersome and complex to set up the desired organization within the U.N. All of these groups could, however, be of value and assistance. It should be noted that other existing international groups, more closely related to materials science and engineering, could also be helpful, such as the International Welding Institute. ICSU conceivably could be prevailed upon to serve as a starting point but is quite scientifically oriented and therefore unlikely to be enthusiastic about the engineering and application functions of a group. In short, it appears to this writer that the best approach to forming a materials union of some kind is to build anew, building, in other words, our own umbrella, using existing international groups in other areas for guidance and assistance.

The successful establishment and operation of the Federation of Materials Societies (FMS) (which itself has an international Constitution) offers good encouragement that expansion of this concept on a global basis may be a promising route to explore; that is, enlisting selected materials societies and materials-oriented societies, wherever they exist in the world, to create a strong nucleus for further expansion. U.K. is considering establishing its own Materials Advisory Group (consisting of a number of internal institutions) to deal with many aspects of materials including, in addition to energy and shortages, better design practice, fabrication, standardization, and recycling. Representatives of several other countries, approached by the writer over the past few years, have indicated a receptiveness to cooperation—if someone else begins the action. The Planning Committee for the 2nd International Conference on the Mechanical Behavior of Materials—to be held in the U.S. in 1976—discussed formation of an international group and announcement and observance of its formation at this Conference, with an expected attendance of 600-1000 from all parts of the world. This Conference is under the general cooperation of FMS. The recurring suggestion over the past 15 years of an International Materials Year—independently and strongly suggested and endorsed at this Henniker Conference—would be another significant aid in launching an enduring international materials organization. From these, admittedly somewhat random, thoughts, this writer derives and proposes the following approach and sequence:

(1) Establish a U.S. Planning and Steering Committee for the establishment of an International Materials Union (IMU) or equivalent.

(2) Develop a tentative but specific plan, based on using existing technical and professional societies throughout the world as sources or catalysts for forming the hard core of this Union.

(3) Establish contacts in other countries, whenever possible with existing societies, for the purpose of forming an International Planning and Steering Committee, under this Committee, prepare a Constitution and Rules for Operation and proceed to specific first steps.

(4) Simultaneously, move toward the initiation of an International Materials Year, both for its own sake and as an aid to promoting and forming the Union.

(5) Set a target of mid-1976 for the announcement of the establishment of the Union, with specific activity to begin, probably, in 1977.

(6) At some stage in this sequence, acquire some financial assistance, direct or indirect.

Summary and Conclusions

(1) A number of reasons, particularly current global problems and the climate of the times, indicate the need for an International Materials Union or organization of some type. No equivalent materials organization exists.

(2) The functions follow logically from the dictating needs.

(3) The scope would be broad technically and worldwide in membership.

(4) Attempting to organize within an existing international group does not appear promising. The alternative of organizing independently, possibly with the aid of other international groups, appears more practical.

(5) The technical and professional *societies*, including groups such as the Federation of Materials Societies, could play important roles in developing the new organization, along lines proposed above.

(6) The thoughts expressed herein will be tested for receptiveness

and, if so indicated, some action will be initiated, probably Step 1 in the above sequence.

SHORT STATEMENTS

Explanatory Note: Because *of* the unavoidable *absence of Mr. Promisel, who had been scheduled to deliver the tutorial paper on the national and international roles of the technical societies, a symposium of speakers was organized at the conference by Dr. Wachtrnan to cover the topic. They spoke ad lib without advance preparation. Subsequently they were limited to commit their thoughts to paper as a part of the proceedings. Their submitted papers follow.*

Statement by Dr. Edmundo de Alba,
Scientific Counselor, Mexican Embassy

No country in the complex technological world of the present day is completely self-sufficient in the raw materials consumed by its people. Even the so-called "supplier countries" in their turn need materials from other countries. This interlinking of availabilities and necessities is the most profound reason to mount an effort to resolve the problem of world materials supply by interdependence within international justice.

The interchange of materials, capital, and technology is an increasing feature of the present time. A just order to assure an adequate share of wealth and commodities at the international level is the main goal. This calls for the creation of mechanisms among nations to promote the well-being of their people by sharing commodities and technology at a just international price.

The efforts for increased international cooperation in the field of technology related to materials can enhance the achievement of the foregoing goals, Some of the proposals for an international materials year produced at this Henniker Conference will help to provide an adequate basis for better understanding. Enhanced communications among the scientific and technological societies of our countries can help to realize the possibilities of global interdependence in justice.

Statement by Jean-Pierre Hugon
Ministere De L'Industrie Et De La Recherche
Republic of France

Problems of supply area main concern for all of us developed nations. We are all thinking about the same kinds of remedies: developing our own resources, improving diversification of our foreign resources, improving our control on domestic consumption and especially improving recycling and control of materials life-cycles.

All of that must be done by each of us: that is necessary to strengthen our national positions, but, above all, the most important fact is that we are now entering a new era of worldwide interdependence.

There is not any estimation to be done: we are condemned to interdependence.

Inferences must be drawn from that new state of things, all over the world.

Particularly, some of you know that for the last few years we, in France, are supporting the idea of building international agreements by commodities: bringing together consumers and producers. That kind of confrontation appears now necessary, even when discussions are difficult and especially with developing countries.

By the way, we know that until now most of the U.S. delegations in international discussions are looking somewhat reticent, We hope that, all together, we shall be able to talk about, in the near future.

MATERIALS POLICY IN THE UNITED KINGDOM

P. J. Fallen
British Embassy, Washington D.C,

Introduction

The United Kingdom position on raw materials is very different from that of the United States. We rely on imports very heavily for many of the essential minerals for our industry, and the same is true for energy.

Britain took 10.4% by value of the world's exports of primary products in 1973, and provided 10.170 of the world's exports of manufactured goods: manufacturing industry accounts for a third of the national output; but it is one of those sectors which are heavily dependent on imported commodities. The agricultural industry in Britain has a very high level of productivity, but we are able to grow only half of what we need and nearly half of the food we do produce is import dependent. We have to import 46% of all the energy we use.

A key factor in any national policy for materials is their supply; and a second aspect is the recovery and reuse of resources when possible. A third element of materials policy is product use and design, and the substitution and conservation of resources.

Supply of Materials

In 1973, 57% of imports to Britain were in the form of finished goods or semi-manufactures for further processing. Another 20% comprised food, drink and tobacco; and the remaining 2370 can be split roughly equally into raw materials and fuel. The cost of these imports was more than £10,000 million, of which as much as £800 million was spent on non-ferrous metals and £300 million was for copper alone. The only non-ferrous metal mined in Britain in significant quantities is tin, but even that accounted for only 20% (£7 million) of consumption in 1973. In addition, oil imports in 1973 cost £1680 million, wood pulp cost £201 million, and iron ore f 152 million.

For such reasons, we have been examining the supply of those minerals which we must import; no two are alike. Some, like iron ore, are widely distributed; others, like chromium and platinum, are concentrated in a few areas of the world. Some vital materials, such as nickel, are produced mainly by developed countries; others, like tin, come from developing countries and make a significant contribution to their economies.

In the past it has been United Kingdom policy to seek supplies of raw materials in the cheapest markets, and with current balance of payments problems this remains our objective. We have largely left it to consumers to make their own arrangements to obtain supplies, but have participated in international organisations like the International Tin Council (1) where appropriate. We have, however, encouraged major consumers to examine their supply policies and to work at the possibility of diversifying sources of supply, entering into long term contracts and participating in mining ventures in third countries.

There are conflicting interests in the raw materials field and in considering measures which might be adopted to reduce dependence on overseas sources we have to bear in mind that changes in technology or social patterns are likely to change patterns of use, and hence the future values of minerals.

We do not consider that the recent world-wide rises in commodity prices represent a chain reaction caused by steps taken in 1973 by the Oil Producing and Exporting Countries (OPEC), apart from oil itself, of course. The very large recent increases in prices are largely the result of a combination of market pressures, originating in the consumer countries. In the short term, commodity prices are expected to fall somewhat from the peak levels reached in the spring of 1974. Price movements can be expected to vary from commodity to commodity, but average prices will still remain above the 1973 level. Some further decline in real terms is likely in 1975; but the critical factor affecting commodity price trends is the level of demand in the industrialised consumer countries, and this is difficult to forecast.

Like most other industrialised countries we have however been reviewing our policies in the light of the recent action of the OPEC countries. It seems unlikely that other producer groupings (e.g. copper, bauxite, mercury, iron ore) will be able to cooperate as effectively as the OPEC countries. Some of the factors which are different are that in general:

Reserves of many other materials are more widely distributed;

Substitutes are more readily available;

Recycling is possible, whereas oil can only be used once,

Many developing countries are very dependent on their income from raw materials exports and could not afford to cut back on production, particularly if the recent fall in prices is maintained.

In spite of this, the possibility cannot be ruled out for the future. We can expect to see all producers of raw materials looking for an improved return on their exports. For our part, we recognise the need for pricing structures which are remunerative to efficient producers and equitable to consumers, but there is no single method which would suit the circumstances of every mineral.

The United Kingdom is participating in the work of a number of international organisations on raw materials. Various committees of the United Nations are actively discussing raw materials issues, and we are represented on international groups on specific minerals: the International Tin Council has already been mentioned; other bodies include the Lead and Zinc Study Group and the UNCTAD Tungsten Committee. The European Economic Community is currently undertaking studies of the supply position of important raw materials with a view to putting policy proposals to the Council of Ministers, but no firm proposals are expected in the immediate future; the EEC Scientific and Technical Research Committee (CREST) is considering research programmed in the raw materials field and their coordination. In the OECD, materials are under consideration in the Science and Technological Policy Committee, Trade Committee, Industry Committee, etc.

Our approach to the methods which might be adopted to minimize future supply problems is similar to that of other countries, though we have tended to encourage industry to take action rather than offering direct financial support. Our strategy has been to:

Commission a programme to provide basic geological information on areas of potential mineralisation;

Provide financial assistance for exploration (in the UK) by companies under the Mineral Exploration and Investment Grants Act 1972. Assistance of 35% of the cost of approved programmed of exploration for non-ferrous metals, fluorspar, barium minerals and potash may be provided, and is repayable if commercial production results;

Support research and development on minerals processing and metal extraction;

Create a regime in which commercial exploration may flourish: and at the same time promote the recovery and conservation of materials.

Mining ventures within the UK may also make use of the assistance that is available to industry in general under the Industry Act 1972.

Whatever we do to promote the development of indigenous resources, we shall still have to rely on overseas for the majority of our supplies. We do not provide any special assistance for this purpose, although United Kingdom companies may benefit from the general assistance available for overseas investment through, for example, the Export Credits Guarantee Department non-commercial risks investment insurance scheme, and under the aid programme.

We are naturally anxious to make the best use of our own sources of raw materials, both for the security of future supplies and to make savings on the balance of payments. The reclamation industry is one of our most valuable indigenous resources: 62% of the lead, 5870 of the platinum, rather more than half of the steel, about 40% of the copper, paper and board, 26% of aluminium and 2170 of the zinc consumed in the United Kingdom are derived from reclaimed and recycled materials.

Recovery is closely bound up with methods of waste disposal (2);

also there are immense problems of coordinating the wide range of organisations, materials and industries. Much of what can be recovered economically already finds its way back into the production system, especially at current high prices, and there are no vast stocks of waste materials which could be easily reclaimed. Also, there are considerable problems of markets, economics and technology to be overcome if significant increases in recycling are to be achieved.

The government's recent consultative paper "War on Waste: A Policy for Reclamation" (3) urges a new national drive to cut down waste and to promote ways of recovering materials, The Control of Pollution Act, passed in 1974, requires local authorities for the first time to examine ways of promoting the reclamation of waste (not just to collect and dispose of it) and gives them new powers for this purpose.

During the past two years, there have been three major studies by industry-led working parties on the special problems which arise in recovering metal containers, bottles, and plastics (4). An official interdepartmental Working Group on Recycling, Reclamation and Re-use of Materials already exists to coordinate government activity and to decide on priorities for action and research in the interest of efficient and economic waste management, in particular the encouragement of reclamation and recycling.

A Waste Management Advisory Council is being established to bring together those involved in the production, collecting, disposal and recovery of waste materials of all kinds. An Advisory Group on Waste Paper Recycling has already been set up, and an Advisory Council on Energy Conservation was established in 1974.

It will be for bodies such as these to make the economic and technical assessment, to advise on the role of government and whether more should be done to encourage reclamation and conservation of resources. The environmental costs of disposing of waste and of obtaining new raw materials have also to be borne in mind. The main issues are to establish what is technically possible now, what is economically worthwhile and what technical developments it would be worth promoting.

Research and development programmed on reclamation are being reviewed and expanded. Such work is carried out principally by the Department of Industry, the UK Atomic Energy Establishment, by the National Coal Board, and in universities and in industry. The present programme of the Department of Industry's Warren Spring Laboratory concentrates on two programmed: scrap and waste processes including pyrolysis and domestic refuse sorting, and the recovery of metals from effluents and sludges.

The Warren Spring Laboratory has been working with industry for some time on the more difficult problems associated with reclamation and recycling of materials, especially the processing of complex materials and residues. Included in this work is the recovery of valuable materials from slags produced by metal processing, from electroplating residues and from effluent treatment plants. Various projects in such fields as pulp, waste paper, rubber and plastic are also being examined. The Laboratory has recently received approval for a Waste Recovery

Service, to provide consultancy and information for producers and processors of waste material.

Substitution, Design, and Conservation

Other approaches to materials problems concentrate onuses rather than supply or recovery; they include research and development aimed at conserving materials and finding substitutes for the most vulnerable ones. The problem in this area is to know where to begin: substitution is a process which is occurring all the time, but whether and at what rate it occurs depends on both technical and economic factors. As far as we know there has been very little investigation of this area but we doubt whether it is feasible to carry out detailed end-use studies of the important materials, or indeed whether it is possible to identify with any degree of certainty the materials for which the risk of supply is greatest.

In the past, manufacturing industry has devoted considerable attention to designing and making machines and tooling to reduce direct labour costs. This approach may change if materials costs account for a bigger proportion of finished goods. But we must also recognise that these are not simply questions of technology or economics: changes in social outlook may also be required, and these may not be desirable for other reasons.

More efficient use of materials could be achieved, without sacrificing living standards, by better design to increase product life and reduce manufacturing waste. Material costs can represent 30 to 40% of the factory cost of consumer goods, and the proportion of the gross material purchased and converted into net saleable goods is seldom greater than 70% and frequently less than 30%.

There are numerous ways in which improved design considerations can assist materials conservation. Standardisation and variety reduction of materials and components can contribute to the simplification of design, and so can reduction in the size of a product or in number of its parts. Extended product life is related not only to design considerations but also to improved selection of available materials for the conditions of service. Reduction in the number of production operations and process waste, and quality control to detect defects at the earliest possible stage all help to save materials and money.

The introduction of improvements along these lines depends greatly on the response of society in developed countries. Although more positive attitudes are developing on the recovery and recycling of waste, the "man in the street" is probably reluctant to accept extended product life (or reduced lifetime cost) if this entails an increased initial outlay; but this attitude may change with time.

At present, responsibility falls mainly on engineering industry to improve the efficiency of materials utilisation. The government has long encouraged the more efficient use of materials mainly but not entirely by supporting research and development; the basic justification for government involvement is to improve the technological and commercial competitiveness of UK industry. Under the customer-contractor concept proposed by Lord Rothschild (5) requirements boards for research and development have been set up by government departments. In the Department of Industry for example these boards function as proxy-customers who are responsible on behalf of industry for identifying research and development needs and for the placing of contracts to meet those needs with contractors both inside and outside government. The most relevant of these boards in the Department of Industry is the Engineering Materials Requirements Board; its general objective is to increase the efficient utilisation of materials, by extending their characterisation and by developing design techniques and criteria,

These are all aspects of materials conservation. The use of fuels may also be regarded as a component of a national materials policy. Energy conservation ranges over such diverse subjects as domestic insulation and the use of smaller motor cars, and is not something which can be achieved overnight; nevertheless action now will yield substantial economies later. In a recent Cabinet Office study (6), recommendations for energy conservation in Britain are made under these headings:

Transport:

fiscal measures; aerodynamically more efficient car bodies; improved fuel use by internal combustion engines; hybrid and electric vehicles and advanced batteries, including sodium sulphur batteries;

Electricity generation:

technical and economic appraisal of harnessing wave power;

Energy in the home and industry:

pricing and fiscal policies for energy supplies; higher insulation standards for new buildings and improvement grants for insulating existing dwellings; combined district heating and electricity schemes; more efficient light fittings; promotion of hydraulic systems in place of electric motors; information campaigns and services for fuel and energy conservation.

Conclusion

It might be misleading to claim that Britain has a comprehensive national policy as such for materials; but some components of the policy exist and are in place. As a country which is highly dependent on trade and on imported basic materials in order to survive, we are conscious of how vulnerable we are to any force which threatens our supplies of food, fuels, and minerals. As a country which is very conscious of the balance of payments between imports and exports, we are concerned to conserve and make good use of those resources we already possess, and of those we are obliged to import.

We are willing to share what we have learned with other countries. Unilateral action by individual nations to protect their own position may only worsen the situation, for in the long run—as in the short term—producers and consumers depend on each other. We must work to conserve resources as best we can—within existing institutions for preference—and to ensure the orderly exploitation of these resources.

1 am greatly **indebted to colleagues** *in Britain for the help on which this note is based,* but its contents *are my personal* responsibility.

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REPORT ON UK CONFERENCE ON CONSERVATION OF MATERIALS

D. W. Ballard
Sandia Laboratories

I had the privilege of participating in a Conference on Conservation of Materials held at the Atomic Energy Research Establishment in Harwell. England, last March and have been asked to comment on the results of the Conference to this Henniker audience. The Conference was organized by the British National Committee on Materials and was co-sponsored by the Institution of Chemical Engineers. Since this was the first materials conservation conference in the United Kingdom, attendance exceeded the hall capacity (250 persons) and spilled over into a lobby where remote loudspeakers were available. Strong press coverage was evidenced by the presence of nine editors and reporters of major UK publications.

The UK attendees and lecturers represented the highest levels of industrial, governmental and academia groups. For example, Sir Alan

Cottrell, Chief Scientific Adviser to Her Majesty's Government and Sir Kingsley Dunham, Director of the Institute of Geological Sciences, gave papers at the opening Keynote session. Dr. Nathan E. Promisel, at that time Executive Director of the US National Materials Advisory Board and President of the Federation of Materials Societies, had been requested to participate in the Keynote session. Dr. Promisel was asked to discuss the results of an extensive USA study on materials conservation as part of an overall materials policy review of the NCMP.

Dr. Promisel broke his hip on a visit to USSR and asked me to prepare and deliver the requested keynote paper since I had chaired the ad hoc committee of the FMS that provided the conservation of materials input to NCMP. My comments were well received and evoked many useful discussions during the Conference. There was a tremendous interest in both the NCMP study and the FMS input report entitled ● 'Conservation in Materials Utilization", copies of which were given to the attendees after my presentation.

Some personal observations which I feel will be of interest to this audience were the following:

1. Our potential materials shortages in the USA are significantly less than the outlook for the UK. A program for internal self-sufficiency in energy fuels as President Nixon initiated in the USA would be impossible in the UK. The same comment would be applicable to many of the other critical industrial materials.

2. A conservation ethic has been in effect in the UK of necessity for a number of years, Nevertheless, all persons agreed that what they have been doing in the recycling and more efficient materials utilization must be intensified as soon as possible. It was quite apparent that they considered our "throw-away" habits and ● 'cosmetic obsolescence" practices in the USA as a major burden on the rest of the industrialized world as well as the emerging nations.

3. A strong concern and anxiety was expressed as to the possibilities of "materials blackmail" practices by the nations with major raw materials sources. It was evident that the success of the Arab "oil blackmail" had triggered this concern.

4. During the final session, recommendations were made that the United Kingdom make a materials policy study similar to our NCMP one, using as much of the NCMP recommendations as deemed applicable to the UK. The wrap-up speaker, Dr. J. Pick of the University of Aston, felt a strong message to Her Majesty's Government should be sent from the Conference pointing out the urgency of maximizing materials conservation practices,

5. Follow-on conferences on various aspects of this subject are planned. These will probably be directed towards specific materials and/or industries in the UK. Several feature articles on conservation methods are planned in technical journals and a new publication, "Resources Policy", is to be launched in September, 1974, by IPC Science and Technology, Press, Ltd. The entire proceedings of the Conference are being published together with the question and answer

sessions and should provide a valuable reference for many of the attendees at this conference.

Statement by C. M. Cosman, Consultant, United Nations

The crisis in raw materials which was brought on by the Arab oil boycott and the subsequent price jump by the OPEC nations, is spreading to other minerals and threatens the pattern of trade and the high standard of life in the world. This situation is ameliorated only where economic or technical alternatives provide relief.

This situation is further accentuated by the fact that the largest oil producers for lack of population and for socio-religious reasons cannot take back from the industrial world products that even faintly measure up to the funds received by these oil exporters. Investment in plant—petrochemical, steel or aluminum production—only further tilts the adverse balance of payments, since the market for these products is largely in the industrial world.

There is a deep sense of malaise on the industrial world as a result of this situation: the flow of funds to the oil producers amounts to a hemorrhage, and must either result in a reduction in the standard of living—with the likely consequence of unemployment and social unrest—or in ever-accelerating inflation—with similar social consequences.

Third World countries that have no oil or exportable mineral resources are now required to pay so much for oil imports and for industrial supplies as to beggar themselves also. This has particularly serious consequences for agriculture, since these countries can no longer afford to provide needed fertilizers.

The industrial world is being blamed for the turmoil that has been created. Conversely, the industrial countries bend every effort to attain energy ‘‘independence’. Enormous research programs are being launched to reduce reliance on imported oil. Work is also being done to lower dependence on bauxite and other imported raw materials.

The pattern of world trade, the pattern of an orderly draw-down of resources—the most economical first, the more expensive later—has been upset. This development arises not only from the events of the last year, but from political actions taken by some Third World countries which make investment in raw material development extremely hazardous. Expropriations and nationalizations do not sit well with investors. And the entire burden of development cannot be shouldered by the World Bank and similar organizations.

Consequently the pattern of commerce which has served the entire world well during the past quarter century seems to be on the verge of collapse. A return to economic nationalism, to autarchic modes of thought, may bring disaster to many nations—especially the dependent ones—a lowering of the standard of living, and the frustration of hopes.

At the United Nations I am associated with a great effort to help Third World countries toward economic growth by finding and developing their raw material resources. With this perceived trend toward economic dislocation—admittedly caused to a considerable extent by actions taken in the developing countries—such efforts are being vitiated.

Before positions become frozen, before decisions are made that set the world irreversibly on the course of economic nationalism, the nations should give pause and get together and evaluate these trends, and see whether there is no possibility of composing these differences, of saving the world-wide exchange of goods and services that has led the world to unprecedented prosperity and stability in the last twenty-five years. It will be necessary, however, to respond more extensively to the aspirations of the Third World.

III. TASK FORCE REPORTS

Following the presentation of tutorial papers, the attendees were organized into five task forces, to consider problems related to the subject of the conference. There were five such topics, and each task force spent one day on one topic and a second day on another, so that ten task force reports were produced.

The following pages present in sequence the terms of reference of the tasks, a short summary of the task force reports. and the ten reports in full.

Task One: THE MANAGEMENT OF MATERIALS INFORMATION

What can be done to improve the availability of pertinent, timely, reliable, and adequate information in all aspects of the materials life cycle to those who need this information in the conduct of materials programs, projects, application, and policy formulation?

Rationale

Decisions on the management of materials depend on the collection and analyses of many kinds of information. Global management of materials implies many kinds of information from many countries. Many systems of materials information have been established, such as the Canadian resources inventory, the ACS and ASM abstracts, journals, technical evaluation centers, translations, critical tables, standards and specifications, materials characterization, alloy tables, process data, state-of-the-art reports, corrosion and deterioration data, and reports of materials research completed and in progress. The volume of all these data is increasing at an exponential rate. Access to needed information is becoming more difficult, even while the literature becomes more abundant and duplicative.

Questions

1. What technical information should be available to users?
2. Is it possible to approach on a systematic basis the problem of consolidating and codifying materials data and information?
3. How can this body of knowledge be structured for storage, analysis, and access for retrieval to be more efficiently responsive to established consumer needs?
4, What methods of information management could ensure the international compatibility and exchange of materials information?
5. What first steps would be most cost/effective toward a global system for materials information management?
6. What would be a reasonable and feasible set of long range goals for materials information management?
7. Where should the initiative be located for a positive program in this field?

Task Two: THE INCREASINGLY INTERNATIONAL CHARACTER OF MATERIALS ISSUES

What is the scope of materials issues shared in common by the nations of the world for which there exists or could develop a broad motivation for cooperative effort at solution?

Rationale

The impact of national materials decisions on the industrial and economic health of other nations has been dramatized by the Arabian management of petroleum and by the inevitable chain reaction of shortages of other materials. Large-scale materials interactions are increasingly an element of international transactions. Concern for international transfers of technology from developed to developing countries has been a major concern of U.S. policy since before 1950. Questions about the complex role of international corporations are of more recent origin, but are of growing importance. Petroleum and mineral resources of the seabed will require international agreement for their orderly exploitation. Science is traditionally international in character, and technology is increasingly becoming so. How can the further development of science and technology, across the total spectrum of materials management, be conducted to the mutual advantage of all nations?

Questions

1. What are the goals of international cooperation in materials science and technology?
2. Can existing institutions be better used and are additional institutions needed to define goals, develop policies and programs, improve communication, and motivate action toward these goals?
3. What national institutions are needed in the United States and other developed countries to further international cooperation?
4. What is the required information base, in terms of long range supply and demand for materials, to enable policy planning and decision-making?
5. What areas of international cooperation would be most feasible and fruitful in terms of mutual benefit?
6. What are the obstacles to mutual cooperation in global materials management ?
7. Can international programs in materials be effective in the conservation of materials?

Task Three: DESIGN IMPROVEMENTS TO INCREASE EFFICIENT UTILIZATION OF MATERIALS

What design improvements will improve efficiency of use of materials and energy?

Rationale

Design improvements can extend the life of systems and improve the economy without major additional cost. Limits to growth are implied by the energy shortage, the agitation for environmental protection against pollution, and problems of waste accumulation and disposal. When high grades of ore are depleted, industry turns to leaner grades. To process these requires increased efficiency of extraction, but also higher cost of the material produced. This higher cost, in turn, requires that more use be made per unit of material, or resort to substitutes like wood and glass, to overcome inflation. In addition, there is implied the justification of a more intensive effort to recycle recovered secondary material. In other words, systematic consideration of the entire life cycle of materials is necessary.

Questions

1. What new designs are implied by the need to improve the efficiency of utilization of materials and energy?
2. What unused or under-used technologies could contribute to better utilization of materials and reduced costs?
3. Where are the most rewarding opportunities for design and process improvements? (Viz,, heat transfer.)
4. What materials are available in quantities and at prices to replace depletable hydrocarbons?
5. Can energy input of aluminum and magnesium be justified by the performance properties of these materials, or by their more efficient recycling?
6. What should be the role of Federal regulations in encouraging improvements in design?

Task Four: MOBILIZING ECONOMICS AND TECHNOLOGY FOR MATERIALS RECYCLING

What actions, public and private, could motivate the more complete recovery of waste and greater utilization of secondary materials, thus closing the materials cycle?

Rationale

A host of studies have shown that there is an abundance of technologies to extract useful values from municipal wastes. Agricultural and forest waste are a large, valuable, and unused or under-used source of energy. Human waste in sewerage is permitted to contaminate surface water instead of providing safe and useful energy and fertilizer. Traditional reliance on virgin materials has created patterns of use that require alteration if secondary materials are to replace them. Industrial locations favor primary over secondary materials. Consumer standards, freight rates, industrial processes, and commercial credit practices favor primary materials. Present collection systems are inefficient and skim off the top, leaving the bulk of municipal wastes to pile up in disposal sites. Costs of waste disposal are not capitalized within the materials cycle. Yet the use of urban land space as repository for wastes is limited and costly. Environmental regulations deter open burning, and the burning of trash—even to generate energy—is increasingly recognized as wasteful of resources. Better management of wastes is almost universally recognized as an essential element of the life cycle of materials.

Questions

1. Beyond the general goal of achieving a closed cycle in materials management, what more explicit and detailed goals are there?
2. What kind of institutional mechanism and aids, private and governmental, could best provide the motivation toward achievement of these goals?
3. If scrap, such as aluminum and iron scrap, represents an investment in energy, should U.S. exports of these materials be permitted—or from other energy-short countries—to countries with surplus energy?
4. Would it be possible to "design" municipal wastes streams by applying regulatory principles to the design of products that comprise the bulk of these streams?
5. What materials should be kept entirely out of municipal wastes streams and how?
6. What techniques could be used to maintain the value of materials throughout the entire materials cycle, to increase the motivation for their recovery and re-use?

Task Five: THE ROLE OF THE TECHNICAL COMMUNITY IN NATIONAL AND INTERNATIONAL MANAGEMENT OF MATERIALS

Can members of materials groups, such as materials societies formed for various public, corporate, and informational purposes of persons in technical disciplines, organize cooperatively for larger national and international objectives and programs related to the combination of disciplines they encompass?

Rationale

There has been a long history of successful international cooperation among societies in basic science. The scope of international scientific activities has gone beyond information exchange to the actual planning of joint projects like the International Geophysical Year and the International Biological Program. Some efforts have been made to extend this cooperation into fields of applied science through bilateral programs, the United Nations, NATO, and OECD. The UN Conference on the Environment showed that there was a lively interest in the interaction of technology with environmental quality. Within the United States it has been found that the Federation of Materials Societies can play a significant role in furthering national materials objectives. Presumably similar technical federations in other national settings could be similarly beneficial. To the extent that technical objectives are shared among nations it is possible that an international materials institution might further these objectives.

Questions

1. What materials goals tend to be most evidently shared among nations?
2. What kinds of programs could be sponsored within nations by their technical societies for public purposes?
3. What kinds of interactions might be fruitful regarding similar programs in various nations?
4. What type of international organization is likely to be most effective?
5. What contacts and exchanges of personnel and information by technical federations across national boundaries might be mutually beneficial to the federations and to the respective national publics?
6. Is there a role for the United Nations or UNESCO in support of international technical federations of materials societies?
7. What limitations would be necessary in the design of international cooperative relationships within an international federation of materials societies ?

SUMMARIES OF TASK FORCE REPORTS

Task One: The Management of Materials Information

Group A	*Group B*
Points of Agreement	
Most elements of a materials information system already exist within the government.	Existing agencies can be utilized in support of a materials information system.
Public interest and participation in the collection and dissemination of materials information should be encouraged.	Public, as well as Government, participation should be encouraged.
Points *of* disagreement	
No major new bureaucracy needed, but should have a central coordinating agency to oversee the collection of data within existing agencies.	New Cabinet level Department should be established to take charge of materials information.
Comments	
Survey is needed to determine what kinds of data are already available. The survey could be done through existing agencies.	Information on mineral resources should be collected by individual agencies and coordinated by the Cabinet level Department.
	This new Department should also be responsible for information on the production, consumption and reuse of materials.

Task Two: The Increasingly International Character of Materials Issues

Group A	*Group B*
Points of Agreement	
Maintain materials stockpiles.	Maintain stockpiles.
Self-sufficiency is not a reasonable goals.	Self-sufficiency is not a reasonable goal.
U.S. should export its materials science and technology, in exchange for raw materials from less developed countries, and for other technologies from more advanced nations.	Materials science and technology are important to furthering international cooperation.
There is a need for better interaction and communication between/among nations. This can be furthered through existing organizations. No new bureaucracies needed.	Increased trade with PRC and USSR could lead to more open lines of communication and trust between ideological adversaries.
No new federal agencies are needed to better this international communication, However, we need closer ties between government and multinational corporations.	MNC'S could be important in encouraging international cooperation and communication.
Wider materials information base needed.	Wider information base needed.
Points of disagreement	
No new bureaucracies needed.	Department of Natural Resources should be created, along with an independent agency for data collection along the lines of the National Commission on Supplies and Shortages pursuant to S. 3523.
Comments	
Best way to foster international cooperation is through exchange of technical information.	Standards for materials information could be a useful form of international cooperation.
Some institutional factors inhibit mutual cooperation. These, in some cases, can be eliminated by governmental action. However, there are other factors inherent to the international political system which will never allow complete trust and cooperation.	

Task Three: Design Improvements to Increase the Efficient Utilization of Materials

Group A	Group *B*
Points of *Agreement*	
There are new barriers to the introduction of new technologies which could result in the most efficient use of materials.	There are many barriers to optimum materials utilization.

Economic constraints are most important, but institutional factors are critical and can be dealt with by the Federal Government.	Institutional factors are important in the encouragement of innovation and current practices inhibit that activity.
A vigorous Federal program is needed to educate the public on materials options.	A Government program is needed to encourage materials conservation.
Need to disseminate information on the life, repairability, and recyclability of products.	Need to find new ways of improving the quality of products, in terms of lifetime and recyclability.
Need to study materials substitution and ways of improving durability of important materials.	Need to improve durability and find areas where substitutions for materials can be made.
Investigate government design/performance specifications incorporating ideas of materials conservation practices.	Government should provide standards for performance in promoting conservation, but should not dictate design criteria.
Investigate areas of direct government intervention which could effect materials conservation practices.	Should identify areas where government standards could result in better materials conservation.
Serious problems are 10-15 years off, but need to begin examining government policy alternatives now.	Indications show serious supply and shortage problems in the future, if action is not taken now.
Comments	
The constraints to innovation include scientific knowledge, education and manpower, capital and equipment, energy requirements, characterization of materials properties, insufficient technology transfer.	Need government incentives for innovation. Revamp government purchasing systems to encourage efficient materials use. Declare an International Materials Conservation Year.
Government should better define the materials/energy content of products.	Need more effective government-industry relationship.

Task Four: Mobilizing Economics and Technology for Materials Recycling

Group A	*Group B*
Points of *Agreement*	
There are weak economic incentives and institutional barriers which limit recycling efforts at present.	There are institutional constraints to the operation of recycling facilities.
Current disincentives should be eliminated, with incentives added to the institutional structure.	Government should enhance marketability of recycled materials.
Promote voluntary industrial programs for purchase and disposal of materials.	Encourage joint government-industry R&D and recycling efforts.
Comments	
There have been no incentives to promote the recycling of materials from the municipal waste streams.	Federal and State governments should share costs of developing recycling technologies.

Reduce waste by promoting product durability, repairability, and maintainability.

There are many recycling technologies, but no single optimum process can be found for use in all locations.

The cost of water used in materials processing—including the cost of restoring it to recyclable quality-is often overlooked.

Landfill requirements/regulations should be re-examined.

Products should have their social as well as economic costs listed, including disposal costs and materials and energy requirements.

Task Five: The Role of the Technical Community in National and International Management of Materials

Group A	Group B
Points of Agreement:	
There are certain goals compatible with the objectives of all countries, which could be discussed cooperatively by technical communities in most nations.	A basic materials goal is improving the international atmosphere to the point where the exchange of materials, goods, and services takes place, and dislocation is minimized.
Technical societies can assist in the exchange of technology and the identification of problems within the materials area.	The technical community should also continual y advise legislators of materials problems and opportunities which warrant legislative action.
There is no need at present for an international federation of materials societies, as this type of exchange already occurs.	Contact should be maintained with technical societies in other nations.
Comments:	
Technical communities should focus their discussions on information needed for materials optimization, substitution, assessments of materials needs and the strengthening of educational weaknesses in the materials science field.	Professional societies could assist in an effort to educate the public, aimed at changing attitudes to produce more efficient use of materials.
A National Materials Policy Commission could coordinate special studies and symposia by single or multiple technical societies, with backing from private and governmental groups.	To increase awareness, an International Mineral Resources Year should be launched.
There is a need for greater cooperation between industry and government in achieving materials policy objectives through international exchanges.	A compilation of international mineral and materials societies is needed.
Technology exchange can be used in furtherance of so-called competitive national goals.	

Task One (A): THE MANAGEMENT OF MATERIALS INFORMATION

Most of the elements of an effective information and data evaluation and dissemination system now exist in the USA. We should build on our present pluralistic system, recognizing that no single approach or massive central organization is likely to meet all our diverse needs. A central organization, almost certainly within the Federal Government, is needed to monitor the adequacy of these services, to point out significant gaps, and to act as a referral center in guiding users to sources of data and information they need.

Some additions and expansion of elements dealing with data on material properties are needed, and there is an unsolved question as to how discipline-oriented evaluation and information centers should be financed.

We can pretty well identify the additional needs for supply/demand statistics on U.S. resources and reserves. On a world-wide basis, the initial need is for a survey to find out what data are now available.

RECOMMENDATIONS :

I. Establish a continuing coordinating office, charged with analyzing U.S. information sources dealing with materials to:

1) Determine the adequacy and timeliness of existing info to meet present and anticipated national needs;

2) Identify and publicize areas where needs are not being met, and whether expansion of existing operations or new operations are required;

3) Make available, by publication and/or referrals, guidance to specific sources of data and info on materials.

(NOTE: This would be the type of service now provided by the Library of Congress, but based on a more detailed base evaluated by specialists. No single organization can do this evaluation job alone. It might be possible to utilize voluntary panels from various technical societies. M might be better to assign portions to organization like the Bureau of Mines, Department of Agriculture, NBS, etc., who are already doing pieces of total job. However, some one central group should be responsible to see that the whole job is done—and maintained up to date. It should be an office whose warnings of gaps in coverage would be listened to attentively by Administration, Congress, and business.)

II. Most of the existing data evaluation and information analysis centers were started with governmental funds, DoD, AEC, NASA, and others. Support for such centers from at least these three agencies has decreased in recent years, and there is as yet no obvious alternate source(s) of support. Such centers must operate along essentially disciplinary lines, whereas most major sources of funds are from organizations committed to programmatic goals. No one funding group will accept responsibility for supporting a center whose outputs are used in many programs. We suggest that the member societies of FMS and other materials-oriented societies and trade organizations accept some responsibility for seeing that adequate information sources (centers as well as publications) exist in their area of interest, and endeavor to encourage their adequate funding from both private and governmental sources.

111. It is recommended that a survey of organizations throughout the world that presently gather supply and demand information on materials be undertaken. This survey should have two purposes: (1) to provide information which will show what sources of data on materials are now in existence, their frequency of collection, timeliness, and adequacy, and (2) to provide information to indicate where there is missing information. This survey would be the first step in providing to the "central referral agency" information sources for supply and demand data. It would also provide this agency with the basis for recommending establishment of other information centers or collection agencies for obtaining missing data.

Organizations that might be possibly approached to perform such a survey are OECD, UNESCO, the World Federation of Engineers, UN Transportation Resources Agency.

IV. The exchange of technical information, resource information, design data, and specifications, among industrial firms is inhibited by the current adversary interpretation of the Federal Trade Commission Act and the Anti-trust laws. This limits the ability of private firms to cooperate in effective utilization of national resources in the national interest. A re-evaluation of the impact of the current interpretation of these laws is needed in view of our changing materials situation, and its present and potential impact on our balance of trade.

V. FMS/OTA Survey. The initial results document in a convincing fashion the diversity of sources of information and the need for more effective evaluation of publications, etc., covering existing information and data. Also the need for an effective, centralized referral source or sources (publications and/or centers) to assist users in finding needed data and information.

We do not believe that any major extension of this survey is needed at this time, nor would it be practical without a major investment. We recommend a modest additional effort to fill some of the major gaps in the Materials Information Matrix and to complete the analysis of replies at about the level of specificity of the initial analysis,

More detailed additional surveys, where and if indicated, should cover smaller segments of the whole field.

Task One (B): THE MANAGEMENT OF MATERIALS INFORMATION

The role of information in our society is always undervalued. Information is not a need which has been perceived with the urgency of no gasoline for your car or no food for your stomach. Therefore, in the process of establishing priorities in the Federal Government, the State Governments, and companies and societies, information needs tend to always get less support in money and resources than the value deserves. One means of redressing this imbalance is to establish, within these organizations, groups with specific missions for developing information and making the results available to decision-makers and making the public and researchers in general aware of the information source.

Information and materials has suddenly become unimportant ingredient in decision-making at all levels. A corporation president wants to know whether he can design a product around chromium and expect to be able to get supplies at reasonable prices five years from now. The Federal Government wants to know whether it has weapons and alternatives available to counter extortion from international cartels. These answers cannot be provided unless there is in place a Materials Information System which can be used to develop the answers.

Against this backdrop, the Task Force makes one general recommendation, followed by specific recommendations on various areas of materials information. We have divided the Materials Information System into three major categories. Category I covers information, usually in the form of numbers, on the scientific and engineering measurements of materials. Category 11 covers information, which may be numeric, but also may be in the forms of texts, maps, and other forms, on the resource base for materials. Category 111 is on the production, consumption, and reuse of materials by society and contains physical information, economic and financial information and qualitative information on such things as government policy and market structures.

General Recommendations. The Task Force urges that a single cabinet level department be established with responsibilities spanning all materials. We define materials as defined in the Boyd Report—that is, those things that are used by Man with the exception of food. This cabinet level department, along with its major programs of operations, should have within it three distinct information agencies corresponding with the Categories enumerated above.

The rationale for this recommendation is that the interconnection of materials is such that a wide diversity of disciplines and talents are needed to manage and develop information systems. It is not the sole province of the librarian and statistician to manage such systems. Inputs must come from all classes of the professions, the physical sciences, the social sciences, the behavioral sciences, and others. The information must be evaluated and judged, which is a professional matter, not a matter for an information specialist, Secondly, the materials problem is now handled by an extreme diversity of federal agencies, which leads to conflicting information systems and conflicting policy determinations. Our task group will not attempt to give the full justification for this recommendation, since it has been adequately developed in a series of hearings before the Congress, but we do emphasize that from the point of view from the Materials Information System itself, there is strong justification for the proposal.

1. SCIENTIFIC AND ENGINEERING MEASUREMENTS.

There are an extremely large number of sources for this type of information. The professional societies, the Federal Government, individual companies who are marketing materials, are but a few of the numbers. In the survey conducted by the Materials Information Committee for the Office of Technological Assessment, well over 500 specific sources were cited by the relatively few respondents to this date.

Knowledgeable researchers in this area have developed for themselves a set of sources upon which they rely, The problem here is to make this body of information accessible to the non-specialist who has need for it and to give him an evaluation of the state of that information. One could characterize that information as being of three general forms: (a) preliminary, in the sense that it is the result of an initial research effort, (b) of intermediate validation where some considerable work 'has been done on the measurement and it might be included in, for example, a handbook, and (c) final, verified, reproducible information, subject to many trials, such information being fully reliable and usable in, for example, products which are essential for the public safety. Any information system which will meet the requirements for this category must specify the category of information provided and must evaluate the information received.

The Task Group makes the following findings and recommendations with respect to Category 1.

a. The system of specialized information centers that currently exists is the proper one, and should form the basis for the Information System. These specialized information centers provide authoritative compilations of data which they have evaluated with respect to its reliability.

b. The Information System requires general shared financial support because in this case, as in all others, information to a substantial degree is a public good. Thus, a significant proportion should be borne by the general public through tax support although the professional societies and the users should also make contributions to the cost.

c. An independent agency, hopefully within a Materials Department, should be given the mission of establishing standards for and overseeing the operations of the above Information Centers; of developing awareness of the sources of information in this area; and to identify the need for new Centers and help establish the same where required.

11. THE RESOURCE BASE FOR MATERIALS.

The information covered by this category goes to the basic resources in the earth's crust for materials and the productivity of the earth's surface in its soils and water for the growing of organic materials. The major agencies involved are many, we mention the United States Geological Survey (USGS), the Department of Agriculture, the Corps of Engineers, Bureau of Reclamation, National Oceanic and Atmospheric Administration (NOAA), the universities, professional associations, companies, both industrial and financial, industry trade groups, national cartographic groups and non-profit organizations. On a world basis, the UN and their specialized agencies affiliated, as well as each individual country's geological survey and equivalent agricultural organizations.

The information in this area exists in the form of maps, stream flow data, soil characteristics and computerized system of numerical information such as the CRIB system of USGS and the analytical computer models of River Basins of the Corps of Engineers and the Bureau of Reclamation.

The Task Group makes the following findings and recommendations with respect to this category:

a. There is an urgent need to coordinate this information by specific geographic areas such as has been done for limited areas by the USGS. Such coordinated information will describe a vertical section of the earth and atmosphere starting with its geological characteristics including its hydrologic characteristics, the characteristics of the soil, the land uses made on the surface and the characteristics of the climate and atmosphere above it. This coordinated information is an absolute necessity for rational land use planning. A specific group within the Federal Government, hopefully the Department of Materials, should be responsible for bringing together this coordinated information by specific land areas.

b. The USGS should be charged with responsibility of being the evaluator of all geological information and should serve the function of an Information Center in regard to this information; the Department of Agriculture should play the same role for the soil and biological information; and the NOAA should play the same role for climate and atmospheric information. All three of these groups should be combined at a proper time in the proposed Cabinet department.

c. The above lead agencies should establish continuing relationships with each other and with sister agencies on a world-wide basis and should determine and make available to the public information on the size, nature, and characteristics of the world resource base of materials.

d. The professional societies, such as the constituent members of the AGI, should continue to publish and catalog basic geologic and geophysical research. These societies should consider establishing a formal advisory committee to the above agencies to further their mission.

III. The Production, Consumption, and Reuse of Materials by Society.

There are many agencies involved in providing information under this category. They include the Department of Interior, Department of Commerce, the regulatory agencies of the Federal Government, the Department of Agriculture, trade associations, research organizations such as Battelle, SRI, and RFF, and hundreds of universities and foreign organizations, most especially of course the United Nations.

One can characterize the information under this category into four major groups:

a. Physical measures of reserves, production, stock, capacity, trade flows, consumption by end use, recycled materials, employment, etc.

b. Economic and financial information such as investment, prices, balance sheets, costs, demand, foreign trade balances, taxes, royalties, etc.

c. Material balances by major industrial process whereby the physical flow of materials as for example, the petrochemical company, would be presented.

d. Market structure information on the organization of materials markets and the structure of Federal and other national policies on a world-wide basis with respect to the production, consumption and recycling of materials.

The Task Group makes the following findings and recommendations with respect to this category:

a. The various information systems which exist are not integrated by standard definitions, standard units or in any other way. It is virtually impossible for the researcher to tie together any information, for example, on the IRS, which is on the basis of the taxpayer, with that of the Bureau of Mines, which is on the basis of the commodity. This results in a greatly reduced value to the current information systems, which are many and large.

b. The information available in Category a above is greater than that in the remaining three categories. However, even Category a needs improvement in terms of standardization and in terms of additional detail and consumption by end-use and in better categorization of reserves, to mention but a few major deficiencies.

c. Given the above two findings, it is proposed that a major federal agency be given responsibility for this portion of the Materials Information System. This agency would contain a wide diversity of professional talent, a substantial capability in survey and information management and a substantial capacity in the analysis of information. It would be made up of parts of existing government agencies such as Bureau of Mines, the Bureau of Census, the Bureau of Labor Statistics, and elements from the Department of Agriculture. It is believed that such an agency properly belongs in the proposed Department of Materials, since one of its major functions will be to provide information for government decision-making.

This agency must have the tools to do its job properly. This includes control of very large computer systems for the handling of data, mandatory authority for collection of data, with appropriate safeguards for the industrial and consuming sectors of the economy, and independence from political control so that the data will have credibility to all sectors of the society. This implies a Commissioner system with fixed terms to run this agency, something like the Bureau of Labor Statistics as a model.

Our Task Group was asked specifically to comment and advise on the survey conducted by the Materials Information Committee of the Federated Materials Society for the OTA. We have reviewed the survey and make the following findings and recommendations:

a. The survey is a very important first step in understanding the characteristics of the Materials Information System.

b. In the continuing conduct of the survey, efforts should be made to broaden its scope to cover materials not now covered, such as textiles, and to broaden its scope so that disciplines not now adequately covered, such as designers, are included.

c. As a follow-on to this survey, new surveys should be designed to sharpen and help implement the recommendations made by this committee concerning the Materials Information System.

d. The OTA should devote a larger proportion of its funds to an evaluation of the Materials Information System, because of the traditional inclination to undervalue these efforts. OTA is in a unique position to urge and help implement the recommendations of this Task Group.

Task Two (A): THE INCREASINGLY INTERNATIONAL CHARACTER OF MATERIALS ISSUES

Question 1. What are the goals of international cooperation in materials and technology?

1. Goals of all societies, world wide, are economic growth, higher standard of living, improved quality of life.
11. Goal for international cooperation is development of a synergistic system in which buyer and seller both perceive benefits. For a stable relationship, each needs to feel it gets as much as it gives (e.g. willing seller to willing buyer).

III. Goal of the United States is to assure an uninterrupted flow of materials when and where needed and at a reasonable price. To attain this U.S. goal, a sufficient world supply of materials is necessary, for interdependence is increasing. Self-sufficiency is not a reasonable goal and, in the long run, would be counterproductive. Stockpiling can overcome temporary aberrations in supply.

Iv. Goal of the United States, therefore, must be to export its materials science and technology in "a consulting firm relationship", for payment.

A. With technologically advanced countries, the United States would both export and import materials technology; for some countries are ahead of the United States, as the increasing number of foreign patents demonstrates. This export/import exchange would include technologies for development of new materials and application of materials as substitutes for materials in short supply. Substitution may be expensive, but it is a protective measure to keep trade negotiations gradual and prevent extreme price escalations.

B. With countries less technically advanced, the United States would export its technology and import raw materials. Resource-rich LDCs will continue to supply primary materials until these countries meet their own industrial goals. The basis of materials technology export has changed.

1. In the past the U.S. exported technology to develop foreign resources owned by U.S. corporations, thus obtaining primary materials for fabrication in the United States for sale—with value added—in the world market.

2. From now on the U.S. will be paid for expertise furnished to help LDCs move into the manufacture of goods from their raw resources. Know-how and management techniques are the exportable items that cannot be put on paper.

v. Goal of the United States should be to maintain U.S. strength in materials science and technology, recognizing these as exchangeable commodities that are renewable and non-appropriable resources.

Question 2: Can existing institutions be better used and are additional institutions-needed to define goals, develop policies and programs, improve communications and motivate action toward these goals?

1. Existing institutions can be better used. Special emphasis should be given to the use of existing international institutions. Among these are the U.N. and its agencies; OECD; World Bank; Export-Import Bank, International Monetary Bank; international corporations and international societies; trade associations; the World Court and patent law.

II. No new bureaucracies should be created, but the missions of existing international and U.S. institutions should be clarified and should be broadened where such change is ascertained to be desirable.

Question 3: What national institutions are needed in the U.S. and other developed countries to further international cooperation?

I. No agreement was reached on the need for a new national U.S. institution to further international cooperation nor on location or nature of such an institution were one to be created.

11. In view of the close government-industry linkages in other countries, closer association between the U.S. Government and U.S. corporations engaged in international trade seems necessary and inevitable. Therefore, the roles of existing federal agencies should be examined to determine whether one or several could be used more effectively to:

   A. Supply reliable information on which corporations can act.

   B. Guarantee capital and insure against loss through political events, with companies paying a fair price for this reduction risk in international investment and trade.

Question 4: What is the required information base, in terms of long range supply and demand for materials, to enable policy planning and decision-making?

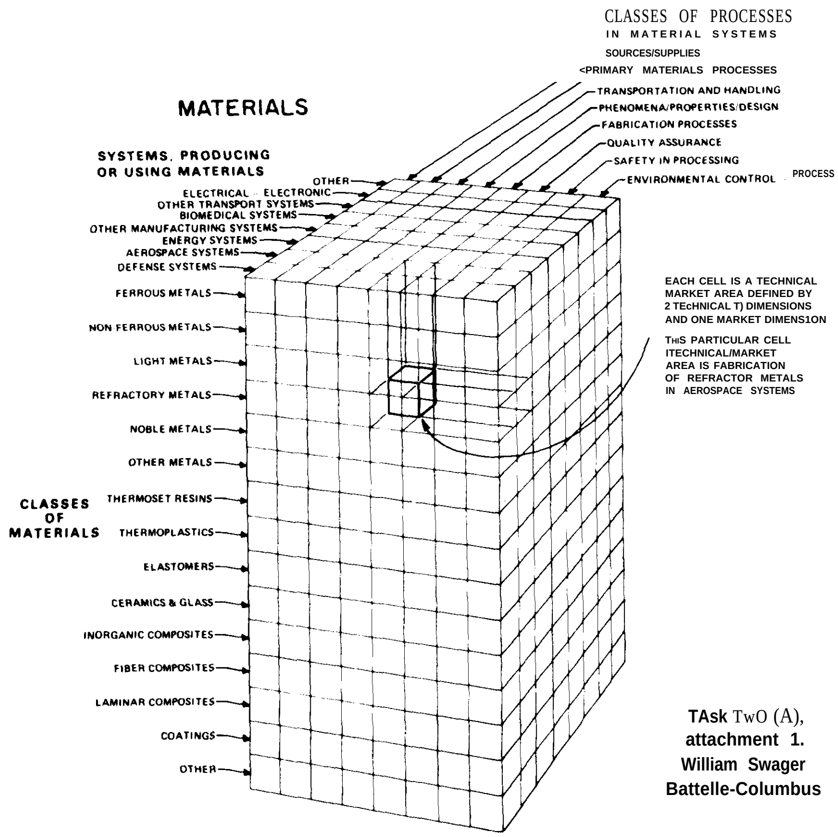
A wider information base is needed than is now collected by the Bureau of Mines on reserves and the U. S.G.S. on resources. Information is required on:

Physical characteristics of primary and secondary supply,
Economic characteristics of reserves,
Demand in relation to specific uses,
Stocks at all levels,
Foreign trade in materials,
Transportation systems for materials.

Question 5: What means of international cooperation would be most fruitful and feasible in terms of mutual benefit?

I. Sharing of technical information is the best way to develop cooperation and respect among nations. The U.N. should be used as the vehicle for international information system development and international standard setting.

II. Establishment and adherence to a well specified, agreed-upon set of conditions under which one nation can transact business with



Attachment 1. Task Two (a)—No caption

another (e.g. a basic framework of acceptable behavior based on enforceable contracts so that buyer and seller will know where they stand).

Question 6: What are the obstacles to mutual cooperation in global materials management?

The chief obstacles are:
Differences in patent law,
Self-interest of companies and nations,
Mistrust between nations,
Absence of desire to cooperate (e.g. insufficient motivation),
Worldwide, a lack of trained manpower in mineral-supply technology science and engineering disciplines.

Question 7: Can international programs in materials be effective in the conservation of materials?

Such international programs can be effective among countries that perceive some reason to use materials prudently. If conservation is defined as "efficient use", conservationist policies in any country will vary with stage of economic/industrial development and availability of materials at a reasonable price.

Goals or some problems in reaching materials goals.

	Trade partners/topics	*Producing* nations	Consuming nations	Status
	Consumption	Want demands evenly spaced.	Want materials available when needed, avoid large inventories.	Conflicting
	Prices	Like upward trend.	Like downward trend for raw materials.	Conflicting
Short term (day-to-day), markets				
	Technology transfer.	Expand capacity. Duplicate technology. Invent new technology.	High productivity. Turn-key technology to other countries.	Conflicting
Long term markets		Growth	Growth	Cooperative

Task Two (A), attachment 2, Developed by F. H. Buttner, Battelle-Columbus.

Task Two (A), attachment 3
A brief statement of position on the question:
International character of materials issues.
By B. D. Lichter, Vanderbilt University

The following is a brief personal statement which attempts to address our topic of integrating (1) information presented at the morning session of Task II(A), (2) information presented at the Monday session, and (3) information included in the publication "Resolving Some Selected Issues of a National Materials Policy" (Henniker H, July 30-August 4, 1972) as well as my own views derived from the reading of the abundant literature and discussions with conference participants and others.

Distinguishing Ends from Means. The entire discussion this morning was hindered by the failure of an adequate statement of "ends" as distinct from "means". This is in no way a fuzzy-minded philosophical exercise; nor, is the practical difficulty of reaching consensus (as experienced in our ''goals" discussion) reason for avoiding clear ends/means distinctions. Although George Watson's statement of the desire to provide improved technology, economic growth and "quality of life" to all the people of the world is one possible statement, it is not an adequate statement of ends, nor was its impact sufficient to influence various statements of "goals of international cooperation" which were offered by members of our group (e.g. "to maintain the U.S. position of world leadership in materials resource activity. . . ."). As examples of alternative statements of ends associated with the international character of materials issues, I offer the following:

1) Recognition that the United States is included within the world materials systems; that the satisfaction of materials and resource needs of any and all of the individual member states is of great concern to all nations; that such needs be satisfied is of particular concern to the United States, from the perspective of a broader notion of self-interest (if not derived from ethical-moral considerations).

OR

2) Recognition that critical resource and materials problems confront the United States in both the immediate and into the mid-range and long-term futures; that these problems arise from previous historical growth patterns in materials use vis-a-vis the world community; that the current 7-fold disparity in per capita resource usage between the U.S. and the rest of the world community must be maintained from further erosion as has occurred since 1950 at which time the disparity was 12-fold; that to resist such erosion will result in serious lowering of U.S. standards, since it can easily be shown that projections of resource "accessibility" together with realistic assessment of future technological innovation both indicate a failure to meet rising world community expectations of uniformly distributed per capita resource availability at present U.S. standards.

OR

3) Recognition that growing interdependence of the Nation states with respect to materials issues among all other issues has led the

NCMP to offer in their final report 19 recommendations that impinge on the question of international character of materials issues; that these recommendations define as suitable an explicit policy of interdependence as opposed to the pursuit of self-sufficiency with respect to materials resources; that our end therefore is a well-conceived "project interdependence' as distinct from an ultimate counter-productive 'project independence.

References:

1. "*Resolving* Some Selected issues *of a National Materials Policy, " Engineering Foundation Conference,* July *30–Aug*. 4, *1972 (Henniker* 11). *pp* 2-7, *12*, 14, 38-45.
2. *Final* Report, National Commission on Materials *Policy*, June 1973. Section *1*, pp 3-8; *Section* 9, *pp 3-27*.

Task Two (B): THE INCREASINGLY INTERNATIONAL CHARACTER OF MATERIALS ISSUES

Goals

The Task Group adopts Mr. Daddario's overall goal of encouraging sound, stable, and growing societies for nations of the world and of avoiding disruption to growth. Subject to these broad goals, the Task Group adopts the five goals of the National Commission on Materials Policy (NCMP), having to do with the energy and materials marketplace, environment, recycling and the material-energy -environment complex as follows:

Energy *and Materials.* To provide energy and materials supplies to satisfy not only the basic needs of nutrition, shelter, and health, but a dynamic economy without indulgence in waste, while recognizing all societies must face up to changes and adjustments.

Marketplace. To rely on market forces as a prime determinant of the mix of imports and domestic production in the field of materials but at the same time decrease and prevent wherever necessary a dangerous or costly dependence on imports.

It is recognized that such primary determinance depends on pluralistic participation in the marketing process, so that distortions and imbalances are clearly absent. For example, where restraints of trade and cartelling are present, or where dependency/interdependency arrangements between trading partners exist, or where mutually beneficial trade deals between partners *exist,* the free marketing process may be distorted or brought into imbalance. In that case market determination or price alone, for example, is not fully realistic.

Environment, Accomplish the, foregoing objectives while protecting or enhancing the environment in which we live.

Recycling—conserve our natural resources and environment by treating waste materials as resources and returning them either to use or in a harmless condition to this ecosystem.

Materials-energy-environment complex—institute coordinated resource policy which recognizes the interrelationships among materials, energy and the environment.

Phasing

The Task Group sees this contemporary time period, up to 1985, as one in which forces of scarcity and high price can overtake our technical and institutional abilities to deal with them. During this contemporary period three response strategies appear to be viable. First, assume a reactive posture, i.e., adjust to the pressures of scarcity and high price as best we can, when and as individual commodity pressures occur. Second, employ the contemporary period for planning to regain control of our destiny by 1985. And third, undertake vigorous research on massive recycling technology and the widest possible substitution technology to bring these potential scarcity-response moves up to speed by 1985.

Accordingly by 1985, the U.S. should be in a position to dynamically exercise all four scarcity-response modes (stockpile, stand by capacity, substitution and recycling) in some cost-effective, optimum mix to deal with any complex of commodity scarcities of the moment. At that time we should move off the reactive stance to a balanced, positive stance wherein we are in fuller control of our destinies.

Institutions

Existing institutions and new institutions were considered and this group endorsed and supported the Mansfield-Scott Bill (S-3523) leading toward the establishment of an independent agency (NCSS) to provide data collection and storage and to aid in the examination of supplies and shortages both in the U.S. economy and in relation to the rest of the world. In addition, this panel also supports the creation of a cabinet-level agency, the Department of Natural Resources, to bring materials management and related factors to the attention of the highest governmental levels. It is also recognized that government cannot function alone in this area but that more effective cooperation between U.S. industry and government is necessary, particularly in external activities.

From the above national institutions, it is felt that determinations will flow regarding U.S. participation in and/or creation of international means of meeting world societal goals and the amelioration of problem areas—including those relating to the seabed. However, at the present time, it would be premature to specify or suggest a form that such international institutions should take.

Data Base

Data are essential to all efforts of the world economies to achieve materials goals. The data base is constantly changing so that gathering systems must be dynamic, timely, consistently accurate to be credible, and responsive to world needs. Raw statistical data must be authenticated to be capable of sound interpretation and broadly available. Sources must be widely developed so that assessments of availability may be applied to decisions in the private and public domain. There are real dangers in the distribution of static inventories of resources.

Areas of International Cooperation

1. The capabilities of the U.S. in materials science and technology form an important national asset that play a part in our export sales and goods and services. Much of it, however, partly by consensus policy and partly by the nature of science technology, is provided free to the rest of the world and is a vital element in our share in international cooperation. Within the limits allowed by public policy this free transfer should be continued.

2. The increased trade with centrally planned economies (PRC, USSR and others) represent an important area of cooperation with ideological adversaries, opening lines of communication and engendering mutual trust.

3. The multi-national corporations, with their global outlook and partial freedom from control by nations may serve to increase cooperation among nations through the former's need to cooperate with the latter in order to prosper.

4. Cartels are an effective force in materials trade and may play an increased role. These cartels currently represent limited international cooperation among producer nations. Similar limited international cooperation by consumer nations may be attempted. While cartels may be beneficial to member countries, their effect is to reduce world-wide cooperation.

5. International material standards (in supply and demand data and in tech data) form a useful area of international cooperation.

Mutually beneficial trade arrangements and tie-in deals involving coupled and uncoupled commodities and volumetric or regional arrangements, are recognized, some of which are new and others have appeared in earlier times of world economic strain. It is also felt that international methods must be explored to discourage the expropriation of large investments of technical know-how and facilities.

6. Oil over next two decades is the world's major source of energy and is transport system lifeblood. The oil producing countries of mid-east possess the capability when acting in concert to disturb the whole system. Longer term, each area in world system will try to develop more energy resources under local or regional control. Also, new impetus for push into oceans resources of all types . . . offshore oil production rising from 17% in 1970 to 34% in 1980's.

7. There is a widening gap between the expanding materials needs for world system community and the financial/political structure of the world system . . . if gap goes too far without some new forms developing can mean near collapses and/or rampant military activities. Patience and faith . . . time and belief to resolve problems is required.

Trade alone will not solve all problems, but it may alleviate problems to some degree.

8. Question: What are the obstacles to mutual cooperation in global materials management?

A. In assessing this question, it was considered that some rough and general perspective of the U.S. position in the world system would be helpful in addressing implementation of a National Materials Policy and obstacles to be overcome in global cooperation:

Emergence of the recent U.S. energy problem . . . is indicative of:

1. basic changes in the balance of the world system
2. other coming problems associated with these changes

Background of U.S. dominance in the world system 1945-1970. . . helpful in viewing changes to date and expectation for further changes over next few decades:

USA—Immediate post-WW II period

50% of world productive capacity (GNP) and only undamaged major power home base

75% of world gold holdings

From this position, the U.S. set out to revive the rest of the industrial world . . . our allies and enemies:

1) Industrially, 2) Economically

This revival considered as being in the best long term self-interest of the U.S. and of the world system.

U.S. aid of all types to 70 nations from 1945-70 . . . about $200 billion:

1) $ for economic revival
2) opened doors to trade and investment for all.

In one sense, the U.S. took on responsibility of an indirect development in cooperation with about 40 nations—15 million square miles—600 million people.

Some direct benefits to U.S. . . . certainly.

Exports increased 10 times

Overseas investments increased 7 times

U.S. business abroad—$200 billion volume in 1970

The revival polity has been successful; now U.S. dominance is not so overwhelming in proportion:

USA FACTOR	PEAK	TODAY	1985 PROJECTION
World GNP	50%	28%	25%
World Gold Holdings	75%	10%	8%

Many people in the U.S. do not realize that the U.S. has already slipped a long way from the top. Now the U.S. must adjust to these changes and that in the international system . . . policies /'finances/ economics/politics are no longer geared (in total) to maintenance of

U.S. predominance in the world system. The post-war status-quo has been and is being disrupted.

U.S. is still the most important element in the world system (just not totally dominant alone). Quality of coming U.S. leadership is crucial . . . Must have constructive vision of world to expedite continued growth and development— neo-isolationism can be problem. Others will lead, if we do not, or fragment; each on its own—Europe/Germany, Japan /etc.

B. The alternate for further expansion of world economy is collapse and international anarchy in a growing interdependent world. Many problems to expansion for world system exist:

1. Financial panics may be endemic for decade.

2. The age of cheap energy is passing and will become even more expensive.

3. Industrial materials and metals are facing demand rise and persistent and steep increases in prices.

4. Longer term resource developments require massive investment of capital and new process systems for recovery of lower grade or remote deposits.

5. Finance system for new capital input will require 10- 15% a year . . . from recent past of 3-4% a year.

6. National raw materials independence in total is almost impossible over coming decades and cost is prohibitive. However, impossibly large cumulative imbalances of payments or trade could be equally prohibitive.

7. Multi-national corporations can perhaps be an engine for revving up and evening out of world economic system (of top 600 world enterprises, 450 were U.S. entities originally); or they maybe an obstacle. The quality of multi-national leadership is also crucial to further potentially positive benefits.

C. Cooperation between trading partners is simple when there is mutual interest in goals of each partners. In some respects, there is mutual interest, in others mutual exclusivity. The basic conflicts that trading partners bring with them require resolution before full cooperation can be achieved.

An example is North/South relationships . . . an affluent North and largely poor South developing or under-developed lands. South has used cold-war levers of U.S. /U.S.S.R. to extract concessions from North. . . South now planning to use raw materials to correct imbalance as much as possible (teaming arrangements among suppliers are proliferating). Tensions and drastic actions are to be anticipated and are likely to increase .

9. INTERNATIONAL TRADE INVENTORY

Rather than having national economic stockpiles built by consumer nations to protect themselves from prices penetrating from price ceilings, we conceive an international trade inventory (ITI), to be managed by an independent, professionally trading management. It would serve traditional inventory functions between suppliers and consumers, and generally serve to stabilize the economies of both producer and consumer nations,

For producer countries, the ITI would (1) be a welcomed customer in times of low demand when traditional customers disappear, (2) avoid economic damage of sudden large increments of demand at times of full production, i.e. by-pass the acceleration effect, (3) stabilize prices and prevent penetration of floor prices, (4) provide de facto, if not former, currency support to producer-country currency and (5) provide a credit base on foreign exchange markets.

For the consumer countries, the ITI would (1) provide an inventory that meets variable demand requirements, (2) avoid economic damage of scarcity, (3) stabilize prices, preventing them from penetrating price ceilings, (4) de facto currency support, and (5) defacto currency expansion without inflation.

The ITI is similar in concept to Graham's commodity currency scheme of the 1920's, which is, in the Task Group's view, worthy of serious, professional re-evaluation in the light of an opposite economic climate to that of the depression years gone by.

Task Three (A): DESIGN IMPROVEMENTS TO INCREASE EFFICIENT UTILIZATION OF MATERIALS

The objective of this task force is to recommend several federal policy actions which would promote the efficient utilization of materials and energy in design. In other words, efficient utilization of materials and energy is assumed to be our goal, and we seek to accomplish this through improving any or all aspects of product design (i.e., durability, repairability, functional satisfaction, recyclability, compatibility, etc.), Therefore, we have asked what should be the role of both the public and private sector in promoting use of new product designs consistent with materials conservation.

Important to this consideration is the realization that the design of all product classes, industrial, constructional, and commercial, could be improved in terms of efficient materials use. Technologies now exist which could significantly change materials use patterns, and it is important to ask first of all, why these technologies are not being used, especially if it is true that they are more efficient and therefore less costly (in terms of materials costs).

There exist many barriers to utilization of these more efficient technologies or design systems, and they can be categorized as economic, technical, or institutional. To be more specific, a list of constraints to innovation might include the following:

(1) Scientific knowledge
(2) Education and manpower
(3) Capital and equipment
(4) Energy requirements
(5) Characterization of materials properties themselves
(6) Insufficient technology transfer
(7) Institutional /managerial restraints

It was felt that one of the more important barriers to new design innovations was the cost of changing capital equipment (i. e., concerns for return on investment). Institutional restraints in the form of management policies, zoning laws, anti-trust policies, design specifications, etc., were also thought to be important considerations when attempting to isolate barriers to innovation. In any case, again and again it seemed to be felt that economic considerations were always primary in ultimately deciding whether or not to adopt new design practices and procedures.

When discussing the role of the Federal Government in minimizing these barriers or constraints to innovation, there was one area of complete agreement: the Task Force Committee recommends that Government design and implement a vigorous program of information collection and dissemination aimed at educating the designer, management, and the ultimate consumer. It was felt that the designer, manager, and consumer, all needed to be made more aware of materials options open to them and the relative life-cycle costs and benefits (i. e.. in terms of longer life, cleaner environment, more repairable products) of alternatives. To be more specific, government should:

(1) Work to better define energy and/or materials content of products, aimed at eventually expressing this in terms of total life-cycle costs. This research must factor in regional data variations, technological forecasts, political scenarios, etc. The Bureau of Mines is already sponsoring a study which is asking materials industries for information on total energy content of their various products. It was suggested that other agencies of the Federal Government might follow this lead by sponsoring similar studies for materials other than energy.

(2) Study and disseminate information on the life, repairability, and recyclability of products. This is to effect primarily the consumer or the designer's market. Again, such information must be translated into dollar equivalents before it would be meaningful to the consumer. There was disagreement as to the efficacy of massive consumer education programs along these lines, but it was felt that a limited effort should be mounted to inform consumers of some purchasing criteria. How this consumer information should be disseminated was discussed and it was felt that voluntary labelling of products might be one action to take.

(3) Attempt to educate designers to broader concerns for materials availability, recyclability, life-cycle costing, etc.

The next area of recommended government involvement was that of funding R&D* in materials properties, corrosion and wear, recycling technologies, and new uses for recycled materials. More specifically. government might want to investigate such research areas as:

(1) Abundant natural resources, not presently utilized (Mg).

(2) Materials used in energy producing systems.

* This falls into the traditional purview of the Federal Government (i. e., funding high risk R&D for potential public benefit) and could be carried out in government labs and/or with contracts and grants to industrial labs.

(3) Materials for water-proofing membranes in buildings.
(4) Life-cycle costs of building materials.
(5) High-strength materials.
(6) Materials which would substitute for scarce materials.

These are merely suggestions, and before deciding on research priorities, government might consider conducting a thorough state-of-the-art study evaluating the state of materials R&D in specific functional areas. Only in this way will government funds be most efficaciously spent in areas most critically in need of advanced study.

Additional studies which could be conducted by government include:

(1) Identification of constraints to innovation and investigation of means for overcoming these constraints.
(2) Analyzing the effects of alternative designs on recycling costs.

Along these same lines a recommendation was suggested to continue find expand programs similar to NBS's Experimental Technology Incentives Program (ETIP) and Interior's Office of Coal Research (OCR), which are attempting to identify and overcome institutional barriers to innovation. It was also recommended that anti-trust laws be investigated as to their prevention of necessary materials R&D; such R&D can often benefit from close industrial cooperation and exchange of data, facilities, and personnel. The unique example of the Electric Power Research Institute (EPRI) was sited as a possible model for initiating other cooperative industrial research organizations.

Finally. it was felt that government should be involved in establishing design and/or performance specifications which incorporate ideas of materials conservation. For instance, it was agreed that recyclability should probably be considered as part of any general performance requirement. Standardization of design and designer's components is another way one could encourage designers to conserve materials. Professional and industrial societies could join with government in setting standardization guidelines. Presently, there are a number of standard setting bodies which impact designer's decisions (ANSI, ASTM, SAE, & SME), and it was recommended by the task force that these organizations get together to reduce the multiplicity of standards in all areas. the thousands of standards documents which now exist could then hopefully be reduced into a single set of national materials standards.

It was also felt that standards in areas of repairability, durability, recyclability y, etc. should remain voluntary. Also, conditions under which products are designed and purchased do change, and standards must remain flexible and not foreclose new technological alternatives.

Investigation should also be made of existing specifications which may be over-restrictive, thus promoting inefficient utilization of materials. For instance, over-demanding and/or unduly restrictive building codes and building materials specifications should be reinvestigated.

Also, it was felt that there should be serious investigation of areas of direct government intervention; i.e., regulation, enforced standards, economic incentives (e.g., tax benefits) which could effect significant increase of material conservation practices. Suggested areas of further study include:

(1) Instituting "life-cycle costing" prices on products.
(2) Tax benefits for a) industries that practice materials conservation and b) consumers who purchase products which have been made with conservation design processes.

Mention was made of a whole host of other government policy options which could be considered in attaining more efficient materials use in design; however, discussion was superficial and no concrete recommendations were drawn up by the committee.

In conclusion, it was agreed that government does have an active role to play in encouraging materials conservation but that this role and any ensuing action must be careful not to foreclose future innovations. In other words. it was suggested that all the recommendations listed above, as well as those suggested elsewhere, be studied to insure that such an action does not inhibit development of alternative technological solutions to materials problems.

Task Three (B): DESIGN IMPROVEMENTS TO INCREASE EFFICIENT UTILIZATION OF MATERIALS

The Task Force adopted as its theme the necessity for the Federal Government and other governmental institutions to assume a lead role in promulgating a new ethic of conservation for the efficient and effective utilization of materials and materials resources. The government should use its regulatory and taxing power and the power of the purse, and through appropriate policies, actions, incentives, programs and mechanisms promote a national awareness and consciousness of the status of our materials resources and the benefits to be derived from efficient utilization patterns. We recognize that the available information on materials reserves and resources do not lend themselves to the characterization of a materials crisis in the near term. But they do indicate serious future supply and shortage problems unless actions are instituted. in concert with other nations, to assure effective development of materials resources, accessibility of materials supply and effective utilization practices. This is indeed one opportunity in which sufficient lead time is available to prevent a serious problem from developing into a crisis. In effect, we see the need for a cultural transformation in the consumption habits of American Society. We recognize that these issues provoke the dichotomy of the dialectical extremes of the Neo-Malthusian Limits of Growth philosophy. on one hand, and the ''cornucopia' -increasing growth school of thought on the other. We believe, however, that rational and sensible actions and implementation of a conservation ethic; i.e., efficient utilization of materials represents meaningful first steps towards charting a rational course of controlled and acceptable growth, between these two unlike] y extremes. We believe that the fundamental issues are not technical nor technological, but really involve preferences and ethics as manifested realistically in our national business and economic decision making process. We suggest that what is needed is a national affirmative action program for materials conservation and efficient utilization of resources.

We see therefore that the design/materials system, particularly as related to mass-produced, high-volume consumer products offers opportunities for instituting this new conservation ethic and action program.

However, we recognize that there are barriers in the design system which inhibit more optimum materials utilization in current design practice. Some of these are:

(1) Inadequate product performance criteria—Unlike aerospace or defense systems many consumer products are not designed to fixed performance envelopes. Thus design practice must factor in consumer service use variability.

(2) Inadequate feedback and long time lag between design system and field performance history.

(3) Design often may be subordinate to existing manufacturing capabilities and facilities which may inhibit design and materials innovations,

(4) Consumer Acceptance is a non-quantifiable but important design parameter. "Quality of Life" can assume equal ranking to functionality.

There was general agreement that the most effective force to impact the design system and materials utilization practice is through the pricing and free market system. Comparative materials and energy costs affect design directly and the utilization of less expensive and/or more available materials.

Government in no way should dictate design criteria, but provide standards for performance and functionality where necessary to meet societal goals. The regulatory, taxing power and related options available to the government should be used, as appropriate, for the internalization of external (social) costs to ensure proper interaction of materials utilization and design practice with the goals of environmental, safety, health requirements, etc.

New parameters will be impacting current design systems in the future, such as designing for recyclability, designing for easy repairability, designing for guaranteed reliability. These will have significant effects upon materials utilization patterns.

On the other hand, the task force recognized that the gains to be achieved in materials utilization through change in design systems may be secondary to the gains possible from new or improved manufacturing technologies. In this respect the integration of design, manufacturing and materials in the design/release systems needs to be vigorously encouraged.

One area of particular importance for Federal encouragement or support is the greater utilization of technological and manufacturing innovations and processes which have materials savings capabilities. Numerous such innovations have been developed or are being developed and remain under-used because of such items as capital and facilities investments, reluctance to obsolete existing facilities, amortization factors, etc. It seems like sound common sense for the government to promote incentives for industrial innovation, particularly where significant materials conservation can be achieved.

Three technical areas may be cited which are significant to our overall utilization of materials and reduced costs.

a) corrosion
b) wear
c) non-destructive evaluation

All three areas impact the important features of reliability, durability, and longer life of consumer products. More effective non-destructive evaluation methods capable of being used as continuous on-line production systems are needed for manufacturing quality control and to reduce waste, scrap and inefficient materials consumption.

Some opportunities which appear ripe for effecting design and process improvements and which should receive attention are:

(1) Modeling opportunities—Improved modeling techniques and systems could result in better trade-off analyses particularly where energy, materials and environment are interactive factors.

(2) Regionalization of use of indigenous materials—To reduce transportation and energy costs and again to increase efficiency in materials utilization.

(3) Re-evaluation of industrial technological experiment stations—an analog to agricultural experiment stations.

(4) Major materials and energy savings through more functional systems in housing, communication, transportation, etc. Housing, particularly can be a major source for energy conservation.

(5) Designing for recycling with particular emphasis on design/materials systems approach.

(6) Opportunities in Academia—Changes in educational systems, curricula, research policies and practices and traditions, etc. geared to education and training a new generation and breed of design, product and materials engineers inculcated with the conservation ethic as a design parameter.

(7) Analysis of government research and education funding distribution to define areas of emphasis and disclose areas of inadequate attention.

(8) Opportunities through government incentives to promote more industry (government cooperation and less of the traditional adversary position.) The new dimension of materials conservation and more efficient utilization suggests re-evaluation of anti-trust regulations, trade barriers, etc. to promote greater industrial consciousness in this area. In particular, the patent regulations of non-defense agencies involving government/industry contracts needs to be examined to determine whether it inhibits development of industrial technology.

(9) A particular opportunity resides in the purchasing systems of governmental agencies. They can provide a real demonstration of the applicability of life cycle and total costs as a more meaningful approach to ‘competitive bidding concepts than the traditional initial purchase costs.

The Task Force suggests some other specific areas in which Federal interaction can be important in affecting materials utilization practice:

(1) Promulgation of an International Materials Conservation Year

(2) a. Develop government/industry cost-sharing and other support programs to introduce and/or develop materials saving technology and practices. Canada and other countries can be examined as possible models for cost-sharing techniques.

b. Extend the IR&D government support programs (now in practice for Defense Contractors) to civilian industry to encourage industrial consciousness of materials conservation programs.

(3) Implement the recommendations of the National Commission on Materials Policy for closer and more effective industry/government relationships. This may be particularly important in this new era of deficit balance of payments, involving to a significant extent the costs of materials inputs.

(4) Bring materials conservation consciousness to a high level of national attention through affirmative action programs.

Task Four (A): MOBILIZING ECONOMICS AND TECHNOLOGY FOR MATERIALS RECYCLING

1. General Features of Recycling.

Recycling as a policy aims at the optimum amount of recovery of secondary materials. This optimum in general is not the physically possible maximum because of energy constraints and in some cases because of environmental constraints, Nevertheless, the closed materials cycle is a useful concept, because it replaces the linear or once-through approach of materials utilization by a circular or continuing approach.

Secondary materials are of three generic types. Home scrap (process scrap) is generated in the primary production process, prompt industrial scrap (new scrap) originates in manufacturing operations and post-user scrap (old scrap) arises as goods are discarded.

Home scrap is an internal concern of the primary producer and poses no major policy problems. The recycling of prompt industrial scrap is usually motivated adequately by economic considerations except in small or inefficient establishments. Post-user scrap ranges from the obsolete equipment of manufacturers, utilities and transportation companies to discarded consumer durables such as automobiles and major home appliances to consumer nondurable; the level of recycling of these objects (i.e. the ratio of recycled to recyclable scrap) decreases in the order listed and at present practically vanishes for those nondurable which enter the municipal waste stream.

Home, prompt industrial and post-user scrap may consist of nonferrous and ferrous metals, paper, wood products, rubber, textiles, glass and plastics. The order in which these materials are listed indicates approximately their level of recycling.

Recycling always serves two functions: conservation of resources and reduction of waste. It usually also results in an energy saving and decreased pollution.

The bulk of secondary materials is recycled by the private sector. Since the driving force is economic gain, the industry concentrates on those materials which have substantial intrinsic value. The activities of the secondary materials industries result in the conservation of resources and only incidentally in a reduction of waste. By contrast, the disposal of household waste is essential] y a local government function serving the public interest.

Current interest centers on the recycling of at least part of the municipal waste stream. However, implementation is difficult for several reasons, particular y weak economic incentives and institutional barriers at the local government/industry interface. .

2. Technology and Engineering.

The established secondary materials industries have in hand adequate technology for the recovery of metals, paper, glass and various other materials. This technology makes the recovery of a large fraction of these materials economically viable. In our opinion there is also adequate technology for recycling of at least part of the municipal waste stream. While related institutional and economic problems are yet to be solved, demonstrations of such technology should not be delayed further. Indeed such demonstrations are essential for further progress.

It should not be concluded from the foregoing, however, that technology is available for the recovery of all types of materials or that existing recycling technology is satisfactory in all respects. Research and development in selected areas, therefore, are still necessary.

The technology of handling the municipal waste stream needs further development. In particular, collection, which accounts for a large fraction of total waste management costs, has to date not been effective] y modernized in technical respects. Recycling requires the separation of the waste stream into its constituent parts. This function is receiving much attention and various techniques are available. However, the separation of mixtures of some materials, for example, paper and plastics, cannot yet be achieved dependable under all conditions.

The metallurgical processing of secondary metals still presents some unsolved technical problems. There are no procedures for removing copper from ferrous materials, the properties of which it affects adversely. Detinning of ferrous scrap is possible but is restricted geographically and in other ways. Except for the usually undesirable removal of magnesium, aluminum alloy scrap cannot be refined. These examples illustrate the need for new process technology.

Research into the benefication of mixed cellulose fibers is desirable for expanded recycling of paper products. The effects of secondary fibers on the properties of paper and paper board are largely unknown. The most extreme lack of technology involves the recycling of plastics. This has often been ignored in discussions of municipal wastes recycling.

An interesting technical and organizational challenge is the design of the municipal waste stream for facilitating recycling. Qualitatively this approach requires the elimination of some mixed materials (pernicious contraries) which cannot be readily separated; examples are bimetallic cans, metal foil/paper and paper/plastic combinations and incompatible adhesives and inks on paper. In quantitative respect a reduction of the volume of the waste stream would result from the reduction of over-packaging or the elimination of non-returnable containers. An entirely different approach to a more tractable waste stream is sorting at the source.

3. Policy and Legislative Recommendations.

The Federal Government should continue to pursue vigorously policies designed to promote recycling of secondary materials with due regard to economic, energy and environmental constraints. Parallel or implementation actions should also be taken on the State and local levels.

We make the following recommendations for specific action in three major areas:

A. Improving the Economics of Recycling.

(1) Eliminate current disincentives, specifically discrimination in freight rates, and unequal tax treatment (depletion allowance, capital gains treatment and preferential treatment of foreign income of primary producers).

(2) Establish positive incentives through preferential Government procurement policies favoring secondary materials and the adoption of a disposal charge on materials likely to enter the municipal waste stream with a rebate for secondary materials used.

B. Improving the Technology of Recycling.

(1) Fund selectively demonstration grants designed to test the feasibility of available new technological systems and to reduce institutional and economic uncertainties now relating to them.

(2) Support laboratory research (i) to solve specific technical problems such as the removal of harmful impurities from recovered steel scrap, (ii) to find new recycling processes, for example of aluminum alloys, and (iii) to develop recycling technology for materials such as plastics that are currently not recyclable.

C. Conditioning Post-User Scrap and Particularly the Municipal Waste Stream for Improved Resource Recovery.

(1) Suppress combinations of materials that are incompatible in current recycling systems by procurement specifications and standards and the promotion of voluntary compliance by industry.

(2) Reduce the volume of waste by promoting product durability, repairability and maintainability.

(3) Encourage the upgrading of the municipal waste stream through source separation by appropriate public interest campaigns.

We recognize that the recommendations made in (A), (B), and (C) above are not necessarily novel. We are making these recommendations now because we believe that they deserve consideration especially as new information or understanding in support of some of them has developed.

D. S. Lieberman:

It is straightforward to see how resources, waste, and pollution are affected by recycling, but its effect on the energy required for producing a material warrants amplification. In a sense, recycling can be considered as a way of "reusing" energy already spent on resource extraction rather than the commitment of an equal amount of energy for the production of a new batch of the same material. Aluminum may serve as an example that will demonstrate that far less energy is required to use a recycled raw material than to start with an energy absorbing primary source: thermodynamic calculations show that 1/20 or less of the original energy is required to produce aluminum from scrap metal rather than from mined ore. This example illustrates why energy savings are a powerful argument for recycling.

F. L. Smith:

Both consumer durables and non-durables are eventually discarded and become part of the municipal waste stream. They thus impose on society downstream waste management costs which at present are not paid by the producer and hence are ignored in production decisions. As a consequence, relatively inexpensive waste reduction measures may be overlooked. Similarly, the producer cannot readily capture savings in waste management costs resulting from a decision to reuse waste materials; such materials, therefore, remain underutilized. The current lack of sufficient economic incentives because of the absence of effective cost internalization tends to inhibit recycling.

Demonstrations would be especially valuable for such dry separation systems as are now being developed by the Forest Products Laboratory (Madison, Wisconsin) and the Bureau of Mines (College Park, Maryland). Demonstrations of techniques for recovering the raw materials in major household appliances should also be funded. Demonstrations and research on resource recovery could be supported by funds generated by the imposition of disposal charges.

Recent developments concerning recycling have been unfortunate. Initially there was great enthusiasm for action but the analytic support was weak. Now after several years of extensive research on various aspects of materials policy, the base for action has been greatly improved but the enthusiasm necessary to translate this new understanding into policy has waned. A rekindling of enthusiasm is greatly needed.

Task Four (B): MOBILIZING ECONOMICS AND TECHNOLOGY FOR MATERIALS RECYCLING

Introduction

The rationale mentions the abundance of technologies to extract values from wastes and abundance of wastes, agricultural, forest, human sewage, industrial and consumer. This is followed by the question: "What actions, public and private could motivate the more complete recovery of wastes and the greater utilization of secondary materials, thus closing the materials cycle?"

Additional questions suggested to lead discussion appeared to be addressed to municipal or consumer wastes and the closed cycle wastes from materials processing. It was decided by the committee that they should address themselves solely to the last two subjects since water, agricultural, sewage and wood wastes were too broad to include. It was emphasized, however, that water is a key ingredient in material processing and could be considered one of our scarcest materials when related to closed cycle materials management. Its true cost including the cost of restoring it to recyclable quality is often overlooked.

It was also emphasized that the divided, multistage processing in the United States makes closed cycle management of materials difficult. Despite this difficulty the costs of disposal should be borne equitably, and better data are needed to determine and distribute these costs.

Question (l): Beyond the general goal of achieving a closed cycle in materials management, what more explicit and detailed goals are there?

Discussion: It is true that there are an abundance of technologies to extract useful values from municipal wastes, but there is an abundance of ignorance about costs, optimum size, interconnecting or tailoring the process to the waste of a particular sector and practical operating data. There is no universally best method which can be used anywhere. Recycling has finite limits based on both economic and ecologic factors.

To approach the closed cycle or optimum disposal, information must be obtained regarding:

Quantity and quality of recycle feed material,
Preferred disposition for that location, for example:
Should combustibles be burned or recycled?
Availability of local markets for reclaimed products,
Collection and transportation methods,
and many other factors which are cost interrelated.

One major goal would be to provide information to guide process selection once the above information has been obtained by the municipality.

Other proposed goals are as follows:

A. Reduce landfill requirements from its present 7 acre feet/year/ 10,000 persons and reclaim filled land for highest quality applications.

B. Attempt to direct landfill materials to longer term use, for example, to construction materials which would not immediately enter the recycle stream (cinder block, road building aggregate, home insulation and sheathing paper).

C. Reduce material consumption by increasing the initial life of the product and by designing for maintenance rather than discard.

Question (2): What kind of institutional mechanism and aids, private and governmental, could best provide the motivation toward achievement of these goals?

Discussion: It is acknowledged that there are built-in constraints between public and private ownership and operation of recycle facilities; there are problems of political boundaries; of capital funding; and there are some barriers set up by regulatory agencies. These must be met and resolved by an equitable and rapid process of reconciliation.

A. Federal and State guidelines and funding should exert leverage to obtain regions and waste recovery units of appropriate size.

B. Total technology is not proven and Federal and/or state should share the funding to accelerate the demonstration plants. The operational information is needed to reduce the risk to the municipalities involved. For example: Clean separation of copper from steel or aluminum from other nonferrous metals has not been achieved. Corrosive effects of burning municipal combustibles are not well known. Inorganic other than metals have no economic use, and even well-segregated glass may not be a viable product. Only selected portions of waste paper are effectively recyclable.

C. Encourage joint government-industry and multi-industry cooperative R&D to accelerate projects in these high risk and potentially low profitability projects.

Question (3): What is the nature of the legislative package which can increase the extent of post-consumer product recycling? What details of legislation can facilitate recycling programs of municipalities?

Discussion:

A. The government should enhance the marketability of recycled materials. There should be legislation to remove penalties or disincentives for the use of secondary materials. Some of these are:

(1) Inequitable freight rates (ICC rates for iron ore vs. scrap).
(2) Depletion allowances for virgin materials.
(3) Pejorative labelling laws. Where feasible, performance should be specified, not recycle material content.

B. The government should expand a purchasing program, rewriting specifications which currently limit or penalize the use of recycle material.

C. The government should be encouraged to continue to sponsor research for the separation, refining, and use of recycle materials. There is now a shortage of mining and metallurgical engineers. Government aid could fund university programs to solve separation problems and simultaneously train students for this expanding field.

Question (4): Would it be possible to “design” municipal waste streams by applying regulatory principles to the design of products that comprise the bulk of these streams?

Discussion: It may be too discriminatory to legislate separation of products in the design stage (although the economics of recycle did cancel the aluminum topped steel can) but incentives based on designs which facilitate separation should be considered.

Question (5): What techniques could be used to maintain the value of materials throughout the entire materials cycle, to increase the motivation for their recovery and reuse?

Discussion:

A. The total social costs of the product should be estimated including the cost of disposal. Much more economic data are needed to do this realistically and should be obtained.

B. Products are now being designed to show efficiency and related energy consumption. Why not add data on recycle value or cost to this effort?

Task Five (A): THE ROLE OF THE TECHNICAL COMMUNITY IN NATIONAL AND INTERNATIONAL MANAGEMENT OF MATERIALS

ASSUMPTION

While every scientist and engineer active in the materials field can and should take individual actions to provide technical input to their professional societies and other materials study groups, their capacity, prestige, and influence in helping to solve national and international materials problems can be multiplied manyfold through the unified backing of an entire learned society (i.e. ACS, ASME, IEEE, ASM, etc.). Consequently, we have interpreted the words "technical community" in our task title as meaning the learned and professional societies organized at the national level in the USA. This task is therefore directed as exploring the possible roles that technical societies are currently playing, and could play, in participation in cooperative efforts on the national and international level, to deal with related materials problems and opportunities. In so doing, we have also identified possible roles that we do *not* feel are appropriate for the technical community.

1. USA AND INTERNATIONAL OBJECTIVES IN MATERIAL POLICY.

The final report of the National Commission on Materials Policy (NCMP) listed five general goals for USA materials policy. Three of these five national objectives we feel are shared in common with all nations, namely:

Provide adequate energy and materials supplies to satisfy not only the basic needs of nutrition, shelter, and health, but a dynamic economy, without indulgence in waste.

Accomplish the foregoing objectives while protecting or enhancing the environment in which we live.

Conserve our natural resources and environment by treating waste materials as resources and returning them either to use or, in a harmless condition, to the ecosystems.

2. COMPATIBLE AND COMPETITIVE GOALS IN INTERNATIONAL INFORMATION EXCHANGE.

In implementing the three common goals identified in paragraph 1, we felt the need to separate "compatible" goals from "competitive" goals. Compatible goals are those which we feel the technical communities in most nations could discuss cooperatively with no constraints on the subject matter. Competitive goals are those where barriers and constraints exist which would impose limitations on open, free discussions and which have a definite "bargaining" connotation.

a) Compatible Goals:
   1) Information on fundamental properties of materials (materials science) sufficiently detailed to provide designers the necessary information for materials optimization and/or substitution.
   2) Information on fundamental factors controlling processing, performance, safe and durable usage, recycling and environmentally compatible disposal.
   3) Realistic assessments of national and international materials needs and reserves of materials, and
   4) Exchanges to strengthen educational weaknesses in the materials science field as related to material scientists, design engineering, governmental materials specialists, information specialists and general public.

b) Competitive Goals:
   1) Maximum prices and stable markets for raw materials exported.
   2) Minimum prices and stable supply for raw materials imported.
   3) Maximum prices and stable markets for manufactured goods and technology exported.
   4) Minimum prices and stable supply for manufactured goods and technology imported.
   5) Concealment of national material problems involving security weaknesses, size of stockpiles, costs, quotas, etc.

3. CURRENT TECHNICAL EXCHANGE AND TRANSFER ACTIVITIES.

a) Many scientific and technical societies and "umbrella" federations of learned societies are currently active in materials information exchange with their counterpart societies at the international as well as national level. These exchanges involve information where proprietary topics are not discussed (intentionally). These exchanges in the materials field can be expected to continue and increase without any external encouragement.

b) Special studies and symposia by single or multiple technical societies are being sponsored and funded by national and international governmental and private groups such as NCMP, OTA, IAEA, OECD, CCMS, NASA, COMSAT, NSF, NMAB, NAS, NAE, etc. These will undoubtedly continue but perhaps may be better coordinated and promoted by a temporary or permanent National Materials Policy Commission (when such a group *is* legislated into existence).

c) Many material scientists and engineers in private industry are participating in the transfer of materials technology and management techniques with counterpart personnel in foreign industry. We can expect this mutually advantageous type of materials information exchange to continue and increase in the private sector of the materials field.

4. COOPERATIVE VERSUS BARGAINING ROLES IN MATERIALS INFORMATION EXCHANGE

a) Choice of cooperative role (for compatible topics) or bargaining role (for competitive topics) depends on the importance of the commodity and its associated technology being considered for information exchange.
b) Choice also depends on whether the exchange is with developed, developing, or emerging nations.
c) Choice may be influenced by assessments of the equality of exchange or the probabilities of accelerating mutually beneficial materials goals by joint effort.

5. INTERNATIONAL MATERIALS AND INFORMATION EXCHANGE THROUGH BARGAINING.

Government and private industry have both separate and cooperative roles to play in the exchange of materials and materials technology. There is a definite need for increased and improved cooperation between government and industry in achieving national policy objectives through international exchanges. To achieve this end, there first must be a more definitive agreement on national objectives in international bargaining in each specific materials supply and technology area. Our task force feels the specific mechanism required to arrive at the above objective is not yet in place. Therefore, we agreed that this area needs serious national attention.

6. GENERAL CONCLUSIONS OF TASK FORCE.

a) Competitive goals requiring bargaining materials and technology exchanges are more important in the short term than cooperative (compatible) exchanges to help resolve immediate materials problems. Hence, they have the major motivation for action.
b) Cooperative exchanges by technical/scientific societies and "umbrella" federations (such as FMS, American Institution of Physics, American Geological Institute, Federation of American Societies for Experimental Biology), though less important in the short term to our national materials policy, have two vital roles:
   - Fundamental materials science information gathering
   - Technical assistance to the "bargaining" organizations
c) Technical societies are ***not*** appropriate "bargaining" organiza-

tions, but they can and should assist in:

- Assessments and forecasts of technological trends
- Recommending areas and topics for bargaining
- Providing the mechanism and knowledgeable materials specialists for technology transfer after bargaining agreements are reached

d) Private industries or governmental agencies (NASA, AEC, NBS, etc.) may be selected or solicited by bargaining organizations to provide the needed technical exchange. If proprietary information is deemed in the national interest for exchange, licensing or royalty payments should it accrue to the private industry releasing such information at the bargaining organizations' request.

7. ANSWERS TO SPECIFIC QUESTIONS IN THE TERMS OF REFERENCE FOR TASK GROUP 5.

a) We feel the answers to all but Questions 4 and 5 listed in the charge to the Task Force are given in the above summary of our discussions. With respect to these two, we see no need or priority at the present time to promote an International Federation of Materials Societies, but we do feel technical liaison between such national federations where they exist should be fostered (i.e., between the U.S. Federation of Material Societies and the British National Committee for Materials).

b) Question 6 asks how existing private and public institutions can be better utilized. We want to emphasize the need for a strong one-on-one relationship as the best means for effective information exchange. Nothing can substitute for a face-to-face technology transfer by the most knowledgeable scientist or engineer in the specific materials field being discussed. A classic example for us to emulate is the County Agent/Farmer relationship in the agricultural field backed up by viable agricultural experimental stations. We should aim to achieve similar effectiveness in materials technology discussions.

Task Five (B): THE ROLE OF THE TECHNICAL COMMUNITY IN NATIONAL AND INTERNATIONAL MANAGEMENT OF MATERIALS

It should be recognized that the existence of a true technical community capable of speaking with a single voice on materials issues is tenuous. There are many allegiances of any individual to his professional society, his employer and his nation, to mention only a few. In order that a meaningful technical community exist on these issues requires vigorous and ongoing education of the constituency. Only in this way may the group expertise and prestige be effective y mobilized. The creation of FMS is encouraging in this regard since it signifies a growing awareness on the part of governing councils of the member societies, at least, of the need for coalition for the common cause.

The Harwell Conference on Conservation of Materials is another indicator of recognition of the need for unity of the technical community in order to provide well-thought-out advice to policymaking and implementing branches of government.

Question 1: What materials goals tend to be most evidently shared among nations?

The dominant goal of each nation is to sustain and better the lives of its citizens and to ensure territorial security. In highly industrialized countries this goal requires an assured supply of energy and raw materials as well as processing and manufacturing facilities to satisfy the civil and military technological needs. In addition, there are, of course, the truly basic needs such as food, clothing, shelter, medical care, etc., which are shared, at varying levels, by the less developed nations. All of these requirements in a market, rather than an internally controlled economy, lead to worldwide flow of materials, skills and data, as well as capital.

Therefore, the world must regard the basic materials concerns within the context of providing for the needs of all people as they arise.

The present concern is with assuring supplies at a time when there is increasing dislocation, both in respect to materials flow and finance. Consequently, a basic materials goal is to improve the atmosphere in which the exchange of materials, goods and services takes place. The danger is the formation of groups which in the long run will divide the world into self-sufficient blocs preventing continued interaction through world trade.

Question 2: What kinds of related programs could be sponsored within nations for public purposes?

Among materials related programs that could be sponsored on a national scale for public purposes are the following:

1. Improved utilization of
   a. Energy and fuels
   b. Minerals through enhanced effectiveness, extension of life of products, recycling and reduction of social costs.
2. Development of alternatives in a and b to minimize dependence on critical foreign sources of supply—this is, of course, destabilizing to the world-trade situation (e.g. Project Independence).
3. Increased awareness among consumers that stringencies require a change in attitude among the public in the highly growth-oriented nations.

Attainment of most of these goals can be greatly assisted on a national scale by involving the active participation of members of the engineering and scientific community through their organizations in each country. In addition, research programs in support of these goals should be sponsored not only within university and industry but also within research institutes and competent government agencies in furtherance of the goals enumerated above.

Dissemination of information concerning these national objectives should be sponsored through the professional societies by government and industry, even possibly including TV programs.

As a final point, materials societies have a vital role to play in advising legislators of materials problems and opportunities which require legislative action.

Question 3: What kinds of international interactions might be fruitful with respect to similar programs?

Among the developed nations there is an obvious need to keep their standard of living high and unimpaired to the greatest extent possible.

The spirit of private enterprise and the profit motive in the countries of the market economies will ensure international dissemination of the fruits of at least the significant innovations resulting from the activities outlined under Question 2 above.

Engineering and scientific societies can play a great role in this endeavor through their many activities, meetings, publications, even through their standards and specifications, and can alert their membership to goals that are substantially analogous within the range of the industrial countries. It is, therefore, desirable to establish closer links with corresponding engineering and scientific societies to coordinate efforts and improve collaboration.

It must be emphasized that much may be learned from countries which have, of necessity, practiced a high degree of economy in the use of materials through past generations.

There are two categories of countries in the so-called Third World, those like Brazil, Mexico, and India which have a highly developed professional class, and those like Mauritania, Upper Volta and Mali which have no organized professional class in science and engineering to correspond with their colleagues in the industrial world.

There is no problem in establishing contact with professional societies in the former group of countries.

However, in the latter class there is no clear communication link other than between governmental bodies or, perhaps, via commercial enterprises whose desire to exploit resources of these nations has established stable relationships. In this regard it should be reiterated that recent formation of raw-material cartels have shaken confidence in these relationships with the less developed countries. Whereas such cooperation has formed the basis for economic growth in these nations in the past quarter century, one is now faced with the growth of self-sufficient economic blocs. Can professional societies do something to reverse the trend that has emerged so strongly during the past year? If so, the efforts toward increased reliance on domestic sources will have to be held in abeyance, and the present trend toward fragmentation of the nations into suppliers and consumers into blocs can be halted.

It is not up to the engineering societies to decide this question, but they should probably draw the attention of their membership, of the public and especially of their lawmakers to the seriousness of the options which the world community faces at this time.

it is therefore appropriate to launch an "International Mineral Resources Year" to publicize the options which the world faces before positions become irrevocably frozen. *

Question 4: What options for international organization exist, what are the advantages and disadvantages of each, and which are likely to be most effective? What course and approaches should be adopted?

International organization will, of course, require some body to take the leadership (i.e. provide the initiative). This could be an existing national or international organization (e.g. UN, IUPAC, FMS) or, less likely, a completely new organization. The possibilities would become clearer if an intense but limited activity such as an 'International Mineral Resources Year" (IMRY) were organized, probably under UN auspices, but with support from individual governments. This would establish a need for international cooperation and the communication links formed would survive beyond the formal end of the "Year" and could become the network for a dialogue on a more permanent international cooperation. The advantages of the IMRY mechanism are that it would provide an important compilation of information on mineral resources at the same time as providing a framework which could evolve into an ongoing mechanism for extended cooperation without the need for pre-judging what the details should be, and without requiring an early decision as to the source of leadership.

Question 5: What role exists for an international technical federation of materials societies?

It is likely that the proposed IMRY would identify or create a body which could function as a coordinating agency for national materials societies. For the present, until more is known about the world materials community, it would be unrealistic to attempt to define the role of such an organization.

Question 6: How can existing private and public institutions be better used in support of the above goals and in support of conclusions derived from the above? What, if any, additional institution(s) is needed?

A considerable difficulty in making meaningful recommendations concerning improved use of public and private institutions is their number

* The suggestion for such an international program originated with Professor Rustum Roy of Pennsylvania State University.

and diversity. It appears that compilation of an inventory of Minerals and Materials Societies covering international and, perhaps, even national societies would appreciably help the situation. It is proposed that the inventory not be a mere listing of organizations by title and address but rather include a short description of the societies, their participating nations, their interests, activities, publications and constituencies by principal professional discipline or trade activity. To make the document most effective, it should be made widely available at low cost and be updated periodically. In the short run such a compilation should aid communication and, perhaps, in the long run could suggest possible reduction of redundancy or formation of federations of compatible organizations (possible alternate to 5).

IV. FRIDAY MORNING PAPERS

Three papers were presented at this session, two prepared and one, by Mr. Vesterlund, as an ad lib contribution with manuscript supplied later. The thrust of Mr. Vesterlund's paper was the imperative need for global cooperation, with the developed nations shouldering more of the burden of technical assistance to those nations less developed.

The two prepared papers dealt with (a) some options for the management of a stockpile of materials for industrial use, and (b) an overview of national materials policy for the United States.

The session closed with a presentation by the Chairman of the main points developed during the conference.

STOCKPILING FOR THE FUTURE

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Introduction

The major advantage to one bringing up the rear in a week-long conference lies with having heard that which has already gone before. But then, there is both bad and good lurking in such intelligence. The bad is that by Friday, almost everything that can be said has already been said. It is highly probable that the audience, singly or in combination, one way or another, will have already covered the ground the Friday speaker comes prepared to present. I will confess at the outset that this is, to a great extent, my predicament this week.

But then the good is, as an old pro once told me, that when you have been preempted, you know what to watch out for, and you can make a speech out of summarizing what everyone else has said. In this way you keep out of arguments and get everyone to admire your magnificent perspicacity for observing the worth of their wonderful ideas.

So that is my strategy. First I will begin with a little summarizing. Then, because, luckily, a little something I came with has survived the week unscathed, I will top the summary off with a few new ideas.

What I really set out to do in this presentation was to identify “ways that a national stockpile could be socially beneficial”, according to Frank Huddle’s directive. As you know, “socially beneficial” covers a lot of ground. It is fortunate that a good deal of what has been said this week has dealt with social benefits. So from that background we can step out and be specific about the social benefits of stockpiling, per se.

About 10 months ago Battelle’s Columbus Laboratories was pleased to have Jim Boyd ask us to review the effect of stockpiling on economic stability. It was a fascinating study, an eleventh-hour effort, that never got past the draft stage. It was never officially published, for a number of reasons, even though a few copies have gotten around in what looks like completed form. Among the more important findings in our study are two things that bear heavily on what we have been talking about this week.

The first takes off from the long standing policy of the American Government to step in and help society combat commodity scarcity whenever it occurs; notably during national emergencies, but also during other occasions as well. Stockpiling has been one, but only one of four, important tools for implementing that policy. History teaches us that none of these tools can stand alone. No one is complete in itself. In large doses any one of them alone is either too expensive, or unsuitable, or both. But, together, they seem to work well in trade-off with each other. I will elaborate on that later. The thing is, however, that for us as a nation to consider turning away from stockpiling is to consider denying ourselves the valuable use of a legitimate and effective tool for combating scarcity. It would be like a carpenter throwing away his hammer just to lighten his tool box.

The second thing is that, beyond being a defensive measure, stockpiling may provide a positive force to bear on world money problems. It may be the opening for financial innovation which we brought out in Task 11 to ease world currency scarcity, lend some support to weak currencies, and loosen constraints in foreign exchange for all nations.

Those are the two things our stockpile study disclosed that bear directly on our deliberations this week. Now, it would be presumptuous of me to promise you that stockpiling would solve all the problems of tomorrow’s world of scarcity. But it doesn’t have to be that good for it to be worth talking about, would it? That’s why I’m here—to run through the rationales behind these points and show you how we came to these conclusions.

Conceptual Model

Our study strategy started out with stockpile history in the United States. Our aim was inductively to work back from history’s lessons to underlying, hopefully, lasting principles. As a result we might find hidden truths that may more than key a better understanding of past events, but provide some measure of prescriptive capability for coping with future scarcity situations.

We started out building a conceptual framework for tying together fundamental cause-and-effect relationships evident in the history of stockpiling. With it we found what appear to be at least quasi-principles for future guidance. Coincidentally, the conceptual model integrates into one interrelated picture many of the things we have all been discussing here this week. So for the double purpose of understanding history, and summarizing some of this week, let's go through the framework and see where it takes us.

We start out by saying there are four major action recourses a nation may use to combat scarcity—Stockpiling, Standby Capacity, Substitution and Recyling. Stockpiling and Standby Capacity have a history; Substitution and Recycling, a future.

For the benefit of the conceptual framework, let us define these terms and note their principal advantages and disadvantages.

Stockpiling we define as a large inventory of critical and strategic materials available to offset prolonged periods of acute scarcities. Its major advantage is that once it gets into place the stockpile provides instant reaction capability to scarcity problems, or an infinitely short lead time to put it to use.

Its major disadvantages are its high capital cost (around $8 billion is what the DPA stockpile came to in 1962), its continuous management cost, its long lead times to build, and its potential disruptiveness in the marketplace. But, I hasten to add to the last that a properly managed stockpile need not necessarily be disruptive.

Stockpile costs for minerals and metals would be high but reasonable and somewhat self-supporting, if we were to rely 100 percent on stockpiles to combat scarcity. Fuel commodities, however, would be impossibly high cost.

Standby capacity we define as a deferrable and/or mothballed mining and/or industrial capacity capable of producing in quantity critical and strategic materials in time of scarcity. Its major advantages are it provides a quick reaction capability to scarcity problems or a relatively short lead time to put it to use.

Its major disadvantages are high capital tie-up, rapid depreciation of capital through obsolescence and deterioration of plant standing in idleness. The losses in mothba[led plants are so great that the temptation has been overwhelming to run the plants instead, and that, like a night out on the town, results in a DPA-like, stockpile hangover. In addition, the deferral of existing equipment and manpower from other less critical activity is disruptive to industry and usually requires special Government bodies set up to manage it equitably. To rely 100 percent on standby capacity to combat scarcity would incur exorbitant costs.

Substitution is the interchanging of materials able to deliver equivalent benefits to the user. Its major advantages, first, are that substitution relieves critical-material demand by replacing them with noncritical materials offering equivalent effectiveness in given uses. Second, substitution, once under way, pays for itself as it goes, except where the replacement material is inferior and requires paying an incremental cost to make up for that margin of difference.

Its major disadvantage is that substitution cannot take the economy far enough to combat broad and deep scarcity situations. Substitution technology is just not that well developed. To take the time to develop it will require long lead times. That is not to say that substitution is not done in industry. It is, but on a relatively small “nutritional” scale, so to speak; not on a sufficient scale to provide the large-scale “therapy” we would need to combat real scarcity.

Even though further technical development appears worthwhile and should take us a long way, it would be visionary to expect a 100 percent substitution to solve all scarcity problems. One can foresee at its best exorbitantly high cost, and, for technical reasons, a significant short fall of the “ 100 percent” goal.

Recycling is the return of obsolete scrap to the system. Its main advantage is that it, in effect, renews nonrenewable resources. Also, it carries a pay-as-you-go feature. Moreover, recycling saves process energy per unit of production. It returns net energy to the system, where collection and scrap processing costs do not wipe out process-energy savings.

Its disadvantages, just as with substitution, are that the technology

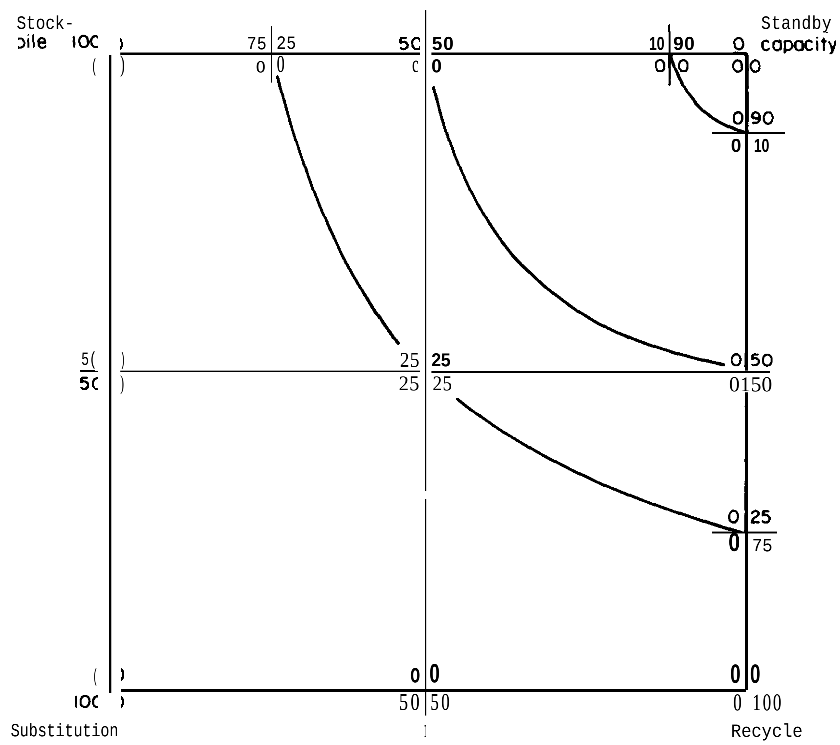

Figure 1, lsoquantic trade-offs percent dependency.

is yet to be developed to an extent required to consider it a therapeutic answer to scarcity. It will require long lead times to develop it fully, as, for example, full recycling of municipal wastes.

It is highly unlikely that we will ever have 100 percent recycling capability. To the extent we recover all materials now in the system is the extent to which we relieve the need for mining. Even at best, mining *will* always be necessary to replace material irretrievably lost in the social system as a whole, and to provide for growth.

So much for definitions. Back to the conceptual framework, we plot these four ''scarcity therapies" each on one corner of a four-dimensional isoquant—Figure 1. This is like Blum's three-dimensional isoquant, borrowed from thermodynamics. Only here we have four elements, which give us curved isoquant lines. So as not to get hung up on isoquant theory and development, let us gain familiarity with it through the application of it to our situation here.

If you were to depend entirely on Stockpile, you would plot into the chart at the upper left corner. To the extent that your "scarcity therapy" employs *some mix of all four* remedies, you fall somewhere on the face of the chart. In the middle, for example, you have an equal, or balanced mix, of all four remedies at work at once, i.e., a 25:25:25:25 percent ratio.

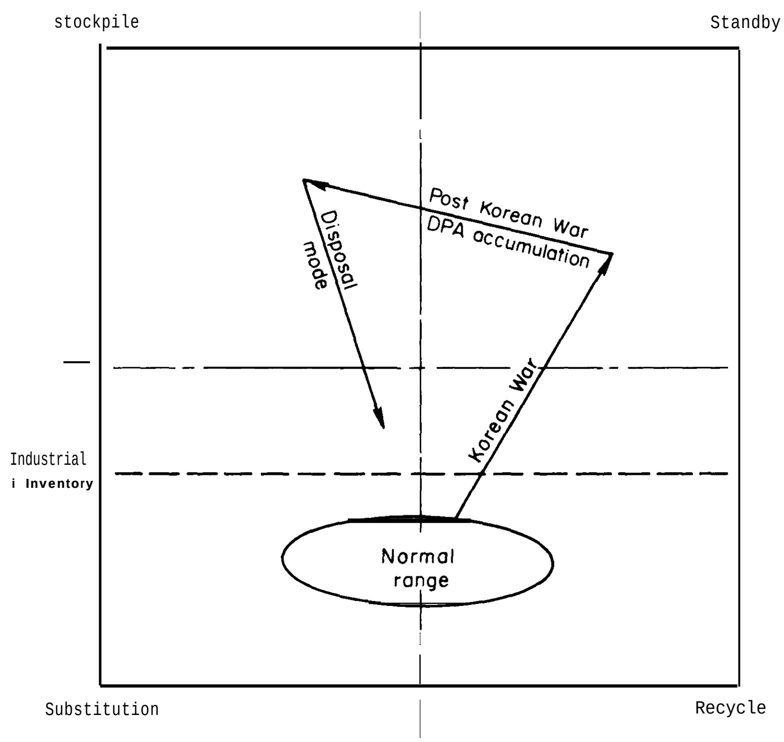

Figure 2. Stockpile history in isoquant.

With that you can plot stockpiling history on the isoquantic chart as in Figure 2. Here you have a “normal range” of mix options, where you would be in a non-scarcity situation; e.g., you use nutritional doses of inventory, excess capacity, substitution and recycling, to keep industry in an abundantly supplied economy going efficiently, say in the pre-Korean War period. Now, history documents the Korean War as taking us toward additional Standby Capacity, then into a hangover period of stockpile accumulation, and finally into a disposing mode that is taking us back toward the normal range again.

Well, what drives these changes—specifically; and why did we go in the directions taken?

What happens is that the economic system always tries to minimize the incremental cost of combatting scarcity. You are more willing to accept higher incremental costs in times of scarcity, than you are in times of abundance. When you do, you increase your options of mixes of the four remedies. Once you widen your options, then your governing

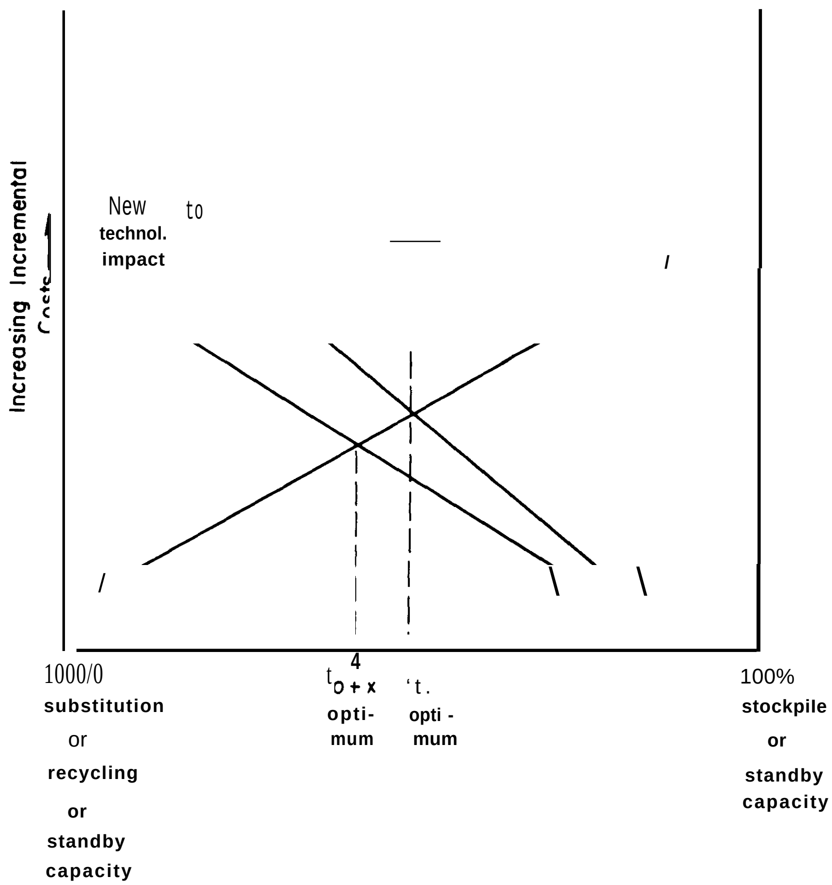

Figure 3. Stockpile trade-offs.

concern moves away from cost and toward lead time, until at the extreme, one hears, "Hang the cost, which alternative gives the fastest response ?'

So let's look at the effect of incremental cost on mix position. Let us take any trade-off pair in Figure 3; say, Stockpile versus Substitution. 100 percent Stockpile is high cost and so is 100 percent Substitution, at the present state of their arts. As these trade off with each other we come to an optimum cost mix as shown at the bottom of the catenary curve. If and when new technology lowers the cost of

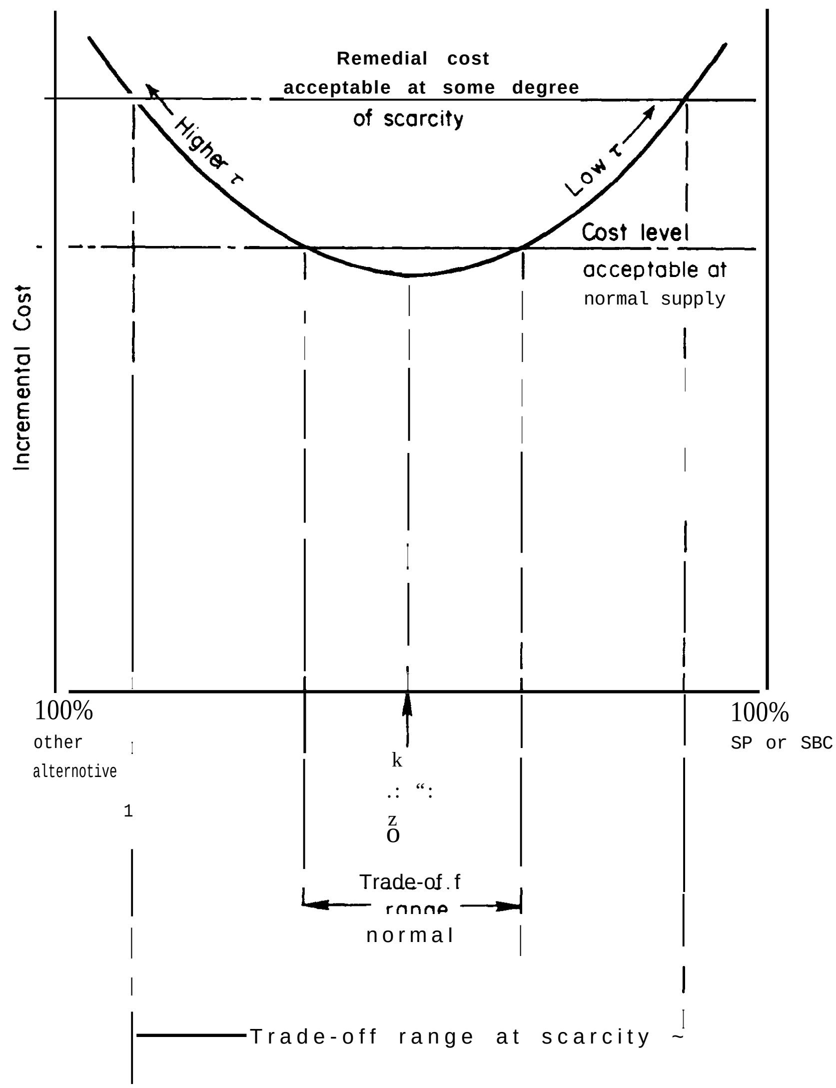

Figure 4. Trade-off-mix range as a function of supply.

Substitution, the bottom and optimum moves to the left, which raises Substitution, and lessens Stockpile in the mix.

Now, normally, your acceptable minimum cost level in a normal supply situation keeps your mix options narrowed around the optimum, Figure 4. But under "scarcity" you accept remedial costs above the normal, or raise the dotted line. This widens the intercepts and increases your trade-off range of mix options. Which option will you go for? The cheapest one, commensurate with the lead time available.

Of course, with four remedies you really have six trade-off pairs. When we combine all pairs in Figure 5, the two-dimensional catenaries

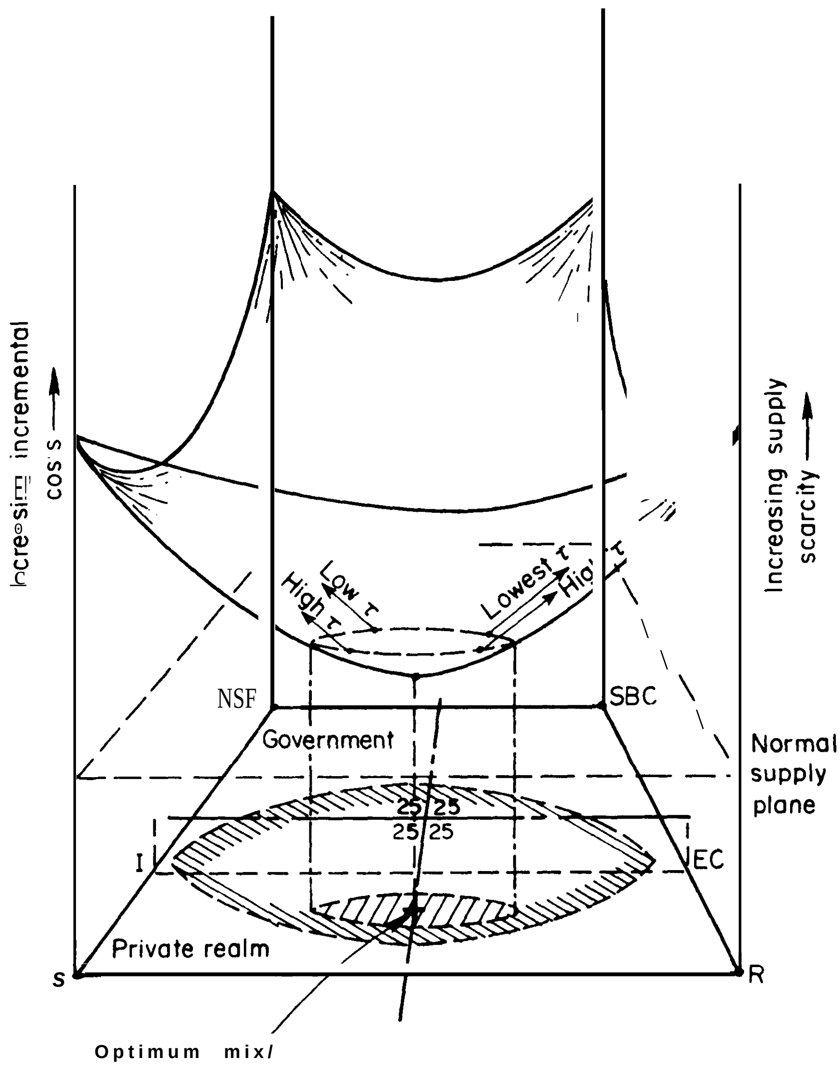

Figure 5. Integrated model.

join up to form a pendulous plane with the low point lying over the "normal" range. Under scarcity the cost-level line becomes a rising supply plane, and your mix options accordingly open out in all four directions.

These diagrams set some principles. Consider, for example, that the International Tin Council or CIPEC, or some other Agreement group gets tough. Say it puts the commodity under quota. The demand is unsatisfied. Much bidding up of price goes on by the scarcity-beset users. Now society will accept a higher remedial cost, or incremental cost to combat the scarcity, i.e., something proportional to the increased price. The dotted plane in Figure 5 rises. The intercept trace widens and the projected circle of options widen accordingly. Now you can move in four directions. What's your move?

Well, we can strike some quasiprinciples of action depending on the foregoing advantages and disadvantages inherent to the four remedial options.

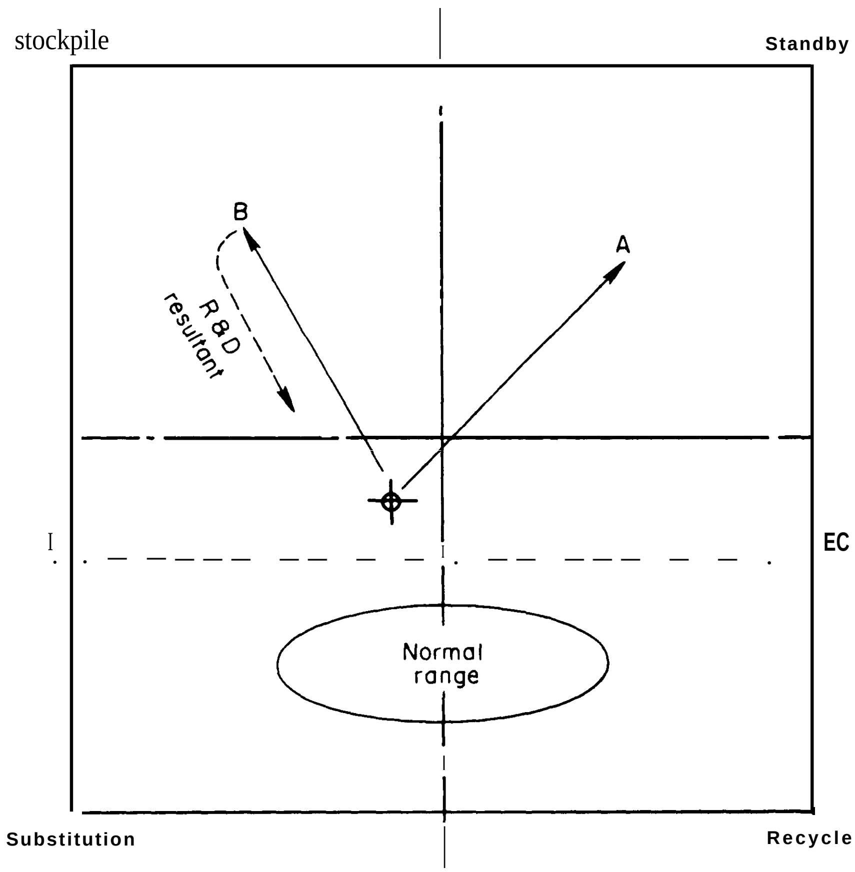

Figure 6. A strategy in isoquant.

The first principle relies on the expectation that every commodity will be different and is a separate consideration. To draw an extreme comparison, it would be absurd to stockpile municipal waste, but not copper. It would be equally absurd to build a standby copper mine and smelter, but possibly not a municipal waste separation plant. Each commodity, accordingly, is a separate consideration.

The second principle is to stay away from the SBC route (vector A, Figure 6) if at all possible. It is fast, but it gives you a hangover in the form of unwanted stockpile (such as DPA). Therefore, if you see a scarcity coming, get with other alternatives and use your lead time to advantage. But if the lead time approaches zero, you have good reason to go the SBC route—it has history and precedent, so it should not be difficult to assess realistically.

Third, go with Substitution and Recycling as far as possible, because, you will recall, these technologies, once established, have short lead times to effect, and pay for themselves as they go. But because both Substitution and Recycling need development, these remedies won't take you far enough at this moment,

Fourth, the strongest strategy at this point in time is to go with stockpile long enough to buy time for Research and Development on Substitution and Recycling; then move away from stockpiling as the latter alternatives take hold with time.

So that, in brief, is how we come to our first conclusion as given at the outset, i.e.,

(1) Stockpile, as one of four inseparable tools to remedy scarcity, is a keystone in a rational plan for the future.

(2) To turn away from stockpile is to deny ourselves of a crucial tactical option in dealing with scarcity.

Financing Defensive

If we conclude that stockpile, to some extent, and of some size, and of some specific commodity profile, is indispensable, we ought now turn our attention to ameliorating its major, but not overriding, disadvantage—high cost,

There are three ways to reduce the cost of stockpile:

(1) Physiocratic Fallacy. We already mentioned this. It is to trade-off Substitution and Recycling to eliminate Stockpile entirely, just as Germany did in World War II and the United States did in World War II and in the Korean War. As already mentioned, the fallacy of the Physiocratic Fallacy is that the state of the art of Substitution and Recycling is presently too undeveloped and hence too costly to take in large doses. It is impractical for moderate to high scarcity situations, and will remain so until such time that R&D gets costs down in both areas. It is practical only in the extreme emergency of life and death when infinite incremental cost will be borne willingly, as in the case of going all out for Substitution.

(2) Defer to Industry. Already studied are several management plans to pare stockpile costs to a minimum. First, the OEP had an objective

consultant look at transferring the DPA stockpile management to industry. He found high interest costs and storage costs so high as to make it unprofitable for private investors. Rather it appeared more economical for society as a whole to carry stockpile management under Government control within Government facilities where many fixed costs could in effect be eliminated.

Second, and now gaining renewed attention, is to authorize industries to expand regular inventories to meet stockpile objectives. By dropping the tax on "stockpile inventory", larger stocks could be accrued. Inventory tax relief is not enough. The remaining cost may be borne by a pay-as-you-go scheme in which cost passes on to the consumer in higher prices.

(3) Overlooked to date is the Coinage Principle; turn stockpile into a commodity reserve currency. Mineral and metal commodities are generally high density, slow to deteriorate, widely valued in consumer economies, difficult to purloin, etc. Minerals can to some extent be a stand-in for gold. While resting in bond in an inventory for long periods, stockpiled commodities can be used as a commodity reserve currency to augment gold-reserve currency. Essentially, the mineral and/or metal commodity would take its place alongside of gold to support the dollar and, accordingly, broaden the credibility base for United States currency, at least among the vast number of people in the world who stubbornly insist in having tangible things of value standing behind paper money and credit notes. The western world has its gold; Iran the crown jewels; now, make it mineral ores, and metal ingots to support any currency. Although commodity currency may not, as Friedman wrote in 1951,[1] meet the "technical efficiency of Fiat currency" on one hand, nor the "emotional appeal of gold" on the other, it may not easily in 1974 "fall between the stools", particularly since mineral commodities of any kind are looking more like "gold" to consumer nations as they enter a peacetime period of commodity scarcity.

As long as the stockpile commodities remain in escrow, so to speak, the owning nation could either print, or create de facto, credible money against the commodity value in stock. Curiously, it avoids interest charges during the escrow period, just as no interest is paid on the gold in Fort Knox. When one uses some of the commodity, however, it comes out of bond and an equivalent amount of currency or credit is retired accordingly.

During the Great Depression and Post-War years, the coinage principle was a much discussed issue among economists. But because the premises for augment are changing, perhaps it is time to revive the subject. Perhaps it might carry the seeds of financial innovation we need to deal with the special new case of scarcity in peacetime.

Beyond Defensive

A major lesson of the Vietnam War years was that a national stockpile is effective in preventing runaway prices to the consuming nation managing it. Earlier than that, producer buffer stocks had already demonstrated for years that they can be effectively managed to prevent witheringly low prices for producers. In none of these cases have the stockpile hoards, such as they were, ever been tied to currency support. Therefore they have either burdened their sponsors with heavy costs, or limited their effectiveness by having to stay within a budget; e.g., the ITC buffer stock, the ups and downs of which in recent years carry headlines in practically every Metals Week issue.

These experiences lead logically into a renewed interest in National and International Buffer Stocks (with the coinage principle attached?). Let's review these, briefly.

National Buffer Stocks have economic-stockpile purposes. That is, they establish accessible reserves of essential commodities, which may be administered such to obtain (1) supply continuity, (2) price stability, and (3) realistic price levels. The National Buffer Stock concept has a formal precedent in the United States. In 1940, Congress set up the Metal Reserves Company under the Reconstruction Finance Corporation. The RFC had acquisition power, administrative control, and disposal power over its stock of commodities. It was strategic oriented, set up to maintain economic stability during times of defense buying in anticipation of World War II.

Another precedent was established late in the 1960's when the DPA operated a de facto economic stockpile, built up as a hangover from the Korean War, but was never openly thought of as being anything but a strategic stockpile.

More recently the Japanese announced they are starting a National Buffer Stock, perhaps the first official buffer stock set up by a consumer nation and designed primarily to protect a consumer-nation's trading interest. Japan recently set aside $800 million for acquisition of materials deemed scarce in the Japanese economy. Japan was the first to act in this direction, but not first to think about it. Previously, England, France, West Germany, and Sweden all have publicly considered building national buffers. In all probability they are still thinking about national buffers to protect commodity price ceilings. With the Japanese precedent set, now it should not come as a surprise if these and other consuming nations follow suit.

Such national buffers or economic stockpiles were studied 40 to 50 years ago by economists as a means to stabilize economies during depressions, or in times of oversupply. The reason why buffer-stock plans were rejected in the oversupply situation of the great depression was because of the long term downward trends of commodity prices. This leaves one to expect that any commodity reserve inventory would continuously decline in value with time, and undercut the long-term viability of the buffer-stock operation. However, in scarcity situations, the prices increase with time, which turns expectations completely around. Should this not suggest new viability to the scheme in coming years of scarcity? Perhaps the pros might do well to take a new look at National Buffer Stocks as a positive new force to exercise in coming years of scarcity. I refer you to Grondona's Price Stabilization Corporation (PSC) as a start toward such a new 1ook.[2] His scheme has the unique features of operating outside government control, of management by professional guidelines, and of avoidance of partisan political influences. It allows no meddling by any government, which can only participate to the extent of managing by objective, and by monitoring progress toward such objectives as previously agreed to.

PSC has a valorizing formula to determine when to automatically buy and sell. In operation, the PSC is passive, never enters the market as a trader. It would operate only at the initiative of buyers and sellers, and then only as their court of last resort when the free market system temporarily breaks down when prices reach extremes, i.e., break through price ceilings, or price floors. Otherwise, free market operates as usual.

Administrative costs were expected to be low. Buying at price lows, selling at price highs, and profiting from a continuous price appreciation of stocks on hand provides operating funds. Its benefits are that it (1) counters inflation, (2) strengthens the currency, and (3) builds stability into the national economy.

Its operation essentially duplicates our own de facto national buffer or economic stockpile, as LBJ managed it during the Vietnam War. The PSC would be free of political pressure to move swiftly to buy and sell with dispatch. It would proceed according to an undisputable policy, or formula at buy-floor and sell-ceiling points.

Beyond these theoretical ideas are the factual signs of the times that lead us to note real and active trends toward National Buffer Stocks. These operations real and imminent are being modeled after our own DPA/GSA operations! Good or bad, these operations have set precedents that other nations plan to follow.

Although the United States de facto economic stockpile was conservatively operated with minimum political interference, one should not expect this to always be so, everywhere and at all future time. That is why Grondona's should be revisited, and his caveats reviewed with care. He may have a better idea than the one LBJ fell into by expedience. Now is the time to correct precedent, if need be; now is the time to work up an enlightened policy on a national buffer stock, or economic stockpile, or national inventory in the United States.

International Buffer

Picture, now, ten years off, the likelihood that several national buffers will be operating, most likely the United States, Japan, and common market countries.

These operations may find themselves defeating their own purposes by competing with each other by bidding up prices for open-market mineral and metal commodities, particularly if any one were to get skittish, for some reason, and over buy.

To avoid rifts in what should be a united block of consuming countries, I suggest to you Benjamin Graham and his concepts of a comprehensive International Buffer program that he calls a Commodity Reserve.(3) Because it never got past the proposal stage, it is referred to in the literature as the Commodity Reserve Proposal (CRP).

In a word, the CRP replaces the many National Buffer stocks with a single economic-stockpile, (under a Corporation comprised of several consumer countries). Again, it has a formula for goal setting, in storage commodity profiles, formulated buying and selling. It is an international buffer that operates on the foregoing principles of a national-buffer operation. It has the advantage of becoming a vehicle for international cooperation between consuming nations, and between blocks of consuming and producing nations.

Its dominant objective is to reduce the amplitude of world price fluctuations encountered in economic cycles.

Its two unique features are (1) complete automaticity of operation, leaving minimum scope for administrative decisions and partisan influences and (2) a "coinage principle", i.e., issue currency or credit on stockpile purchases; and retirement of credit on sales. Otherwise, its stabilizing benefits, international agreement characteristics, and usefulness to both the consumer's economic stability and the producer's economic stability are the same as for the National Buffer operation.

Again, the administrating agency is independent and international under a corporate structure—International Commodity Corporation. The Corporation was expected to be marginally profitable during long-term periods of declining prices without the coinage principle. It depends for its viability on profits from buying low and selling high. It might become viable with rising world commodity prices without employing the coinage principle. This is encouraging, because the coinage principle on an international scale would cause serious alterations in international monetary operations. That would not be easy.

Here again, it would be presumptuous of me to say that Grondona's PSC or Graham's International Commodity Corporation concepts would solve all the scarcity problems consumer nations imminently face. As a matter of fact, it would be surprising if the concepts would not require tailoring to adapt them to modern problems. After all, both were working in a different trade environment, i.e., commodity overabundance, not scarcity; declining world prices, not rising world prices; all commodities including food, not just minerals and metals; and a different geosocial world than today 's.

Therefore, it would seem advisable not to look to Grondona and/or Graham for perfect panaceas, but rather for strong concepts upon which to build better ideas.

I would, for example, opt for a complete overhaul. I would begin with a new term to replace the name "stockpile", with all its nationalistic and aggressive connotations from years past. It is inconsonant with the spirit of free trade and its emphasis on international cooperation, on mutual benefits for consumer and producer countries, and on a sense of relaxation of tensions.

May I suggest, instead, the terms National Trade Inventory (NTI) on the national level, and/or International Trade Inventory (ITI) on the international. Inventory carries creative connotations built upon the concepts, methods, and success of company inventories anywhere. It is agreed that company inventories, whether carried by producers or consumers, benefit both parties by supplying various goods to meet needs promptly as they arise and thus assure uninterrupted operation of the business. Similarly, the NTI or ITI might be counted on to assure uninterrupted operation of national economics. To gain such advantages for both the consumer and producer countries would be at once the objective of the Inventory, and the common objectives to underly international cooperation in a free-trade world.

Specifically, the advantages of the Inventory might include the following.

To Consumer Countries. An inventory would:

(a) Relieve the disruption of hand-to-mouth material procurement.

(b) Avoid economic damage of sudden scarcity. Bypasses a "decelerator effect". (The decelerator effect occurs when a scarcity idles consumer's manufacturing capacity requiring him to carry higher costs.)

(c) Stabilize prices, preventing them from penetrating ceilings that add to costs; i.e., idle-equipment costs, which reduce profit margins and create an increment of inflationary pressure.

(d) Introduce de facto currency support by virtue of a nation's ownership of part of the inventory, thus strengthening its currency convertibility and valuation.

(e) Introduce de facto expansion of currency via extending credit against ITI stocks, thus relaxing need for IMC to be prepared to lend money to nations faced with sudden rises in demand for foreign currency.

To Producing Countries. An inventory would

(a) Become an inventory-customer to stand in for disappearing consumer-customers in times of depressed demand and prices.

(b) Avoid economic damage of sudden high demand bypassing the "accelerator effect". (Accelerator effects occur when an increased demand pushes producer beyond his capacity, requiring him to raise his investment. A five percent increase in output, above capacity, would, as a rule, raise the investment/spending budget by perhaps 50 percent.) The Inventory would absorb the shock of a sharp discontinuity in demand, and relieve pressures on that investment/spending budget; also allow for an orderly expansion over time if demand proves to be continuous.

(c) Stabilize prices (of inelastic commodities) preventing them from penetrating floors that reduce revenues at a time when (1) idle capacity may be increasing unit costs due to lower productivity and (2) reduced revenues, and profits bear hardship on producer country.

(d) Introduced facto currency support of producer-country currency in foreign exchange. Currency convertibility increases with knowledge that valuable raw material is available in its ITI account to holders of the producing country's currency.

(e) See (e) under '*Consuming Countries".

In conclusion, I would like to raise a point described in Task II. That is, there are inherent short term conflicts in the value systems of producing countries (LDC's) and consuming countries (DC's). Inherent adversary relationships grow out of such conflicts. Thus, any negotiation toward a cooperative datum plane starts out in a hole. The Inventory can resolve two of these; evening out of supply/demand discontinuities, and price/economic stability on both sides without disrupting each one's normal way of going about its own business. It is conceivable that a knowledgeable Inventory management could smooth away the rocks in the pathways of technology transfer from developed to lesser developed countries as well.

1 hope that with an opportunistic and optimistic attitude we can contrive to pursue some of these avenues, and down the road find ways to head off some of the world tensions we see facing us.

References:

(1) *Milton Friedman, "Commodity-Reserve Currency", Journal of Political Economy, Vol. 59, June 1951.*

(2) *L. St. Clare Grondona. "Vitalizing World Abundance", George Allen and Unwin, Ltd., 1958.*

(3) Benjamin Graham, *"World Commodities and World Currencies", McGraw-Hill, 1944, pp 57-71.*

SOME INTERNATIONAL ASPECTS OF THE MATERIALS POLICY

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I have been asked to give some personal comments on the international aspects of materials policy. I have to confess, however, that my personal opinion in this particular matter coincides with the official Swedish view as it has been expressed in the United Nations.

The finite natural resources of the world are certainly a big problem for the future but not necessarily the most critical problem. As has been pointed out by many scientists and economists the resource scarcity problem can be resolved by proper actions undertaken by politicians and other decision makers, starting today.

But the resource scarcity problem is closely linked to another problem, which I think is even bigger; the world's economic and political structure and its failure to achieve a fair distribution of the world's wealth.

This can be illustrated by the fact that today 70% of the world's population has to exist on only 30% of the world income. An economic balance sheet that was distributed to our task force this week shows a projected growth in GNP per capita for USA from the present 6,300 dollars to 12,000 dollars in 1985 and, for the less developed countries, or developing countries, as we prefer to name them, from the present **240 dollars to** *450 dollars.* This is certainly a doubling for both categories but their relative proportions are grotesque. This is the perspective in which we have to consider the international materials policy when dealing with this particular category of countries. I think it is important to separate the poor materials-producing countries from the industrialized countries and also from the rich oil-producing countries which are now obtaining an increasingly powerful position in the world's economy.

Political independence is the first objective in order to obtain a fair distribution. Although it is a slow process, a lot of progress has been made. But we also need an economic independence which guarantees the developing countries freedom from domination and exploitation. This means that every country must be entitled to a permanent sovereign y over its natural resources. The term economic independence as explained above does not exclude an economic interdependence in which respective countries mutually benefit from an exchange of goods and services.

A central issue is the multinational corporations which in many countries are controlling the exploitation and marketing of natural resources. Even if this control is not misused, it tends to undermine the efforts of the developing countries towards economical independence. It must therefore be in the interest of the international community to bring the activities of the multinational companies in line with national and international policy objectives. Today, they are often not even accountable to any specific one of the countries in which they are operating.

It is obvious that the developing countries need a widened access to science and technology, but also financial support of research and cooperation projects in fields of trade, industry and transportation. Here we come to the issue of foreign aid which can be dealt with separately, but which also can be highly integrated with the international materials policy, whereby the developing countries in return for commodities receive cash flow, but also science, technology and educational manpower. In the case of ''pure" foreign aid, Sweden is next year going to achieve the goal to give out 0,7% of the GNP. If all developed countries followed this example, it would mean that another 8-10 billion dollars a year would be put at the disposal of the developing countries.

As Dr. deAlba, my Mexican colleague, stated the other day, we must remember that the developing countries, as well as the developed countries are consumers as well as producers of commodities. We will best serve the interests of both producers and consumers if we can secure a balance between supply and demand within the framework of a sustained total growth.

I agree with task group 5B when they say that "a basic materials goal is to improve the atmosphere in which the exchange of materials' goods and services take place". This seems to me more constructive than other proposals that have been heard here this week such as the one that the United States should act out of a strong dominant position, the full meaning of which I must admit I have not really understood.

I have also found chapter 9 of the so-called Boyd report(*) to be very interesting. There is especially one paragraph (p 9-14) I would like to point out:

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* *Final Report* of the *National Commission on Materials Policy June* 1973

"These complementary interests must be realized through contractual type relationships which recognize both industrial country needs for materials as well as developing country needs for a fair return from the sale of their materials and greater control over materials exploitation. Methods of doing business that are mutually acceptable will be developed if the will is present".

The Swedish government considers that for many important commodities, international agreements are the best means to achieve stable markets and provide the producing developing countries with increased export earnings which are essential for their development.

We cannot just cynically conclude, as someone did here the other day, that it is difficult to cope with interdependence with unequals. It is my strong feeling that we must work towards an equality that may be a good base for interdependence.

MATERIALS; THE NEXT CRISIS?

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"We have become great because of the lavish use of resources and we have just reason to be proud of our growth. But the time has come for us to think seriously what will happen when our resources are gone; when the coal, the iron, the oil and the gas are exhausted, when the soil is still further impoverished and washed away in streams, polluting the rivers, denuding the fields and obstructing navigation. These questions do not relate only to the next century or the next generation . . ." These comments were made not in 1974, or even 1973, but in 1908 in a speech by President Theodore Roosevelt.

In 1974, the President of the United States was again concerned with the availability of resources. In his State of the Union Message, the President stated that ". . . it is imperative that we review our current and prospective supplies of other basic commodities. I have therefore directed that a comprehensive report and policy analysis be made concerning this crucial matter, so that governmental actions can promptly anticipate and help avoid the damaging shortages . . . ." A few months later, William S. Paley, the chairman of the 1952 Presidential Commission on Materials Policy, expressed concern even more strongly-". . . The energy crisis can be a blessing in disguise for America. A warning has been sounded. We could be heading into stormy seas unless we heed and act now. We face a problem centering around this key question: Does the United States have an adequate supply of raw materials to feed its expanding economy and defend its security? The answer leaves no room for complacency. My experience as chairman of this Materials Policy Commission which studied the subject exhaustively along with current developments has convinced me that we have reached a watershed in our national life. For the first time we must deal with a wholly new fact . . . that the well from which our resources flow is not bottomless. . . ."

While these three quotations appear to express like apprehensions about serious problems for the continued availability of materials resources, the nearly three-quarters of a century between the two presidential statements was a period that seemed to prove that the Malthusian warning of 1908 was misplaced. Over that period, both the United States population and its national wealth grew with associated increases in the consumption of materials and energy. In the face of these increases and despite the need to move to leaner and leaner ores as the richer mineral deposits became worked out, the ''reserves" of the major industrial materials remained stable or increased over the same period and the material cost (in constant dollars) declined continuously. This contra-trend was due in large part to the ability to provide continual improvements in the technological efficiency of extracting and processing these basic materials. This experience of long-term downward trends in the constant dollar cost of materials was in large part responsible for the rise of the "Cornucopia School" of resource economics, which assumes that necessary technological advances will continue likewise into the future.

However, the two statements made in 1974 point to a relatively recent change in attitude towards materials resources which involves concerns both for shortages in the near-term and for the finiteness of the earth's supply of materials. Both these latter concerns—frequently jumbled together in a confusing way—have led to a great deal of current public debate in newspapers, television and technical journals. This revival of neo-malthusian thought was stimulated sharply by the Club of Rome's study "Limits to Growth". Since the onset of the energy crisis in 1973, there have been numerous Congressional Hearings on materials shortages. Indeed, at this moment a bill proposing a National Commission on Supplies and Shortages, supported by both the Majority and the Minority leadership and by the Executive Office is being considered in the Congress. The United Nations held a Special Session of the General Assembly in April of this year on "Raw Materials and Development". In Paris, in June, the Council for Economic Development conducted the "first World Symposium on Energy and Raw Materials".

These various events and activities are all directed to the question that is the topic of this talk. The important point at issue is whether these recent concerns for materials really correspond to a materials ''crisis', in the sense that the word crisis means a pivotal decision point or a turning point. In trying to answer the question it is useful to consider in turn, for both the United States and the world at large, the problems of the near term and those of the period beyond the rest of this century.

Concern with the supply of materials over the near-term future, i.e. the period of the next 10 to 20 years, appears to have arisen directly from the events triggering the recent oil crisis, when a small group of oil producing and exporting countries were able to withhold oil supply both to force a four-fold increase in price and to influence a political issue— the Arab-Israeli conflict. The United Nations Conference mentioned above was initiated to bring together energy and other raw materials exporting countries to demand an improved trading position with respect to the principal raw materials importing countries. Although the United States is a major producer of both energy and raw materials, she has become increasingly dependent on imports from other countries to supply her large and expanding needs. As a result, the country has become vulnerable to supply cutoff or price increase, particularly for several key industrial materials. In 1970, the United States, with only one-twentieth of the world population, consumed approximately one-third of the world's raw material supply. For twenty non-fuel minerals, including the important industrial metals—platinum, chromium, aluminum, nickel, and zinc, the United States imports more than half its supply from abroad. For seven of these non-fuel minerals (platinum group metals, chromium, strontium, cobalt, tantalum, aluminum ore and metal, manganese) the imports for each amount to 95 percent or more of the U.S. annual consumption.

This dependence on imports has arisen either because such supplies are cheaper than using indigenous U.S. sources (as is the case for the ore for aluminum, bauxite) or the material is not indigenous to the United States, but has performance characteristics uniquely suited to specific and desired technological needs (e.g., palladium for telephone contacts, platinum for the catalysis of chemical reactions, chromium for resistance to corrosion and oxidation), Almost all the other industrialized nations are more dependent on importing raw materials than is the United States and hence have an even more vulnerable position. It is the concern with the price and reliability of supply of such imports over the next several decade that is really the major issue in most current discussions on materials "shortages". In addition, there is an immediate and serious problem of the present actual shortages in many processed materials such as steel, aluminum, copper, etc. These particular shortages appear to be due principally to the undercapacity of the United States and world materials producing industries, resulting from a long period of underinvestment in new capacity and the unprecedented period of high rate of economic growth that has occurred simultaneously in most of the developed countries. The resulting higher prices for materials, also driven up by energy price increases, is stimulating some cautious expansion in production capacity and some improved efficiency of materials use or substitution in the materials and manufacturing industries. Such changes can be expected to alleviate this particular source of shortages but will not resolve the questions of vulnerability to imported raw materials.

Is there indeed a "Materials OPEC" threat and what can be done if it occurs? To the first part of the question there is no certain answer, only best judgments, as to its component uncertainties of the odds of collusion and the odds of successful collusion. However, it is helpful to consider the likely effects of any such success. In general, price multiplication of raw materials should affect product prices much less than has been the case for energy. Thus, bauxite has been close to $12 per ton, whereas the price of aluminum ingot is some $600 per ton. Even allowing for the fact that it takes about 4 tons of bauxite to produce 1 ton of aluminum, it is clear that the doubling of the bauxite price should not influence the final metal price as strongly as the changes in crude oil prices increased the resulting prices for energy fuels. However, while the impact of such price increases should accordingly not be as traumatic as was the case for energy, there is evidence that along with price increases for raw materials, the producing countries will press for setting up industries for materials processing and fabrication rather than simply exporting raw materials. Such changes in industrial structure could not only result in significant changes in the rate of economic development, but could also, depending on the future level of world demand for materials, influence the structure of the U.S. materials industry. Correspondingly, at the present time the prospect of "a Materials OPEC" is the subject of strong examination both inside and outside the Federal Government. Such considerations have led already to changes in the character of discussions in international trade relations from the focus of the past several decades on ''access to markets" towards one of "access to supply". The statement by Ambassador William Eberle (Special Representative for Trade Negotiation) at the recent Hearings on Materials Shortages before the Joint Economics Committee of Congress pointed to such an Administration view on the development of a stable and equitable framework for international trade in raw materials.

The second part of the question, addressing what might be done if the threat becomes reality, involves science and technology issues more strongly. Both increases in price and uncertainty of supply are likely to stimulate the following technical responses:

a. Materials substitution (i.e., the use of a different material, to perform the same function, such as copper or aluminum in conductors).

b. Process substitution (i.e., the use of a different raw material, such as alumina clays in place of bauxite).

c. System modification or substitution (i.e., reduce or avoid the need for a specific material by changing the engineering system, such as the use of a magnetic circuit breaker in a car ignition system in place of the conventional electrical circuit breaker).

d. Stockpiling either of materials or of technology.

The implementation of the first three of these responses is known from experience to require relatively long lead times to effect the technical change involved. For example, the substantial substitution of natural fibers by synthetic fibers has taken some 40 years. More recently, the replacement of open hearth steelmaking technology by the basic-oxygen process has taken some 10 years. In general, historical experience indicates that the substitution of a material or a new process for another takes on the order of 20 years. Usually, exceptions to this time scale occur only when little or no capital investment or write-off of existing plant is required. Such conditions were met in the case of the introduction of hybrid corn, which took only 2 or 3 years for almost full substitution to occur. Crash programs can also effect unusually rapid change as was the case for the development of the atomic bomb or in the program to place a man on the moon, but the investments of resources required are extremely large.

In the case of stockpiling materials, the U.S. experience to date has been primarily with ensuring supplies in the event of war. There still remain serious questions as to the effectiveness of materials stockpiles for the purpose of economic security, and as to whether they should be privately or publicly funded and managed. Furthermore, it is uncertain whether economic security is better met by international stockpiles analogous, for example, to the producer-consumer managed stockpile involved in International Tin Agreement rather than by national ones. The latter clearly are required if military security is the question. The stockpiling of technology can occur either as standby production plants or excess plant capacity, or by subsidizing the operation of higher cost production processes that permit the use of non-vulnerable resources. Compared with maintaining stocks of materials themselves, the costs incurred in stockpiling technology are very large and it appears doubtful if the insurance provided would be worth it. Since we are really trying to insure against finite dislocations in materials supply and /or price, stockpiling of materials appears to be the least expensive solution and the one that can be implemented most rapidly. A major relevant issue of science and technology policy is whether the Federal Government should underwrite research and development for alternative technologies, substitute materials or raw material supplies. However, such an issue is really more concerned with long term impact than the needs of the short term.

These various considerations lead to the conclusion that, for the short term, materials is not the next crisis for the United States or indeed, the world at large. Undoubtedly, there will be price changes, supply perturbations and alterations in industry structure, but in economic terms none of these developments appear likely to result in a crisis situation, i.e., one comparable to the world energy crisis of the recent past and the world food crisis that appears possible in the near-term future.

Let us turn now to the long-term questions, that is, the ones of the world of the year 2000 and beyond. Recently, we have seen a rekindling of the conflict of view between the resource optimists and the resource pessimists. The former correspond to the cornucopia school of resource economics, where it is assumed from past history that technology will provide an answer to the gradual decline in quality and quantity of the resource base. In sharp contrast, the resource pessimists, corresponding to the theory advanced by Malthus in 1798 of the inevitability of conflict of arithmetic growth in food supply with geometric growth of population, are concerned with the potential impasse between the finiteness of physical resources* and the limits

*To no small degree, sharp differences in some of the public debates as to the seriousness and immediacy of the problem of the adequacy of resources for materials are associated with the frequent failure to distinguish between reserves (i. e., identified sources that are economically exploitable with current technology) and resources.

perceived to technology. While the strong resurgence of these ideas has been associated with the ''Limits to Growth" study, already during the 1960's public attention had been drawn to the worldwide pervasiveness of the hazards of nuclear explosions in the atmosphere and of the increasing pollution of water and air from the wastes generated by industry and private individuals. Thus, the dramatization of the resources situation by the Club of Rome study found a receptive public and rapidly generated wide concern for the finiteness of "Spaceship Earth" and its resources, and raised serious questions as to the wisdom of continued economic growth. For many, the current demographic projections of the doubling of the world population for the year 2000 with corresponding pressure on resources has reinforced the import of this analysis.

Like the question "will there be a materials OPEC?", the optimist/pessimist question cannot be resolved with certainty. Moreover, it appears likely that this may not be the right question to ask because the issue is going to be really one of choosing among alternatives, all involving some restrictions of present choices, rather than ''continue as before" versus "catastrophe".

How finite are the world's resources? In the sense that the entire globe is composed of minerals, the answer is a number so large that it is essentially infinite in comparison with the likely world demand; in particular when account is taken, in evaluating such demand, of the evidence for a saturation of the level of the per capita consumption of materials in advanced countries and the fact that problems other than materials are likely to force a solution to the increasing pressure on all resources from population growth long before world population reaches "standing room only" levels. Similar considerations apply to the world supply of "renewable resources" of plants, trees and animals, in contrast to the minerals or non-renewable resources. In this very long term sense, the question whether or not materials resources are finite becomes academic. Much more practical is the question of the costs likely to be incurred, as opposed to the benefits, by continuing high rates of materials production and consumption and how can they be reduced. How can the pain of the transition period be modified? What is the role of science and technology?

The economic and social factors to be taken into account in seeking an optimum solution to this question of balancing costs and benefits in providing and using materials in the economy are principally the integrity of the environment, human health and safety, energy consumption (in particular, associated with the need to use progressively lower grade ores), competing uses for land, water and capital, and the stability of international relations. Science and technology can assist beneficially in this process of optimization through activities that offer options for both the supply of materials and reducing demand for new supply. Thus, increases in supply can be developed through:

1. Advances in the understanding of mineral formation and the techniques for exploration, and of plant biochemistry
2. Creation of new materials or processes that open up new resources

(e.g., synthetic polymers, new mining techniques for minerals on land and in the oceans)

3. Improving the physical efficiency of the extraction of minum and steelmaking, or wood products)

4. Develop lower cost alternatives for existing materials (i.e., substitution of materials or systems to provide the same performance or function), including the possibilities for greater use of the more abundant materials, such as magnesium and silicon, or of renewable materials, including current organic wastes such as lignin.

Opportunities for reducing demand for new supply lie in:

1. Better integration of materials selection with component design to develop manufacturing processes that reduce materials loss during manufacturing

2. New or improved materials to permit engineering designs that reduce the amounts of material required to perform a given function (e.g., miniaturization, as in solid-state devices, or improved reliability)

3. Conservation in use through improved materials performance that provides increased service life (e.g., reduction in rates of deterioration by corrosion and wear)

4. Improved recovery or direct reuse of materials during processing, manufacturing and after completion of the useful life of capital or consumer goods.

At the present time, there is increasing recognition that market forces alone may not move the United States and other developed countries rapidly enough towards ensuring that these science and technology activities develop timely contributions to the solution of meeting needs for materials in the future, Involved in this recognition are such issues as "the problem of the commons" and the internalization of external costs that have not yet been incorporated adequately into economic theory. Thus, a major question is how, where and to what extent should the Federal Government become involved so as to encourage effective use of resources and technology, and to anticipate the materials requirements of the future. A variety of deliberations and activities in the Congress and the Executive Branch, in the Organization for Economic Cooperation and Development, and in the United Nations are focusing on different aspects of these issues. Some movement is apparent towards addressing the most difficult question, that of the feasibility and wisdom of developing a more comprehensive approach to the management of materials resources.

From the above discussion, it appears that, while the reasons differ from those for the short-run case considered earlier, the longer term likewise does not threaten a materials "crisis". In particular, it is improbable that the world will "run out of materials" before other potentially critical issues intervene. However, the conclusion that no real crisis is likely for materials does not mean that, in the absence of appropriate attention, serious problems may not arise in their supply and use. Public choices in both developed and developing countries will have to be made between the costs and benefits involved, especially over the immediate future when expanding new production will continue to be the principal means of meeting consumption requirements.

Recently, two wide-ranging and complementary studies have examined the principal questions involved in such matters. The studies point to the close inter-relationships between materials, energy and the environment that, together with the concept of the total materials cycle, are central to adequate management of materials resources. The report of the National Commission on Materials Policy in June, 1973, entitled "Materials Needs and the Environment Today and Tomorrow", examines the characteristics of current and future supply and demand for materials in the United States and the world, and the policy issues to be faced. The National Academy of Sciences report in January, 1974, entitled "Materials and Man's Needs: Materials Science and Engineering", focuses on the science and technology of materials themselves. In addition, it examines the institutions in industry, government and university that conduct research, education and manufacturing to develop understanding and control of materials properties and performance, and to provide materials for individual and national purposes. Together, these reports offer an excellent starting point and framework for larger public examination of the needs for materials and the opportunities for meeting them. A variety of technical and organizational opportunities are available and given adequate and timely consideration followed by action, alleviation of short-term materials problems in addition to those perceivable as likely over the longer term can be expected.

V. SUMMARY OF THE CONFERENCE BY THE CHAIRMAN

At this third Henniker Conference on National Materials Policy five themes emerged.

First, there was a great stress on the need for closer cooperation of Government and private industry.

Second, the conference again demonstrated the pervasive nature of the information function and the need to strengthen its performance and organization.

Third, there was renewed recognition of the importance of ethical or moral considerations in materials management, trade, and engineering design.

Fourth, attention was called to the need for definition of both the capabilities and the limitations of the free enterprise system.

And fifth, the conference brought out the need of national materials policy to search purposefully for the right trade-off between national independence and international interdependence.

In my opening remarks to the conference I spoke of the rising tide of national interest in materials policy. I presented the charge to the conferees to suggest ways in which this concern might best be put to use by the Congress, the Administration, and the public to motivate sound implementation of the Paley Report of 1952, the National Commission Report of 1973, and the other great studies of the subject. I reminded you that the title of this conference was Requirements for Fulfilling a National Materials Policy.

In his welcoming remarks as incoming president of the Federation of Materials Societies, John Wachtman recalled that the Federation itself had been brought into being, in part, at the first Engineering Foundation conference at Henniker on national materials policy. As a federation of materials societies with a half million members, FMS had a broad charter to support the interests of these members and to serve the public interest as well. The Federation, he said, had contributed a report on materials conservation to the National Commission on Materials Policy and was currently evaluating national materials information systems for the Office of Technology Assessment.

KEYNOTE ADDRESS

In his keynote address, Mr. Emilio Q. Daddario, director of the Office of Technology Assessment, made three points. First he documented thoroughly that the Congress is responsive to the results of these Henniker conferences, because they help to identify where legislative action is needed. And he showed that the Congress has a keen interest in national materials policy.

Second, he called attention to the Mansfield bill, S. 3523, which proposes to create a temporary commission on supplies and shortages. This commission would have two functions: it would design a permanent institution to keep tabs on materials, sound the warning in case of threatened dislocations, and propose remedies. And second, it would serve in place of the permanent institution until Congress acted to create it.

Mr. Daddario's third point dealt with OTA'S plans for assessing national materials problems and opportunities. The OTA had been asked by the House Committee on Science and Astronautics to review the extent and seriousness of U.S. dependence on imported materials, and assess the role of research and development in alleviating uncertainties of foreign supply.

OTA'S plan, still in the formative stages, has a short-range and a long-range component. The short-range element consists of:

—an assessment of the present adequacy of materials information systems;

—an assessment of ways to conserve energy through materials management;

—an assessment of ways to ease U.S. materials vulnerability through production of domestic materials; and

—ways to use the stockpiling principle to encourage domestic materials production, put materials recycling on a sound economic footing, stabilize prices, and reduce vulnerability to foreign actions.

Mr. Daddario referred to work already underway by the Federation of Materials Societies to assess materials information systems for OTA. He described the formation of an ad hoc advisory committee by OTA in national materials policy. And he appealed to the third Henniker Conference on national materials policy to address both national and global problems of supply stability, frugal use and recycling, and cooperation to share expertise in the solving of world wide problems in materials.

MATERIALS RESOURCES—R&D RESPONSE

In an unscheduled Monday evening presentation, Dr. Julius Harwood of the Ford Motor Company's Scientific Laboratory described a study of materials shortages and policy responses developed by his company.

Materials costs, he said, were at an all-time high and were expected to rise still higher. In response, the automobile industry proposed to mount a strong R&D effort directed toward "materials substitution, recycling, solid waste disposal, and materials processing, to provide new sources of materials, reduce scrap generation, and increase productive utilization of available materials . . ."

The energy crunch was a related problem. It made weight reduction a must in the auto industry; and the speaker identified technological options toward this goal.

Considerable attention was being given to the materials and processing problems associated with the recovery and recycling of useful materials from junked cars.

And, in summary, the interdependent relationship among materials, energy, and environment required the auto industry to integrate "materials, design, and processing into a materials system approach".

Address by Dr. Richard W. Roberts, Director of the National Bureau of Standards:
"Materials Research: A Strategy to Improve the Performance of Materials."

Dr. Roberts opened his address with a succinct statement of the problem. Increased population and economic growth posed rising demands for materials. To meet future U.S. needs for materials required attention to every phase of the materials cycle—supply, usage, and recycling.

A program of action implied first that policy was needed, and second a means of implementing it.

With respect to the materials cycle itself, it was necessary to give more attention to the improvement of performance of products and therefore to the improved performance of the materials used to make them. Attention should be given to life cost of products, safety of the consumer, and meeting consumers needs more closely. Substitute and alternate materials needed study. Energy conservation was an important criterion, and also materials with special properties needed to build new kinds of capital equipment for energy generation.

To achieve better product performance required: new materials, new processing techniques, improved manufacturing and fabricating methods, better nondestructive inspection techniques, and improved design theories and concepts. To stimulate this betterment we should learn how to reward the innovator, to promote cooperation at every step in the development process, and to exploit the scientific and technical resources of industry and Government more fully. There were technical opportunities in many directions, and others on the horizon.

To activate these kinds of actions called for strengthened national materials policy. There were many policy Acts on the books, but they tended to cluster around the supply and disposal ends of the materials cycle. More attention should be given to the middle—to the usage part of the cycle. New policy was needed but how was it to achieve political acceptance? Said Dr. Roberts:

> "Despite the great effort by these groups, until there is a well-defined organizational structure to take the recommendations of advisory groups such as this one and fight for them through the legislative process, I can guarantee that no unified materials policy will ever be established or implemented".

He cited the move in the Executive Branch to construct a new coordinating committee on materials within the Federal Council for Science and Technology. He recognized the existence of the Office of Technology Assessment, and its developing relationship with private industry and technical societies—particularly the Federation of Materials Societies. He saw these developments as evidence of the evolution of an ". . . organizational framework necessary to guide the development and implementation of a unified materials policy. We have to see that framework through to completion if we are to receive the support we need to carry policy and strategy through at the technical level". Then he concluded with a challenge to the conference:

> "The time has come for us, as individuals, as technical managers, as members of influential societies, as concerned citizens, to call for, to participate in, and to implement a national materials policy".

TUTORIAL PAPERS

The purpose of the tutorial papers was to provide a technical information base to help the task forces to deal more knowledgeably with their subjects. There were four of these papers.

Dr. Jack Westbrook: Federation of Materials Societies Interim Report on Materials Information Survey.

Dr. Westbrook noted that some 4,000 questionnaires had been sent out to the materials community and that 668 responses had been received, about evenly divided among university, industry, and Government. The questionnaire addressed information supply and needs within a matrix of materials functions and classes of materials.

The findings to date have been that about nine out of ten respondents judged materials information to be important or highly critical in the conduct of their affairs. The major need was for solid compilations of up-to-date, machine-readable information. There were important needs also for better availability of information, for resolving problems with proprietary information, and for better supply-demand statistics.

The respondents divided about evenly as to whether they preferred a single national information system or a pluralistic network of systems. About half identified gaps in the existing information supply.

Only one respondent in three was concerned with the lack of foreign information.

Nearly all respondents said there was a need for better education in the use of information systems. More than half favored the sharing of the costs of information management among Government, users, and technical societies.

One remarkable fact was that of the 668 responses there were 574 different “prime sources” of information identified.

Less than half the respondents regarded present scope of information systems as good, with many needs not served. Two-thirds spoke of deficiencies in quality and almost half criticized the accessibility of information.

It was also significant that about half of the respondents were critical of the extremely technical language in which information was presented.

In short, it could be concluded that information systems were important and imperfect; and that the needs for improvement were clearly evident.

Sheldon Wimpfen: The International Flow of Materials and U.S. Vulnerability.

The thrust of this report, based on a series of slides describing the dynamics of international trade in materials, was that U.S. minerals supply was falling behind demand and that there was an urgent need to improve U.S. technology of mineral discovery and extraction.

The economy of the United States now requires more than four billion tons annually of new minerals. The 1973 deficit of exports over imports was $8 billion. This lag, further exacerbated by the rise in petroleum prices, threatened to upset gravely the U.S. balance of international payments. There was further reason to be concerned with the prospect of expropriations and forced agreements, competition for world mineral supply, and domestic problems with financing, transport, and environmental quality.

The information base for decisions on national minerals policy was grossly deficient.

Left undetermined was whether the United States could afford to rely on the operation of a free market to determine the flow of minerals, in view of the possibility that it could lead to an increased “dangerous and costly dependence on imports. ”

Ira G. Hedrick: The Designer and Materials Conservation.

This paper recalled with approval the FMS definition of “materials effectiveness’:

> “In the most general sense and in relation to materials use and conservation, it means that in a given application or product, our aims are:
>
> “(1) To develop, select, and design into products materials that most efficiently meet application requirements, that have optimum durability and life, and that are recyclable;
>
> “(2) To process and fabricate materials so as to consume, waste, or disperse the least amount of materials for equivalent performance’.

There were two obstacles in the application by industry of these principles:

> How could the design engineer be trained, equipped, and motivated to implement this shift toward materials conservation?

How could industry be motivated to overcome its “traditional reluctance” to accept new materials and processes?

With respect to the first point, the design environment involved a trade-off between customer appeal and price, The first included appearance, performance, reliability, maintainability, durability, and life. The second included development, overhead, direct labor, marketing, and raw materials.

When materials cost was an important factor, conservation tended to be motivated in design, But when it was not, there were three possible courses: a shift in customer appeal, an introduction of a pricing mechanism to stress the true value of materials inputs, or the introduction of “artificial constraints and controls”. While customer appeal was not easily swayed by logical appeals, the Federal Government as a major consumer could tailor its purchases to materials conservation requirements, and could also influence design codes and general rules. (The speaker regarded this last item without enthusiasm.)

However, the Federal Government could help the design engineer by providing better means to integrate cost into the design process to quantify at that level the “costs and the performance of the building blocks which will ultimately comprise his completed design”.

Another approach was life cycle cost. (For example, first cost was only one-third of the total cost of an automobile to the user.) Choice of materials determined this cost to a large extent.

Dr. Hedrick’s second point dealt with ways to accelerate the utilization of new materials and processes. He noted that the time span from laboratory development to widespread application was on the order of 10 to 15 years. Continuous boron filaments, for example, were reported in 1959; they involved development costs exceeding $400 million over the succeeding 15 years; and now show promise of wide application.

There were four causes of delay: technical, economic, managerial, and contractual. Attention was called to a recommendation of the National Materials Advisory Board for the “. . . establishment of a continuing function under the auspices of an interagency Government organization to assist in providing the necessary guidance, knowledge, and funding for the development of materials and processes which show potential for wide application to national problems”.

Seymour Blum: Materials and Energy Conservation through Recycling.

The time is at hand to find ways to reconcile the traditional motivation of materials recycling for individual profit with the new social motivation to conserve materials and reduce the costly accumulation of space-consuming wastes. A systems approach is needed to plan and direct incremental growth in recycling of materials. Three factors are involved: technological, institutional, and economic. The system will be incomplete without adequate attention to all three items, and their interactions.

For example, recovery can supplement and ease shortages. It can prevent pollution. It can reduce the energy costs chargeable to production of new materials. It can reduce the wasteful use of urban land for disposal sites. The combustible content of the waste stream can be used to generate energy.

There were four broad issues in the national approach to systematic management of solid waste: formulation of national policy, evaluation of alternatives, validation of relevant information about the state of the art, and action for enforcement of the program selected. However, these four issues could not be approached separately; they were closely interconnected and required iterative analysis.

In this approach, the technical ingredients appeared to be most highly developed; the economic, less so; and the institutional, least of all.

N. E. Promise]: International Problems and Opportunities; A Role for the Technical Societies and Many Others. *

Mr. Promisel's paper called attention to the controlling role of materials in many national and international problems, and to the absence of an international institution to provide a focus founded on materials and processes. "There is no such organization, " he said, "able to serve as a knowledgeable and adequate forum or mechanism for discussion, information exchange, mutual planning, international cooperation, or even integrated response to materials problems and needs . . . ."

The world, he declared, can no longer afford "random, incidental, casual, or limited international cooperation'. Among the areas requiring such cooperation were:

Interactions of materials with energy and environment;
Assistance to developing countries;
Shared technological problems;
Information exchange;
Personnel interchange;
Exchange of information on policies, organization, and administration;
A formal mechanism for exchange of critically useful information;
A mechanism to define the world's materials problems; and
A means to mobilize a global effort to solve these problems.

Mr. Promisel called for the formation of a global mechanism for international discussion, to formulate international programs, to facilitate communication, to stimulate advances in materials sciences, to promote appreciation of the importance of materials to national and international policy, and to provide a source of materials expertise to international bodies in other fields.

A suggested approach, in Mr. Promisel's view, would be a six-step operation, beginning with the formation of a U.S. planning group toward an international materials union, the formulation of a plan to engage existing societies as the basis for organization, the enlargement of contacts abroad to form an international planning group, the activation of a related plan for an International Materials Year, the setting of time schedules, and the provision of funding for the enterprise.

*This paper was not delivered at the conference, but was supplied to the editor later. This summary is inset-red at this point for the sake of completeness.

In the absence of Mr. Promisel, it was suggested by Dr. Wachtman, who chaired the session, that a number of the conference participants might be called on to offer their views pertinent to the topic of the role of the technical societies. Six volunteers were invited, and spoke as follows:

D. W. Ballard, Sandia Laboratories

He presented a brief account of a recent conference in England on materials conservation. The conservation ethic, including materials recycling, was stronger in the United Kingdom than in the United States. The British were eager to cooperate with this country by exchange of reports and visits, and by joint international technical conferences.

S. V. Radcliffe, Science and Technology Policy Office

The opportunities for international cooperation among institutions appeared to be increasing. Reference was made to the government-to-government activities of NATO, and OECD, and to the leadership roles in the United States of the National Science Foundation and the Bureau of Mines. One possibility was that the technical societies could mount programs to support these agency activities internationally.

C. M. Cosman, United Nations

Attention was called to the information resources, and international contacts of the United Nations. This institution had as one aim the building of a data base on the materials resources and trade of member countries, and could provide a medium for international contacts among technical societies,

Edmundo de Alba, Science Attache, Embassy of Mexico

The nations of the world, small and large, rich and poor, whether they accept it as a policy or not, are condemned by the circumstances of the world we live in to global interdependence. There must be recognition of this practical fact, and an understanding of its consequences for national behavior.

J. P. Hugon, Ministry of Industry, Republic of France

In the modern world no nation could be self sufficient in materials. While the different nations had different patterns of resources, and differing needs for imported materials, there were many problems of national materials policy shared by all nations of the world, Interdependence was thus both a necessity and the source of wide opportunities for cooperation among nations.

P. J. Fallen, Assistant Science Attache, Embassy of the United Kingdom

Of all major industrial nations, Britain had the largest stake in the development of a global policy of interdependence. It had many institutions that dealt with materials and each of these was searching for options in the orderly global management of the flow of materials.

THE TASK FORCE REPORTS

Task One, Materials Information: The two task forces that dealt with the first task handled it quite differently. One report recognized the need for an institution to survey continuously the adequacy, completeness, and timeliness of U.S. information on materials, and to provide guidance on sources. It called for a study of means to fund information systems. It urged a world survey of the management of materials information— who gathers it and who needs it—leading to creation of a ''world referral center'. With respect to the Federation of Materials Societies survey, the report observed that it confirmed our suspicions concerning the imperfection of our systems, and should not be unduly prolonged; it would be enough to make a modest effort to close gaps in the matrix of coverage.

The other report proposed an elaborate structure in the form of a Cabinet Department for materials in which the information function would be vested. Information was considered essential for decision making in three areas:

Scientific and Engineering Measurements
The Resource Base for Materials
The Production, Consumption, and Reuse of Materials by Society.

Management in each of these three areas would be supported by an information system.

For the first area, it would suffice to build on existing information centers, with shared public/private funding, and with operating standards prescribed by a monitoring activity. The second would be coordinated geographically; it would be grouped into geologic, agricultural /biological, and sea-air information; these functions would be assigned to existing agencies grouped in the proposed Department, with the professional societies providing to each mission their publication and advisory support. In the third area (involving quantitative, economic, industry flow, and market information) the need was for standardization of statistics among agencies, a finer grain of data, and a higher degree of staff professionalism.

With respect to the FMS survey, the task force called it "a very important first step", urged the broadening of its scope to other disciplines, proposed further follow-on surveys, and urged stronger OTA funding support for evaluation of the materials information system.

In the comments from the floor on these two papers it was suggested that fragmentation of functions among agencies was costly, and might justify the otherwise unsupported proposal for a Department of Materials. The question was raised as to whether information was a service function that needed to be intimately attached to all Government and private activities, or whether it could and should be institutionalized (i.e., centralized) in one agency. It was pointed out that the costs of centralizing the management of information were enormous. For example, to abstract and index one document costs $35 to $50 and a national center for materials information would contain many millions of such items. Another question was whether more attention should be given to bibliographic information—the management of author-prepared abstracts—and to the collection of preliminary research findings. Classes of information needed to be sorted out and perhaps separately managed. Specifications and standards were also insufficiently recognized as important classes of materials information.

Task Two, International Flow of Materials: The two reports on this subject established similar goals: generally sound, stable economic growth, human betterment, adequate materials and energy resources, protection of the environment, and adaptability to change. Means to achieve these goals led variously to a number of second-order goals, including general reliance on market forces, acceptance of global trade interdependence and U.S. export of technology for mutual benefit, stockpiling to stabilize materials supply, and a search for an optimum mix of these strategies coupled with conservation and recycling. Timely information on materials supply and flow would be an indispensable element in these second-order goals.

Institutional changes to achieve the desired goals were less explicitly stated. Existing institutions could be better used, both nationally and internationally. Corporations engaged in international trade could be brought into closer functional relationship with the U.S. Government. Other suggestions included a wider information base, protection for foreign investment, a “world” materials stockpile in the form of an “international trade inventory”. The role of the United Nations might be extended to the encouragement of information systems and the establishment of standards for such systems. Obstacles to international cooperation appeared to include differences in patent law, national self-interest and mistrust, disinterest, and shortage of trained manpower.

The issues that arose out of the discussion of these two papers could be expressed in the form of a series of questions:

How effective was research and development in the United States as the source of an exploitable “renewable resource” of technology?

Was international cooperation a credible goal, with the dismal events of the oil crisis in the immediate past?

Were new ideas needed about international financing under conditions of global instability?

What should be done about the issue of growth and what were the trade-offs ?

In other words, how is growth controlled by the marketplace, if it is? And if it is not, can we trust the marketplace?

The discussion ended on a sour note: one conferee declared, “Never have materials been so short, at so many places, at the same time”. And another asked, “What chance have we got to influence international materials legislation when the obviously essential metric system Legislation is rejected”?

Task Three, Materials Conservation through Design: Both reports recognized the opportunity of achieving large gains in the conservation of energy and materials through engineering design. They identified barriers as technical, economic, and institutional—specifically (1) lags in field data and feedback, inadequate scientific knowledge, insufficient characterization of materials, and insufficient technology transfer; (2) the economic tyranny of manufacturing process rigidity associated with rigidity of industrial equipment and practice, consumer resistance to change, and costs and scarcity of capital; and (3) deficiencies in the system for training and educating skilled manpower and other institutional/managerial restraints. Both reports called for innovative motivation toward the acceptance by industry and the public of a “conservation ethic’.

However, at this point the two reports diverged. Each offered some 15 or 20 specific recommendations for approaches to achieve conservation through design innovations but there was remarkably little duplication. Those interested in the opportunities for materials conservation should look to the reports themselves; they are concise, meaty, and creative. Both reports stressed various needs for improved information and technology transfer. Both explored opportunities for Government intervention to promote research, standards, and—through Government purchases—better product design. One interesting proposal was for Government sponsorship of an International Materials Conservation Year.

Task Four, Materials Recycling: The two reports on this task were quite different in content. The “A” report presented a concise discourse on the nature and occurrence of secondary materials and the technology of handling the municipal waste stream. It then proposed Federal, State, and local government action, vigorously pursued, to promote recycling through positive incentives, reduced obstacles and disincentives, improved technology, source separation, control to eliminate unmanageable classes of waste, and the improved marketability of recovered metals. It also called attention to the reduction of waste through improved product life.

The “B” report went directly to the question of action. The cost of water quality should be factored into the waste disposal account. Field data on wastes were poor and unstandardized; improvement was urgently needed. Federal funding could help communities achieve optimum economy of scale in disposal facilities. Other Federal action was needed to help overcome consumer resistance to recycled materials, to continue research and development. “Incentives based on designs which facilitate recycling should be considered”. University courses in waste management and recycling should be considered.

The comments on these two papers were equally constructive. Among suggestions from the floor were these:

It is important to deal with packaging excesses;

Externalities like environment, health, and energy values and savings, should be internalized;

We need to develop standards for recycled materials and to eliminate prescriptive (i.e., "virgin materials") standards and specifications;

The systems concept in waste management should be further exploited;

Freight costs of transporting wastes and recovered materials are still controversial; the issue should be resolved;

Waste paper, the largest component in the waste stream, has many chemical and fuel values (e.g., conversion into alcohols);

Something analogous to the depletion allowance for mineral extraction should be devised for waste recovery processes;

Other countries manage waste recycling better than we do—why not try to learn from them?

Task Five, Role of the Technical Societies: The two reports on this topic were both closely reasoned and analytical. Report "A" distinguished national goals and shared international goals. An example of the former was buying cheap and selling dear. An example of the latter was shared basic research information and educational improvement. International exchange of information was already well in hand. Studies by technical societies could be better coordinated by a National Materials Policy Commission. There was a need to promote closer cooperation between industry and Government, particular y with respect to the achievement of national policy objectives through international exchanges. Technical societies and federations could contribute internationally by the gathering of fundamental scientific information, technical advice in the negotiation of exchanges or sales of technology, assistance in assessments and forecasts of technological trends, targeting objectives of international bargaining, and managing technology transfers. The report did not call for an international federation of materials societies but suggested technical liaisons among national federations. In the transfer of technology nationally or internationally there was no substitute for the face-to-face relationship of the expert possessing the technology and the user seeking it.

Report "B" called for a more self-conscious and defined materials community concerned with meeting human needs of the world. A basic goal was the creation of a global climate to secure the free exchange of materials, goods, and services, The report proposed as an agenda for action:

(1) Improved utilization of energy, fuels, and materials through enhanced effectiveness, extension of product life, and reduction of social costs;

(2) Minimized dependence on imports through substitutions:

(3) Consumer acceptance of "stringencies" and moderation of attitudes toward growth;

(4) Minimized waste and improved recycling.

"Dissemination of information concerning these national objectives should be sponsored through the professional societies by Government and industry . . ."

The report recommended the establishment internationally of "closer links with corresponding engineering and scientific societies to coordinate efforts and improve collaboration". It was therefore appropriate to launch an International Mineral Resources Year. The rest of the report was devoted to an elaboration of this theme, calling upon the conference to support the compilation of an Inventory of Minerals and Materials Societies as a first step.

It was interesting that discussion from the floor centered almost entirely on ways and means by which the proposed International Minerals Resources Year (or perhaps *Materials* Resources Year) might be made a reality. One comment was that the "Materials Community" needed defining. Another was that concurrence and support should be drawn from a wider public, including, for example, the League of Women Voters.

FRIDAY MORNING SPEAKERS

The first speaker this morning was Fred Buttner of Battelle. He offered some interesting insights into ways in which the stockpiling—or as he prefers to call it, the "trade inventory''—concept could be combined with other policies to mitigate and even control shortages of materials. According to Dr. Buttner, stockpiling is one of four tools to combat commodity shortages; the other three are standby capacity, substitution, and recycling. These four can be combined in an effective trade-off system but none is complete in itself. The advantage of a stockpile is that it is instantly available for use in time of shortage. Its disadvantages are cost to buy and maintain, long lead time to acquire, and disruptiveness of markets. Stockpiling fuels would be prohibitively expensive; metals and minerals would be costly but within our capability to stockpile.

Standby capacity also offers advantage of speedy availability on a short lead time. Its disadvantages are large commitment of capital, rapid depreciation through obsolescence, high cost, and industrial disruption.

Substitution reduces criticalness and when used pays for itself, but development of anything even approaching a full system of substitutes for potentially critical items requires a long lead time, much research and development, and—again—high costs.

Recycling has many advantages. It is a pay-as-you-go means of converting exhaustible resources into renewable resources. It conserves energy. But again the technology is incomplete and total recovery is unrealizable.

The solution is to apply all four strategies selectively in a complex trade-off, that will differ for each material according to its special circumstances. Stockpiling is only one of the four tools but it is the keystone of a rational plan for the future.

One possible approach to reducing the cost of the stockpile is—in effect—to monetize it, by using it as a base of the currency.

A value of stockpiles is that they can be used as buffer stocks—the Japanese have already started a national stockpile for this purpose. The principle of buffer stocks is equally appropriate for national or international management. Faced with the prospect of future scarcities of materials and rising prices we could expect stockpiles to gain value. It could buy cheap and sell dear. Moreover, it could be designed to operate insulated from political intervention.

If a number of countries adopted the buffer stocks principle they could work against each other to drive up prices. This risk could be obviated by making the buffer stocks an international enterprise. Its dominant objective would be to "reduce the amplitude of world price fluctuations . . ."

A National (or International) Trade Inventory would benefit consuming countries by normalizing materials procurement on a long-term basis, eliminate sudden shortages, stabilize prices, stabilize national currencies, provide a basis for enlarging investment credit, and improve currency convertibility. It would benefit producing countries by stabilizing demand, prevent sudden surges of demand, stabilize prices, stabilize national currency, provide a basis for enlarging investment credit, and improve currency convertibility.

Dr. Buttner did not mention two other possible applications of the buffer stocks principle: to provide a means of stimulating recycling by the purchase and upgrading of materials recovered from scrap, and to stimulate new mineral development by placing long term contracts to buy materials from newly discovered deposits for future delivery.

Our second speaker this morning was Mr. Yngve Vesterlund, assistant scientific attache, Swedish Embassy. He stressed the need for fairness in international materials management, toward the goal of equality among nations, developed and developing.

Global scarcity of materials, he said, is secondary to the need to achieve a fair distribution of world wealth. Political independence is only a first step. Economic independence must follow—based on permanent national sovereignty over natural resources. This requirement does not preclude economic interdependence for mutual benefit, The multinational corporation tends to undermine economic independence; it must therefore be controlled and held accountable. Foreign aid should be closely integrated with global materials policy. All nations are consumers of materials and supply must be balanced against demand with this fact in mind. International trade must be conducted on a basis of fairness to all participants.

Our third morning speaker was Dr. Victor Radcliffe, of the Science and Technology Policy Office. This is the unit that supports the Director of the National Science Foundation in his recently assumed role as Science Adviser to the President.

Dr. Radcliffe cited several warnings of materials shortages, widely separated in time, in order to pose the question of whether the world had reached a major turning point. The oil crisis was one "triggering" episode. The vulnerability of the United States to supply cutoff or price increase of essential imported materials warranted analysis. Was there indeed a "materials OPEC" threat? His observation was that, while still uncertain, the risk was sufficiently real to justify analysis on two time frames: actions in response to the immediate threat and actions for the long range future.

For the short range, supply vulnerabilities could be eased by a mixed strategy that involved material substitution, process substitution, system modification (i.e., function substitution), and stockpiling.

For the longer term—beyond the year 2000-the question of balancing materials supply and demand is one of employing technology to hold down prices to manageable levels, by both increasing supply and reducing demand.

On the supply side, technological advances would be helped by applied science in mineral occurrence, plant biochemistry, development of new materials and processes, and improved performance of both materials and processes.

Conversely, demand could be eased by conservation in materials selection, hardware design, materials performance, and materials recycling.

Dr. Radcliffe concluded his remarks by raising the question as to the appropriate role of the Federal Government in dealing with national materials policy. He cited both the National Commission report and the COSMAT report as useful guidance on this question. Together they offered suggestions for sound Government action for both the short- and the long-range future problems of meeting materials needs effective y.

A FEW CONCLUDING OBSERVATIONS

For me this has been a rewarding and instructive conference. I shall leave here with a great many more ideas than I had when I came. The virtue of bringing together a hundred concerned and knowledgeable people for a week of discussion is that everybody has a chance to contribute and to learn.

The themes that I heard debated were:

How can we improve our national management of materials information?

How can Government and industry achieve closer cooperation?

Can we reconcile the ideas of coordination and pluralism in our various materials programs?

How can we achieve the widest possible acceptance of the Conservation Ethic?

What shall we do about Growth?

Are materials becoming more scarce or is it the materials-energy-environment complex that is deteriorating?

How can we invoke the systems approach at every point in the Life Cycle of Materials?

What sort of national institution do we need to collect, manage, and apply materials information?

Should we aspire more strongly to the consolidation of materials information on a global basis?

Is international cooperation possible in the field of materials? Or conversely,

Is it a fact, as one of our conferees suggested, that we are "condemned to interdependence" so that we should make the best of it?

POSTSCRIPT*

THE MATERIALS PROJECT OF THE OFFICE OF TECHNOLOGY ASSESSMENT

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In his remarks at the beginning of this conference, Mr. Emilio Q. Daddario, Director of the Office of Technology Assessment (OTA), described the early stages in the development of the OTA Materials program. In the following five months, this program has continued to develop.

An assessment on materials information systems is now underway. Assessments are also being designed in the areas of: a) national stockpile policies, b) resource recovery, materials recycling and reuse, and c) institutional constraints on domestic mineral accessibility. Further assessments on other aspects of the cycle of materials use, including conservation of materials and conservation of energy through more effective materials utilization are under consideration.

These assessments were developed in response to Congressional requests. The House Science and Astronautics Committee, which has since become the House Science and Technology Committee, made a broad request. In their first letter, dated January 22, 1974, Chairman Teague and ranking minority member Mosher emphasized four areas for possible OTA study including a technological data base for Congress and research and development programs to lessen United States dependence on importation of critical materials. In their second letter, dated December 13, 1974 they specifically requested studies of 1) materials information systems, 2) national stockpile options, and 3) reuse of materials.

The Senate Commerce Committee, in a letter from Senator Magnuson dated January 24, 1974, requested studies of the solid waste problem

*Added January 1975.

**On assignment from the National Bureau of Standards.

including I) reduction of waste at the source, 2) recycling and resource recovery, and 3) energy recovery.

Representative Morris Udall, a member of the Technology Assessment Board, in a letter dated September 19, 1974, raised several questions to be answered by assessments:

"What means do we have to deal with impending resource scarcities? What kinds of roles will such methods as substitution of new materials for scarce ones, rationing, altered pricing systems, reuse and recycling. new efficient production technologies and new regulations governing land use play under these conditions?"

Senator Ted Stevens, a member of the Technology Assessment Board. requested a study of mineral accessibility in a letter dated November 6, 1974.

In addition to the interest in materials shown by these specific requests to OTA, there is widespread Congressional interest in Materials.

As Chairman of the Senate Commerce Committee, Senator Warren Magnuson in a letter dated January 15, 1975, endorsed a request by Senator John Tunney for a study of means of conserving materials through reducing wastage of materials by reducing corrosion and other wastage processes. Senator Magnuson asked for: " 1) an assessment of the kinds and amounts of materials wastage; 2) techniques for reducing wastage; and 3) technical and institutional impediments to applying these techniques, "

Over 140 separate bills on Materials were introduced into the 93d Congress in the areas of Materials management, Materials recycling, Materials shortages, and Materials stockpiling. One bill which subsequently became law established the National Commission on Supplies and Shortages. This new commission is required to make recommendations

> "with respect to institutional adjustments. including the advisability of establishing an independent agency. to provide for a comprehensive data and storage system. to aid in examination and analysis of the supplies and shortages in the economy of the United States and the rest of the world. "

In addition, the Commission is required to report on

> ''necessary legislative and administrative actions to develop a comprehensive strategic and economic stockpiling and inventories policy which facilitates the availability of essential resources."

The development of materials assessments is being assisted by a Materials Advisory Committee Chaired by Dr. James Boyd, former Director of the United States Bureau of Mines and former Executive Director of the National Commission on Materials Policy. The committee members are:

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The OTA Materials Advisory Committee studied the technical urgency of various aspects of the total Materials cycle, the legislative interest, and the feasibility of assessment. On the basis of these factors they recommended that OTA carry out a technology assessment in each of the following areas:

1. Devise Materials Information Systems for Reliable Input to Policymaking.
2. Establish a National Stockpile Policy.
3. Stimulate Efforts to Hasten Materials Recycling.
4. Develop means to encourage and assist manufacturing industries to use materials in fabricating products employing materials more effective! y.
5. Manage materials so as to conserve energy, but in a manner to minimize economic and social dislocation.
6. Expand and strengthen domestic minerals industry.
7. Stimulate education, research and development in the mineral extraction and processing fields.
8. Assess the interaction of environmental concerns with effective utilization and production of materials.
9. Manage materials so as to conserve materials, but in a manner to minimize economic and social dislocation.
10. Examine land use in relation to laws regarding mineral exploration and production.

The OTA staff, assisted by the Materials Advisory Committee, next proceeded to prepare work statements for the four assessments mentioned previously. These were chosen from the Committee's list as those of highest immediate Congressional interest and were submitted to the Technology Assessment Board and Technology Assessment Advisory Committee for their review.

The first assessment, on Materials Information Systems, will evaluate pertinent features of these systems in terms of their past, present and expected stages of development. Major deficiencies in the existing information systems will be identified and alternatives for their removal described and evaluated. The establishment of a materials information system may call for the creation of a new comprehensive system, expansion of present activities, or the establishment of an institution charged with insuring efficient and effective use of existing systems.

This assessment is designed primarily in response to the request by the House Science and Astronautics Committee but is also designed to assist the new National Commission on Supplies and Shortages. The assessment is now underway. Pertinent portions of the Henniker Conference, including the results of the FMS Materials information survey, will be used. An interim report is due on February 21, 1975, and a final report on November 15, 1975.

The second assessment. on national stockpile policy, will examine the attributes and consequences of alternative national stockpile policies. The possible uses of a national stockpile for broader purposes than the limited national security purposes for which the "Strategic and Critical Materials Stockpile" was established, will be assessed.

This assessment is expected to begin in February, 1975: the final report will be due in late summer of 1975.

The third assessment, on resource recovery, materials recycling and reuse, will examine the institutional barriers to, and incentives for, achieving substantial resource recovery from urban refuse using the best current technology. To accomplish this task. assessments of interrelationships among (1) technology requirements, (2) economics, (3) institutional barriers and incentives, and (4) social factors will be made. The assessment will include consideration of barriers to policy-making and to decision-making as well as to operational implementation of resource recovery technology.

The fourth assessment, on institutional constraints on domestic mineral accessibility, will consider the potential effects of modifying the structure of Federal laws and other institutional factors affecting the accessibility of domestic mineral resources. This study will include consideration of all steps leading to and including the application of technology for the purposes of mineral exploration, development, extraction, processing. and delivery.

In developing detailed plans for each of these assessments, OTA has drawn upon relevant portions of the Henniker conference proceedings which have been very useful. It is anticipated that these proceedings will continue to be very helpful in the continued development of OTA'S Materials program.

VI. APPENDIX

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D. MacInnes
N. Matthews
M. F. McFadden
G. Murphree
D. Novick
V. Radcliffe
C. Spencer
Y. Vesterlund
S. Wimpfen
E. Woods

TASK THREE (A)

P. McWethy, Chairwoman

S. Blum
K. Boland
W. Coster

TASK THREE (B)

J. Harwood, Chairman

D. Ballard
M. Bever
W. Blum

W. Flanagan
C. Ford
G. Frohnsdorff
A. Gray
K. Higbie
J. Hugon
J. Johnson
H. Leavenworth
T. Leontis
C. Lieberman
L. Macdonald
A. Purcell
K. Reimann
C. Spencer
H. Witthoft

F. Buttner
F. Celli
R. Doell
R. Goldhoff
R. Harmon
M. Hoch
R. Jones
B. Lichter
R. Marshalla
H. Pebly
R. Pry
T. Schlabach
W. Tyler
E. von Wettberg
D. Vieth
G. Watson
J. Zerbe

TASK FOUR (A)

M. Bever. Chairman

H. Cannon
R. Doell
P. Fallen
M. Flemings
H. Gunther
J. Harwood
M. Hoch
E. Horowitz
D. Lieberman
N. Matthews
G. Murphree
F. Smith
Y. Vesterlund
E. von Wettberg
Mr. W. Walsh, Jr.
Mr. J. Zerbe

TASK FOUR (B)

C. McFarland, Chairman

S. Blum
H. Bullis
N. Carlson
C. Graham, Jr.
E. Hess
K. Higbie
J. Hugon
P. McWethy
C. Lieberman
A. Purcell
K. Reimann
S. Schilling
L. Sharpe
J. Wachtmann, Jr.
Mr. H. Witthoft

TASK FIVE (A)

D. Ballard, Chairman

J. Boyd
M. Coler
R. Goldhoff
C. Gravatt
E. Hess
R. Marshalla

TASK FIVE (B)

W. Walsh, Jr., Chairman

E. de Alba
B. Conlin
C. Cosman
W. Coster
W. Dresher
C. Ford

M. McFadden
R. Pry
V. Radcliffe
W. Tyler
D. Vieth
J. Wachtsnan, Jr.

G. Frohnsdorff
M. Malin
R. Marvin
F. Meadows
I. Servi
D, Vincent,
J. Zerbe