Resolving Some Selected Issues of

A NATIONAL MATERIALS POLICY. 1973.

Resolving Some Selected Issues of

A NATIONAL MATERIALS POLICY

Papers Delivered at an
Engineering Foundation Conference on
NATIONAL MATERIALS POLICY
July 30–August 4, 1972
at New England College, Henniker, New Hampshire

These proceedings were prepared at the request of
Hon. H. CALEB BOGGS
U.S. Senate

by

THE SCIENCE POLICY RESEARCH DIVISION
CONGRESSIONAL RESEARCH SERVICE
LIBRARY OF CONGRESS

December, 1972

February 1973

U.S. GOVERNMENT PRINTING OFFICE
WASHINGTON : 1973

THE LIBRARY OF CONGRESS

Congressional Research Service

WASHINGTON, D.C. 20540

December 29, 1972

The Honorable
J. Caleb Boggs
United States Senate
Washington, D.C.

Dear Senator Boggs:

With your support, Franklin P. Huddle of the Science Policy Research Division, Congressional Research Service, accepted the invitation of Dr. Sandford Cole to organize a second Conference on National Materials Policy, under the sponsorship of the Engineering Foundation. This conference was held at New England College, Henniker, New Hampshire, during the week of July 30 - August 4, 1972. A number of pressing issues of national policy were assessed by the conferees, and a considerable effort was exerted toward reaching agreement on ways to resolve them.

Subsequently, you communicated to Dr. Huddle the wish that he assemble these findings in a form suitable to be made generally available, as was done after the 1970 Henniker conference on materials policy. The following pages have been compiled in response to this request.

It is hoped that this collection of statements and studies on materials policy will be useful to the Congress. It is to be understood, of course, that the Congressional Research Service accepts no responsibility for the substance of recommendations evolved by the various task forces reported herein, and that the individual statements remain the responsibility of their authors. It is also hoped that the role of the Congressional Research Service in assembling these items in this form will prove to have been a constructive one.

Sincerely,

Lester S. Jayson

Lester S. Jayson
Director,
Congressional Research Service

THE LIBRARY OF CONGRESS

Congressional Research Service

WASHINGTON, D.C. 20540

December 29, 1972

The Honorable
J. Caleb Boggs
United States Senate
Washington, D.C.

Dear Senator Boggs:

With your support, Franklin P. Huddle of the Science Policy Research Division, Congressional Research Service, accepted the invitation of Dr. Sanford Cole to organize a second Conference on National Materials Policy, under the sponsorship of the Engineering Foundation. This conference was held at New England College, Henniker, New Hampshire, during the week of July 30 - August 4, 1972. A number of prepared papers on national policy were presented by the conferees, and a considerable effort was exerted toward reaching agreement on ways to resolve them.

Subsequently, you communicated to Dr. Huddle the wish that he assemble these findings in a form suitable to be made generally available, as was done after the 1970 Henniker conference on materials policy. The following pages have been compiled in response to this request.

It is hoped that this collection of statements and studies on materials policy will be useful to the Congress. It is to be understood, of course, that the Congressional Research Service accepts no responsibility for the substance of recommendations evolved by the various task forces reported herein, and that the individual statements remain the responsibility of their authors. It is also hoped that the role of the Congressional Research Service in assembling these items in this form will prove to have been a constructive one.

Sincerely,

Lester S. Jayson
Director,
Congressional Research Service

U.S. GOVERNMENT PRINTING OFFICE
WASHINGTON : 1973

PREFACE

This is a report of the second conference on National Materials Policy sponsored by the Engineering Foundation at Henniker, N.H.

The conferences of the Foundation are intended to develop information on emerging technical problems of national importance.

Participants are usually selected to provide an audience having considerable expertise in the subject matter before it, with some admixture of persons having advanced skills and experience that can be helpful in the analysis of the subject.

It is not customary for verbatim reports to be made of papers, statements, and recommendations developed at these conferences. Accordingly, the task force findings presented in chapter III are not intended for attribution; they stand on their own as findings, each set of which approximates the views of 10 to 15 persons after 1 day's exposure to a problem statement. The reports are an opening up of problem areas, and do not purport to be the last word on the subject.

However, it should be added that each statement was twice exposed at the conference to an assembly of all participants, and some of the statements were modified on the basis of this review. No strong dissent emerged on any of the points offered, which suggests that they warrant some measure of respect.

The three formal presentations to the conference offer the views of individual spokesmen for three agencies: the Department of the Interior, the National Bureau of Standards in the Department of Commerce, and the National Commission on Materials Policy. They deal respectively with national minerals policy, economic opportunities in new technology, and the philosophy of the Materials Commission.

These three presentations provided a basis for the final review of the conference findings at the closing session. The general discussion at this final session can perhaps be epitomized as follows:

> An optimal balance should be sought between national self-sufficiency in materials and a balanced global sharing of supplies to meet the demands of nations. Materials should be managed intensively rather than extensively, with throughput replaced increasingly by the closed cycle of recovery and reuse. Emphasis should be on quality rather than on quantity. Flexibility of means should replace a sedulous orthodoxy in the design and implementation of effective national programs in materials. Internal dislocations and external interruptions in materials supply will require perceptive forethought and resourceful action, both coordinated nationally.

PREFACE

This is a report of the second conference on National Materials Policy sponsored by the Engineering Foundation at Henniker, N.H.

The conferences of the Foundation are intended to develop information on emerging technical problems of national importance.

Participants are usually selected to provide an audience having considerable expertise in the subject matter before it, with some admixture of persons having advanced skills and experience that can be helpful in the analysis of the subject.

It is not customary for verbatim reports to be made of papers, statements, and recommendations developed at these conferences. Accordingly, the task force findings presented in chapter III are not intended for attribution; they stand on their own as findings, each set of which approximates the views of 10 to 15 persons after 1 day's exposure to a problem statement. The reports are an opening up of problem areas, and do not purport to be the last word on the subject.

However, it should be added that each statement was twice exposed at the conference to an assembly of all participants, and some of the statements were modified on the basis of this review. No strong dissent emerged on any of the points offered, which suggests that they warrant some measure of respect.

The three formal presentations to the conference offer the views of individual spokesmen for three agencies: the Department of the Interior, the National Bureau of Standards in the Department of Commerce, and the National Commission on Materials Policy. They deal respectively with national minerals policy, economic opportunities in new technology, and the philosophy of the Materials Commission.

These three presentations provided a basis for the final review of the conference findings at the closing session. The general discussion at this final session can perhaps be epitomized as follows:

> An optimal balance should be sought between national self-sufficiency in materials and a balanced global sharing of supplies to meet the demands of nations. Materials should be managed intensively rather than extensively, with throughput replaced increasingly by the closed cycle of recovery and reuse. Emphasis should be on quality rather than on quantity. Flexibility of means should replace a sedulous orthodoxy in the design and implementation of effective national programs in materials. Internal dislocations and external interruptions in materials supply will require perceptive forethought and resourceful action, both coordinated nationally.

CONTENTS

CONTENTS

I. INTRODUCTORY SESSIONS

CHARGE TO THE CONFERENCE

F. P. Huddle

Two years ago, while the National Materials Policy Act of 1970 was pending, we held a conference here to develop themes that would be of concern to a National Commission. The papers delivered at that conference were collected and made available as a congressional committee print, and have been useful to the Commission as we had hoped. Some of this gathering participated in the 1970 conference.

Since then, as the prospectus for this conference has indicated, there have been a number of important developments in materials policy. Those responsible for these developments are here to contribute and to listen to the contributions of others with important thoughts to offer. I refer to the membership and staff of the Commission, and staff members of the Departments of Interior, Agriculture, and Commerce—including the National Bureau of Standards—and the National Science Foundation. Also present here are representatives of the National Materials Advisory Board and the Committee on the Survey of Materials Science and Engineering of the National Academy of Sciences-National Research Council.

Unlike the last conference which was mainly a forum for the presentation of prepared papers, this one will be a working conference, in which everybody here will be called on to participate in the analysis of problem statements. This conference was proposed by the Engineering Foundation on the presumption that because the National Commission on Materials Policy would be in its final year of operation the time would be ripe to expose its thinking to a substantial and well qualified group of experts, and to review some of the major issues with which the Commission was concerned.

I agreed to chair this conference, and late last year convened a steering committee consisting of the following:

Dr. Earl Hayes, chief scientist, U.S. Bureau of Mines and Chairman of the Interdepartmental Council for Materials, of the Federal Council for Science and Technology.

Mr. James Owen, director of materials, Department of Commerce, on loan to the Commission.

Dr. Harold Paxton, director, Materials Research Division, National Science Foundation.

Dr. Alan Chynoweth, assistant director for Materials Research, Bell Telephone Laboratory.

494-649 O—73——2

Dr. Victor Radcliffe, professor of materials sciences, Case-Western Reserve University.

Mr. Nathan Promisel, executive director of the National Materials Advisory Board, National Academy of Sciences and president, American Society for Metals.

Dr. John D. Morgan, Jr., Mineral Analysis, U.S. Bureau of Mines.

This steering group prepared a list of persons to be invited, prepared a conference prospectus, identified problems to be taken up by the conference, and helped to prepare a set of terms of reference on these problems. Staff assistance was provided by the Bureau of Mines, the National Bureau of Standards, and the National Commission on Materials Policy.

The plan for the conference will be as follows. The opening day will be taken up with presentations by spokesmen for the National Commission on Materials Policy; by a series of discussions by persons associated with the Committee on the Survey of Materials Science and Engineering; by a speaker from the National Science Foundation; and by a representative of the U.S. Bureau of Mines.

The speakers today will be Dr. James Boyd, director, and Charles J. Ryan, assistant director for policy development, of the Commission; Dr. Victor Radcliffe for Professor Morris Cohen of Massachusetts Institute of Technology (regrettably absent by reason of illness), Dr. Walter Hibbard, Dr. Fred J. Wells, Dr. Richard Claassen, and Mr. Promisel who have all been active in the Committee on the Survey of Materials Science and Engineering; Dr. Paxton, director of materials science for NSF; and Dr. Hayes, chief scientist of the Bureau of Mines.

Tuesday and Wednesday will be taken up with studies by task forces. The plan is to divide the conference up into eight task forces, and each will spend 1 day on each of two tasks. The coordinator of the task force program will be Dean Reed Powell, director of the Division of Research, College of Administrative Sciences, Ohio State University. The eight topics to be examined by the task forces (each of which will be assigned two topics) will be as follows:

1. Central Government Planning and Coordination: Where in the Federal Government should there be a top planning and coordination body for national strategy in materials? What should be the scope of its function?

2. Opportunities and Responsibilities Facing Private Industry in the Materials Field: Is there a need to restructure the traditional role of private enterprise so as to strengthen the national response to the challenges and opportunities of a national materials policy?

3. International Competition and Cooperation in Materials: What U.S. policies are appropriate concerning reliance on overseas supplies of materials in view of rapidly advancing competitors and also the changing policies of developing countries?

4. Research and Education: What should be the roles of research and education in improving the national position in materials and materials management?

5. The Effective Application and Management of Knowledge: How can information, documents, data, and analytical studies be managed as knowledge resources in support of national materials policy?

6. The Closed Cycle Flow of Materials: How can improved management of materials be reflected in enhanced value of the materials flow throughout the cycle and reduced volume of wastes that deplete flow through the cycle?

7. Demands, Rights, and Responsibilities of the Consumer: What burdens on the consumer are implicit in the concept of improved management of materials, altered patterns of materials availability, and internalization of environmental costs?

8. Economic Opportunities and Constraints in Materials: What are the possibilities and limitations of the free market? What are the constraints of foreign trade? What actions are needed to strengthen the responsiveness of the corporation? What can a national policy for materials contribute?

The task forces will make their reports to the entire conference on Thursday, with open discussion. Thursday evening we will have three invited speakers: Hollis M. Dole, Assistant Secretary (Minerals Policy), Department of the Interior; Lawrence M. Kushner, Acting Director, National Bureau of Standards; and Jerome L. Klaff, Chairman of the National Commission on Materials Policy.

Friday, there will be a series of short papers or informal talks: by H. W. Pfeffer, of the Canadian Department of Industry, Trade, and Commerce, Minerals Branch; Philip B. Yeager, counsel, Committee on Science and Astronautics; and Jerome Persh, Chief of Materials Research in the Office of the Director of Defense Research and Engineering. The conference will close with a recapitulation by the chairman of what the conference has accomplished.

The following communication was read to the conference by Dr Boyd:

COMMUNICATION TO THE CONFERENCE FROM SENATOR J. CALEB BOGGS

July 26, 1972

Dr. Franklin P. Huddle
Congressional Research Service
The Library of Congress
10 First Street, S.E.
Washington, D.C. 20540

DEAR MR. HUDDLE: May I take this opportunity to ask you to express my very best wishes to the Engineering Foundation Conference, "Some Problems of National Materials Policy."

The Conference you conducted on behalf of the Foundation 2 years ago served as an excellent base for the progress since then. The information and views developed at that meeting, I believe, were most helpful in winning subsequent passage of the National Materials Policy Act, and in providing the Commission with a considerable amount of useful source material.

With the Commission well on its way toward the publication of its report, next week's Conference should have equal importance and value. The Conference will, I know, have a positive influence on the Commission's work, clarifying further the issues involved in its evaluation of a national materials policy.

The Congress and the Nation are awaiting with interest the results of the Commission's work.

I wish you and the other members of the Conference every success.

With high personal regards and best wishes, I am

Sincerely,

(Signed) J. CALEB BOGGS.

JCB:hbi

PROGRESS REPORT: ACTIVITIES AND PLANS OF THE NATIONAL COMMISSION ON MATERIALS POLICY

James Boyd (Abstract)

The purpose of the National Materials Policy Act of 1970, Title II of the Resource Recovery Act, approved October 26, 1970, is

* * * To enhance environmental quality and conserve materials by developing a national materials policy to utilize present resources and technology more efficiently, to anticipate the future materials requirements of the Nation and the world, and to make recommendations on the supply, use, recovery, and disposal of materials * * *.

Under the act, a Commission (the NCMP) was to be appointed to—

Make a full and complete investigation and study, for the purpose of developing a national materials policy which shall include, without being limited to, a determination of—

(1) national and international materials requirements, priorities, and objectives, both current and future, including economic projections;

(2) the relationship of materials policy to (A) national and international population size and (B) the enhancement of environmental quality;

(3) recommended means for extraction, development, and use of materials which are susceptible to recycling, reuse, or self-destruction, in order to enhance environmental quality and conserve materials;

(4) means of exploiting existing scientific knowledge in the supply, use, recovery, and disposal of materials and encouraging further research and education in this field;

(5) means to enhance coordination and cooperation among Federal departments and agencies in materials usage so that such usage might best serve the national materials policy;

(6) the feasibility and desirability of establishing computer inventories of national and international materials requirements, supplies, and alternatives; and

(7) which Federal agency or agencies shall be assigned continuing responsibility for the implementation of the national materials policy.

Pursuant to this act, members of the Commission were appointed and confirmed; funds (about $2 million) were appropriated by the Congress; and a staff (some 10–12) was recruited and housed. But it became obvious at the outset that the large assignment to the Commission could not be completed by the due date (June 30, 1973) with in-house resources. Doubtless, it was the intent of the Congress that the Commission should constitute itself a coordinating mechanism to elicit advice and muster help from all elements of the materials community. This the Commission and its staff proceeded to do.

An Interagency Steering Committee representing all interested Departments of the Federal Government was convened, and its members serve as a link between the Commission and relevant Government agencies. Next, the Commission went to the National Academy of Sciences and the National Academy of Engineering; three studies have been commissioned and these are to be completed for the program in the fall of 1972.

Contact was made with the industrial community by sending out some 250 letters in the fall of 1971, inviting statements of problems and proposed solutions. Further discussions are planned, both with management and labor organizations and qualified individuals from the industrial community.

The Commission has also sought the advice of the academic community. Eight regional conferences have been held at eight universities: at UCLA, Stanford, Colorado School of Mines-University of Utah, University of Texas at Austin, University of Minnesota, MIT, Pennsylvania State University, and Georgia Institute of Technology. The results of these university forums are to be described by Mr. Ryan, the next speaker.

I would conclude by urging the staff of the Commission and those present at this conference to keep an open mind—to "keep loose" as the saying is. We are confronted with a heavy weight of responsibility to help the President and the Congress to find answers to big problems. Only by maintaining a flexible attitude, and a willingness to lay aside old dogmas, to recognize the existence of new problems and the need for new solutions, can we hope to fulfill the charge to the Commission. We need all the help we can get, and we are grateful to those attending this conference for their willingness to contribute their thoughts.

THE NCMP UNIVERSITY FORUMS

Charles J. Ryan

The eight university forums were originated to profit from the thoughts and advice of the academic and intellectual community concerning issues and possible solutions of the Nation's immediate and long-term materials problems. The forums were held in May and June of 1972.

The subjects discussed in this report are those which were covered at the forums. The conclusions are those of the participants and do not necessarily reflect the thinking of the Commision. Many technical papers and discussions served to highlight the policy questions. However, this report covers only the policy aspects and considerations of the forums.

The period since World War II is characterized by extensive worldwide industrial development, increased per capita income and per capita consumption of materials in the industrialized countries, and population growth, especially in the developing countries. This development, which is sometimes referred to as the second industrial revolution, was stimulated by consumer demand, defense needs, and the reconstruction of industrial capacities destroyed in the ravages of war. When increasing demand for raw materials persisted after the postwar boom, the sources of material supplies shifted incrementally from developed nations to the developing countries. While the developed countries accelerated their development rates and increased their industrial and other productive activities which contributed to the phenomenal growth of their economies and standards of living, the developing world, with a chronic shortage of development capital and technology and an ever-increasing burden of population, diminished in relative importance in world economic affairs. While accounting for 70 percent of world population, the developing countries command about 18 percent of the world economy and about 7 percent of material consumption, whereas the United States, with about 6 percent of world population, commands about 28 percent of the world economy and about 40 percent of world material consumption.

The unparalleled scale and rate of growth of this period was accompanied by an ever-shrinking world through communications and technology. These two factors almost totally changed the pre-war modes of economic and social concentration and distribution; and these changes had an enormous impact on the world of materials.

Changes in transportation and the nature of political alliances have created a world market for raw materials. Mineral ores are being moved half way around the world today to refineries and smelters, and finished products move all over the globe to countries of different political systems with hardly a word being said, as it was 20 years ago, of dealing with friendly nations of the free world. With the advent of the multinational corporation, the internationalization of production is an operating reality. The nations of the world have become increasingly interdependent, especially with regard to materials. The

movement toward de facto interdependence, tends to suggest policies along the lines of internationalism, while there still remain forces tending toward isolationism, "fortress America," and greater development of domestic supplies.

Japan, Canada, and Western Europe, who were regarded as trade partners in the past, are becoming more and more regarded as trade competitors, not only in finished products but also in raw materials. In some cases they have surpassed the United States in productivity and technological sophistication, and they are gaining a larger share of the world market.

There is also growing cohesiveness among developing countries in raw materials export. This gives them a stronger bargaining position in the seller's market which has been created by long-term increases in demand.

As U.S. demand for raw materials has increased, the issues of self-sufficiency and foreign dependence have been accentuated but in no way resolved by a coherent national materials policy. Things seem to have just "happened" without any governor or guiding principle. Following immediately in the wake of the self-sufficiency/foreign dependence issue are the considerations of balance of payments and trade, national defense, and economic vulnerability.

In the very recent past the most serious problem of environmental degradation has resulted from the volume and kind of materials production in the world. It will become the most important determining factor in the future of supply arrangements.

Because of predicted worldwide increases in population and per capita demand for materials to the turn of the century, the materials system will become even more complex than it is today. The resulting effects on the Nation's economic structure and health, the environment, and social and political life are unforeseeable.

Significance of the Forums

In perceiving the Nation's materials problems, the forums' participants divided into two main groups. The smaller group of the two held that the structure of current policies is sound, and that remedies for the Nation's materials problems can be found through carrying on the same policies, but to a greater degree. In the main this group concluded that there should be much greater reliance on use of domestic sources of supplies because reliance on foreign imports posed a serious threat to the security of the United States. Environmental degradation does not pose as serious a threat to the national welfare for them as does foreign dependence, for example. They tended to focus on questions of increasing supply and supported measures that involved technological solutions. They tended to be less interested in economic and institutional remedies that treated the demand side of the equation. Their ultimate recommendation was to reinforce current practice and policies.

The majority of participants, on the other hand, observed that the world in general, as well as the world of materials, is undergoing vast changes, as witnessed by all of the indicators of past and projected growth. They recognized the empirical causes of growing demand for materials—population and per capita consumption increases, etc. While recognizing the current environmental and social disbenefits of growth and cognizant of some of the predicted disastrous results of continued growth, the group was not against growth per se. The main thrust of their recommendations revolved around greater efficiency and conservation at every point in the life cycle of materials, with particular attention given to mechanisms that will encourage the process of closing the materials life cycle.

Taking materials per se, the largest concern was how to meet the predicted need of the future. This question broke down to the supply and demand sides.

On the supply side, the suggestion was put forward that the United States should make a concerted effort to be self-sufficient, but this proposition did not find much support. Nor did the proposition that the Nation should rely on foreign supplies to the maximum extent. It was generally concluded that the market system is the best means of allocation, with the Federal Government intervening in critical situations involving national and economic security. It was generally agreed that the Federal Government should assist faltering and strategic industries through research and development funds and, in some cases, through relief from antitrust legislation when they were suffering the adverse effects of foreign competition. However, the proponents of free international trade did not subscribe to this position on the basis that the American public should not pay higher prices for domestic goods unless a serious question of national welfare was involved. This led to an inconclusive debate on the changing definition of national and economic security in an increasingly interdependent world.

There were a number of specific considerations and recommendations about securing raw materials from the developing countries. In the main, these were made in recognition of the de facto dependence of the United States on developing nations for raw materials. They noted the need for a change from the attitude that the developing world is dependent on the United States, to one that recognizes the interdependence of nations. Some recommendations addressed themselves to the related, although separate, issue of dealing with the other developed nations of the world which would be competing for the same sources of supplies. Greater cooperation in the development of world resources and free trade were the underlying principles for this set of recommendations.

On the demand side, the forums made a distinction between demand for material commodities and ultimate consumer demand. The ultimate demand of consumers is for services such as shelter, nourishment, transportation, education, medical care, national defense, etc. All of these depend to a lesser or greater extent, mostly greater, on finished

products such as houses, food, cars, school, hospitals, etc. The question of which material commodities (iron, wood, aluminum, etc.) are used to produce these service-rendering products is determined in the market place on the basis of price and availability.

How to meet the projected demand for materials was only one aspect of the supply problem. In meeting the demand, what are the costs and trade-offs in terms of capital investment required, greater foreign dependence, and more pollution? Substantial consideration was given to more efficient and less wasteful means of production so that some pressure could be taken off the demand for materials without reducing ultimate consumer demand. The participants felt that this approach represented a great opportunity for the Nation. Recommendations ran through the report for sponsoring substitutions, application, and design; new materials; more efficient energy conversion, conduction, and conservation; programs to reduce materials deterioration, loss from wear, and incentives against planned obsolescence. The long-term salutary effect which recycling could have on the environment, the conservation of energy, and the municipal solid waste problem was one reason for the unanimous support of recycling by the participants. While there was no general estimate, it was recognized that recycling could have a major impact on long-term supply-related problems. The Government should introduce incentives to create greater markets for recovered materials, and support research and development for recycling technology.

It was concluded that more research and development were needed in new power sources and energy conversion, pollution, new materials, and substitution. Because of the lead time involved, options for tomorrow are created by today's research, and it should be more diversified. Some of the strongest recommendations of the forums revolved around the direction and amount of Federal R. & D. Basic, nonmission oriented research is necessary for the national welfare and is the prime responsibility of the Federal Government. Some types of applied R. & D. which have been carried on in the past should be expanded, e.g., energy, the strategic and mature industries, education, and the earth and material sciences. Some of the newer areas for more intensified work are ecological systems, environmental processes, recycling, material selection and substitution, and the economy.

Environmental questions and considerations were discussed at almost every session. While the recommendations section shows numerous calls for more knowledge, there was also an awarness that societal and political choices have to be made. This process has already started with environmental legislation, especially in the area of regulations. It is the Government's responsibility to monitor environmental damage along with the effect of that damage on people, industry, and on every facet of the society that it touches in secondary and tertiary effects. There was considerable concern for ignorance of how ecosystems work and the effect of materials production and flow through these systems. An equivalent concern was shown for ignorance of the effects of environmental feedback loops on the economy, e.g., the effect

494-649 O—73——3

of regulations on economic dislocation. In addition to more knowledge across the board, the recommendations identified the main economic remedy as internalizing external costs, and the main technological remedies as the creation and application of clean technology. There was strong support for the idea that environmental considerations have to be taken into account at all levels of decisionmaking and planning both in the public and private sectors, and that ultimately environmental costs have to be incorporated into the element of land in the three basic elements of production—land, labor, and capital.

In the absence of complete knowledge, or a complete understanding of the root-causes of environmental degradation, the Government would have to "muddle through" in its effort to mediate between the Nation's need to produce and the need to protect the natural environment. However, it was noted that political choice and goal-setting cannot wait for perfect knowledge.

Recycling won unanimous approval as a source of domestic supply and because of its beneficial effects on environmental quality and energy conservation.

The subjects of the environment, the volume and kind of the materials throughout, and growth were frequently associated. These three subjects were discussed with some uncertainty, especially growth. Growth has been a traditional social, political, and economic credo in America. It has been perceived as having only benefits until recently, when some of it disbenefits, especially those related to environmental and other social costs, have been identified. The specter of the amounts of materials that are projected for the future as a result of population growth and increasing per capita consumption of materials put into question the availability of the earth to provide the materials, and the capacity of the environment to handle the volume of effluent charges that would result from such levels of production. There was greater agreement on the terrestial abundance of materials because of technology and the changing definition of resources than there was on the carrying capacity of the environment. It was suggested and generally agreed that the weak link in the chain of long-range human welfare was not resources, but other factors such as food production, pollution, and psychological strain caused by overcrowding.

In general, uncertainty characterized the discussion on growth because there was no clear agreement on its causes, its benefits and disbenefits, and the feasibility in making changes to the current configuration of growth.

An economic no-growth policy was hardly discussed because it was rejected out of hand. Some forms of selective growth seemed desirable and politically and economically attainable in the near future. The steady-state was discussed as a possible desirable objective at some time in the distant future. There were some strong policy recommendations to start moving in this direction.

Considerations relative to the impact of materials use and policy on equity and the fabric of society were raised. While the linkages were recognized, no clear positions were taken on this question.

Throughout history, materials have been the means of man's individual survival, as well as the means of nations' growing rich and powerful. Man's ever-increasing ability, since his beginning, to refashion parts of nature more to his desires has culminated in a prodigious creation of goods through industrialization in the last 200 years. At the same time, his reproductive capacities have followed the same upward curve. The question is being asked today if the 20th century is not the century in which mankind's productive and reproductive faculties will not be limited by factors such as the earth's size, the carrying capacity of the biosphere, and social organization and behavior. If this is true, the principle of control will be introduced as a new element to the historical tradition of growth that heretofore has been limited only by man's imagination and ingenuity.

In a slightly less grandiose way, and at the national level, this was the main issue of the university forums. Two seemingly conflicting, but not mutually exclusive, goals are operating in the Nation at the same time—the need to produce goods, and the need to protect the environment.

I. Directions for Policy

The broad policy directions which emerged from the forums are:

- The life of the Nation is carried on in a multilevel system which is comprised of geophysical, ecological, technological, economic, institutional, sociopolitical, human, and cultural elements. All of these levels interact and affect one another. Change in one area produces change in another area. Materials are the base of this system. Materials policymaking must use the systems approach in the sense that it recognizes the all-pervasive position of materials in the system and how they affect and are affected by the other elements. The policymaking structure must be adjustable to changing national goals and new situations. Materials policy must be comprehensive in the above sense and coordinate with economic, environmental, foreign, energy, transportation, and defense policies. Laws and taxes must follow national policy, not determine it.
- The commodity approach to materials should be expanded to consider the process through which materials flow, from extraction through processing and use, to disposal and recycling. This approach, called the life cycle of materials, allows for more flexible selection and substitution of materials through regard for their properties and end-use functions. It also shows broader scale problems such as the relationship between inefficiency and waste at the nationwide level.
- Faced with the prospect of either shortages in many materials vital to national needs, or, unacceptably high real and social costs of meeting increasing future demands, two broad courses of action are open. One is to expand supply, accepting the costs.

The other is to reduce materials demand without reducing consumer demand through conservation methods such as recycling, and greater efficiency in materials use by better application, processing, design, and substitution. Both approaches are needed. In the area of energy materials where both demand and the social costs of demand are particularly high, greater efficiency and end-use policies could have an important effect on the supply/demand balance. It was the feeling that recommendations on efficiency and conservation for all materials are well within the current interpretation of national goals and the public good as they are defined today. While the types of economic and institutional change necessary to implement these recommendations would not be easy in every case, they would find substantial support.

- The current structure of private, public, and social costs must be scrutinized and assessed to strike a balance between the two indispensable systems for the Nation's survival and progress, the economic and ecological systems. At least one change is necessary: environmental resources must be factored into the land element of the three basic costs of production—land, labor, and capital.
- Greater Federal R. & D. efforts, some in new directions, are necessary in the areas of materials, environment, and economics to maintain the Nation's current position and to promote its further well being.
- World resources must be developed and distributed with cooperation between the developed and developing world. Competition for resources can lead to serious global problems.
- Man has the capacity to establish and maintain a harmonious, managed, and rewarding steady-state relationship with his evolving system, and should prepare to move incrementally in that direction instead of waiting until he is forced to do so abruptly with possible major dislocations.
- Because materials are the base of world economic activity, materials policy in the long term must recognize questions of equity between rich and poor, both among nations and for citizens of all nations.
- The Federal Government has the most serious charge of mediating the forces of "production" and "protection" to the best interest of the public good.

SOME VIEWS FROM THE MATERIALS COMMUNITY

During the afternoon session of the first day of the Conference, a number of speakers addressed the subject of national materials policy from the point of view of scientific or technological practice. They were invited to discuss such subjects as the rights and responsibilities of the materials community, the identity and organization of

the materials engineering profession, the role of the professional societies, and the methods and tools of this community that would be useful in the development of national policy. Reference was made by some speakers to an ongoing Survey of Materials Science and Engineering (COSMAT) under the aegis of the National Academy of Sciences-National Research Council. Abstracts of their presentations follow.

The Scope of the Survey of Materials Science and Engineering
Dr. S. Victor Radcliffe

During the past several decades, materials science and engineering has become recognized as both a broad field and a specific new concept. The field involves recognition of a commonality of features underlying properties and behavior, and draws on activities and contributions from several established disciplines (solid state physics and chemistry; electrical, mechanical, and chemical engineering; as well as metallurgy, ceramics, polymer science, materials science, and materials engineering). The new concept couples the science and engineering of materials to the functional needs of an engineering design or problem.

The field occupies a key position in the total materials cycle.

The COSMAT study is concerned with the nature of the field, its institutions, its relationship to national needs and materials policy, and its ability to provide options to assist in meeting these needs.

The Importance of Linking Science to Engineering
Dr. Richard S. Claassen

The MSE concept of "purposefully coupled materials science and engineering" has been shown to operate successfully in a significant region of the total materials cycle. Case histories of materials development in both high and low technologies were described to illustrate its operation and applicability.

Materials Institutions
Dr. Walter Hibbard

In materials producing and using industries (other than communications and electronics) with market orientation, property functional characteristics predominate rather than structure properties. The MSE concept is not used.

During recent years of austerity, industrial R. & D. in materials has been severely reduced with respect to long-range research and strongly focused to product and time schedule for marketing. At the same time, industry is facing a variety of challenges from environ-

mental requirements, labor costs, resource limitations, new social orientations, and successful foreign competition in technology. The Federal Government has developed a substantial regulatory role that is affecting the effectiveness of industry as "the engineering arm of society." In the universities, there are about 30 materials research centers and no shortage of trained people. But the research has not connected effectively to industrial application.

A new approach is needed to stimulate industry to face and deal with these new challenges and needs.

Materials and National Goals
Dr. Fred J. Wells

The tendency in developing policy by obtaining a consensus of majority opinion of practitioners is of doubtful value, since their opinion is often based on inadequate facts. Many problems relevant to materials and national goals are researchable and policy developments should be undertaken only after such research (e.g., the problem of long-range scarcity) by independent research organizations to achieve maximum objectivity.

International Activities in Materials
N. E. Promisel

Mr. Promisel said that international activities in materials science and engineering (MSE) add up to a set of operations necessary for success in the pursuit of economic and social well-being on both a national and international basis. Thus it behooves a country, even one such as the United States with a major MSE program of its own, and a marked degree of self-sufficiency in many areas, to be alert to and to cooperate in international MSE activities.

He dealt with seven major activities: general policy, long-range planning, R. & D. programs of new technology, natural resources, education, communication, and standardization.

He covered activities of the International Standards Organization (ISO) and the European materials standardizing group, ALCMA, and their importance to the United States even as a factor in international trade. Then he described the evolution of the Materials Research Advisory Group in OECD (the International Organisation for Economic Cooperation and Development), the formation of which was stimulated to a major degree by the United States. This group has dealt with such important topics as technological forecasting, innovation, the "technology gap", education, biomaterials, helium requirements, the materials life cycle, national policy considerations, and others. The final major international materials group described was the NATO Advisory Group for Aerospace Research and Development. This group is primarily concerned with specific technical topics

related to military technology, such as (in the materials field) advanced composites, nondestructive inspection, fatigue monitoring, fracture, design, and others. Another group in NATO has dealt with long-term projection of opportunities and roadblocks in materials, and their report has been widely distributed throughout the United States.

Based on his relations with these and other international groups and individuals, he offered some general conclusions:

(1) The United States has benefited in some of its technical problems by utilizing many excellent contributors and fresh viewpoints and the special talents and equipment abroad. An intimate, friendly, cooperative international materials community has been built for direct approach for help and information.

(2) National science and engineering are in transition in both character and organization.

(3) Some countries are helping to create new industries or strengthening existing ones by coupling arrangements among universities, semiprivate research laboratories, industry, and government.

(4) Government risk capital is often available in the above arrangements.

(5) There is a major interest in resources supply; this leads him to conclude that the United States can expect supply problems.

(6) New technologies are generating new materials R. & D. needs—e.g., high speed transportation.

(7) Government-encouraged high technology in other countries is increasing their advantages versus the United States.

(8) Effective means for utilization of research results exist, e.g., Max Planck Institutes.

(9) Much of U.S. materials technology has been purchased abroad or based on concepts generated outside this country, especially in process innovation (float glass, continuous castings, BOF steel-making, and others).

(10) United States is ahead in development of university centers for materials research.

(11) Materials information disseminates rapidly abroad to all who can use it.

He concluded by emphasizing that MSE and materials are truly international in character and it is in the best interests of the United States to be an intimate participant in appropriate international activities and by no means a complacent isolationist.

Basic Research in Materials at NSF
Dr. Harold Paxton

The National Science Foundation maintains a variety of materials research programs. With the exception of the RANN program (research applied to national needs), the emphasis is on basic scientific

investigation. Some of the research is concentrated, as in the case of the Magnet Laboratory and the program of Materials Research Laboratory (formerly called the Interdisciplinary Laboratories) which were transferred to NSF from Department of Defense. Other NSF-sponsored researches in materials cover a wide range of subject matter. The primary task of the NSF Division of Materials Research is to identify and find opportunities to sponsor good research. This task, with its strong basic scientific orientation, does not lend itself readily to conversion into problemsolving related to national materials policy. Nevertheless, it is the view of NSF that a healthy program of materials science and engineering cannot be long sustained without the underpinning of a strong basic scientific program in the materials sciences.

National Minerals Policy
Dr. Earl T. Hayes

Pursuant to the Mining and Minerals Policy Act of 1970, the Secretary of the Interior has issued, in March 1972, the first annual report giving the status of domestic and imported minerals supply and requirements, present and prospective. Particular emphasis is warranted with respect to energy materials—coal, petroleum, and natural gas. The growing disparity between what the United States is consuming and producing in these materials—with respect to gas and petroleum—will result in an increasing drain on the U.S. balance of payments and generate a need for vigorous corrective action. Even in coal mining, the various governmental and economic constraints at work have put a halter on domestic output. In only a few mineral materials required by industry are domestic supplies now adequate.

II. ADDRESSES TO THE CONFERENCE

On Thursday evening, August 3, three formal papers were presented to the Conference. At this session, Dr. James Boyd served as chairman. The speakers were the Honorable Hollis M. Dole, Assistant Secretary for Mineral Resources, Department of the Interior; Dr. Lawrence M. Kushner, Acting Director, National Bureau of Standards; and Jerome L. Klaff, Chairman, National Commission on Materials Policy.

REMARKS BY THE HONORABLE HOLLIS M. DOLE

The Mining and Minerals Policy Act of 1970 is a most welcome statement of intent by the Congress, and one of the most attractive things about it is the fact that it is one of the shortest documents ever enacted into law. If anybody here is interested, it contains only 312 words, including the title, which, when you think about it, is quite an achievement for any government body.

In part, the Minerals Policy Act simply restates and gives the force of law to a philosophy of mineral extraction and exploitation that has prevailed ever since the founding of the Republic, and which is implicit in most of the basic mineral laws that are already on the books.

It declares, for example, that it is the policy and interest of the Nation to develop our domestic mineral resources in a sound and economic manner, and that this should properly be done by private enterprise. The Federal Government is enjoined to encourage the development of economically sound and stable domestic mining, minerals, metal and mineral reclamation industries to this end. There is nothing new here, except that it is comforting to see this basic philosophy solemnly reconfirmed by the national legislature at a time when both private enterprise and the domestic extraction industries are being blamed for just about all the Nation's ills that can't be charged up to the military and the oil import control program.

The new aspect—at least in the long-term historical sense—is the emphasis given to environmental protection in the act. Paragraph 4 explicitly calls for "the study and development of methods for the disposal, control, and reclamation of mineral waste products, and the reclamation of mined land so as to lessen any adverse impact of mineral

494-649 O—73——4

extraction and processing upon the physical environment that may result from mining or mineral activities." This innovative language very much belongs in any expression of national minerals policy, because taking care of the environment is of serious concern to the mineral industries, the Government, and the public at large.

The other new item in the act was the specific assignment it gave the Secretary of the Interior to report annually to the Congress on the state of the domestic mining, minerals, and mineral reclamation industries, including an assessment of the trend in utilization and depletion of our resources, and recommendations for further needed legislation.

On March 31, 1972, Secretary Morton submitted the first of the annual reports called for in the act, and this report, a copy of which I have here, will be the basis of my remarks this evening. As you can see, there is a bit more here than I can cover in any detail on this occasion, so that my treatment of its contents must necessarily be in summary form. I propose only to cover the state of the minerals industries in the broadest sense, and to comment on some trends and events which we believe have particular meaning for the future.

I would like to preface my remarks by noting that although the thrust of the report is addressed to the domestic minerals industries, it is quite impossible to discuss them without reference to what is going on in the rest of the world. A strong growth in demand during the decade of the 60's encouraged the mining industry to open many new mines, most of them abroad. This was followed by the worldwide fall-off in business activity beginning in 1969 which dampened demand at just about the time when the production from the new mines was entering the market. So we are in a period of cyclical readjustment which has been typical of the mining industry, and these readjustments are felt earliest and hardest by the high-cost producers—specifically the United States.

We have now begun a period of strong business recovery. For the first half, gross national product expanded by 7 percent—in real terms. Profits were up, savings are up, employment is up—by 3 million workers in the past 12 months. Housing starts are at a record high rate of 2.3 million annually, and orders for durable goods are running 12 percent over last year.

In the face of this excellent outlook for business we could ordinarily expect a revival of investment in domestic mineral production. This is by no means assured, however, because many existing requirements and policies may make it extremely difficult to persuade mineral producers to make long-term commitments in the United States.

Most of these hurdles have to do in some way with the so-called "environmental ethic," which in its nonpolemic form, is simply the requirement that the production and use of goods be accomplished with the least practicable amount of damage to the environment. It is environmental concern in its polemic form, however, that poses the difficulties that now face the minerals industries; the insistence on performance standards that are more rigorous than necessary, to be

achieved under timetables that are too short for the development of the technology needed for suitable remedies; the denial of access or withdrawal from development of mineralized lands; and the restrictions placed on both consumption and downstream production processes which create problems at the source of mineral production. A few case examples will help illustrate what I mean.

Historically, coal has been the dominant fuel for producing electricity, and a significant source of heat and power for many industrial operations. It is being regulated out of these markets because of its sulfur content, but it will be 8 to 10 years before we are able to solve the problem of burning high-sulfur coal without emitting its oxides to the atmosphere. It will be about the same length of time before we are able to turn significant quantities of coal into clean, sulfur-free gas and liquids. So because of this inflexibility in timing of compliance requirements the erstwhile consumers of coal are having to turn to oil to satisfy their needs, and this oil must come from foreign sources because we haven't been able to produce our full requirements for oil since 1967. The result is a significant addition to our already increasing dependence upon foreign sources for petroleum, plus an additional burden on our balance of payments.

The nonferrous metal industries share this sulfur disposal problem, which appears when the ore is reduced to the basic metal at the smelter. The displaced sulfur in the ore combines with hydrogen or oxygen to form off gases from the smelting process and the removal of these gases from the effluent creates cost problems that the industry has not been able to surmount. One direct result is that whereas there were 14 zinc smelters operating in 1969, only seven are in business today, and one of these is scheduled to close next year. This means that by the end of 1973, zinc smelter capacity will be down to 740,000 tons as compared with 1,300,000 tons in 1969. We have historically imported something over half our zinc supply, with well over half these imports being ores and concentrates. The large reduction in our smelter capacity will mean a proportionate increase in the import of finished metal and a consequent further burden on our balance of payments.

Copper is also having its difficulties with sulfur removal, and while the decline in copper smelting has not been as marked as in the case of zinc, it is entirely possible that we may be short by some 900,000 tons of copper smelting capacity by 1980—well over a third of projected primary demand. Unlike zinc, however, imports have accounted for only a small share of our copper supply until now, so that the shortage in domestic smelter capacity translates almost directly into foregone production from domestic mines. Thus, in the case of copper, we are facing the prospect not only of a qualitative change in the grade of imports—that is, from semirefined to finished copper—but a large absolute increase in imports as such, with all it implies for our exchange position.

This export of processing capacity is of course highly compatible with the objectives of the source countries who would much prefer to sell us the higher-valued metals rather than the basic ores. The aspira-

tion of these countries to become something besides quarries is certainly understandable, but the direct implication is that we are going to become even more hard pressed than ever to find a rational-basis for settling our accounts with other nations. For example, our imports of aluminum and its ores in 1969 amounted to $500 million. Most of it—70 percent—was in the form of basic bauxite; 20 percent was in the intermediate form of alumina, and only 10 percent consisted of the metal itself. If all our aluminum imports that year had been in metallic form the debit to our merchandise account would have been $2.76 billion—five times the actual amount.

We are, in fact, already importing large volumes of processed materials of mineral origin—residual fuel oil, steel, aluminum, chemicals, and like items—to the extent of $6 billion in 1971—half again the value of the raw minerals we imported that year. There is every reason to believe that this gap will widen rapidly unless the requirements for profitable operation of smelters and refineries can be accommodated to the need—the legitimate need—for protecting the environment.

The arrest of normal growth of the minerals industries at the intermediate processing stage is one aspect of the restraints imposed by environmental concern. The exclusion of these industries from access to mineralized lands at the primary extraction stage is another. The fact is, however, that despite the expressed objective of the Minerals Policy Act, mining companies are being barred from highly significant ore bodies that they have actually located and delineated, but which have post facto been made subject to supervening measures alleged to be necessary for the protection of wilderness areas or wildlife. Other lands which may be highly mineralized have been withdrawn or withheld from mineral entry. The difficulties in securing clearance to build the Alaska pipeline are so well known I do not have to recount them here, and the proposals to lease areas of the Outer Continental Shelf for oil and gas exploration have encountered much opposition. Thus, at a time when our mineral needs are increasing, the area available for domestic prospecting is being reduced.

The result of these constraints upon the operations of domestic mineral industries is to force the Nation to go abroad to meet its mineral requirements. But this is occurring at a time when competition for mineral supplies is rising rapidly in response to increased demand from powerful and prosperous trading entities: specifically, the Common Market and Japan. This is particularly true in the case of oil and iron ore. In 1950 the United States consumed half the world's oil and half its steel, and supplied virtually all its needs for these commodities from its own domestic production. By 1971, the United States was consuming less than a third of the world's oil production and about one-fifth of its steel. Foreign sources supplied 25 percent of our oil and 35 percent of our iron and steel in that year. The United States no longer dominates the world market and the terms of trade in which it engages. Instead, it is just one more player at the table, and this fact is made painfully clear to American firms which are bidding for high

grade mineral resources in other lands against multinational groupings, national firms, and consortia operating with the blessings of governments not concerned with our own concepts of antitrust activity.

Meanwhile, down at the sulfur market, the problem is to keep from drowning in sulfuric acid or being buried under mountains of elemental sulfur. In 1970 sulfur recovered as byproduct from other industrial operations comprised about one-fourth the total sulfur supply, and the market even then was in a surplus position. If full compliance with sulfur emission regulations is achieved by 1980, we anticipate that the supply of sulfur could easily be more than twice the projected demand. The entire market could in fact be satisfied by the byproduct sulfur recovered from coal combustion alone in 1980 if scrubbing technology is available to permit its use. The sulfur industry thus faces an outlook of massive, enduring oversupply unless new uses can be developed for vast quantities of its products.

It would certainly be unfair, however, to blame all the ills of the mineral industries on environmental considerations. One of the penalties of affluence is that it becomes increasingly more difficult, as real income rises, to get people who are willing to engage in the dark, dirty, dangerous occupation of mining. The average age of a coal miner in the United States is 48 years. The prevailing condition in the coal industry is that of labor shortage, even though the miner's pay is among the highest of all industries, and many mines are located in areas of substantial unemployment. Mining engineers are an endangered species—there were 138 of them graduated last June, as opposed to 493 in the class of 1951. The question naturally arises as to how soon and at what cost the mining industry could gear up to the task of a large expansion even if all other inhibiting influences were removed.

Uncertainties about Government policies, in addition to those relating to the environmental cleanup, land use, and manpower, also deter investment. These include such items as mineral taxation policies, exploration laws and regulations, and the disposal of stockpile excesses. The potential of cost increases which could arise from new laws and regulations in these areas cause domestic mineral producers to think twice before developing new domestic properties or expanding old ones. There is, after all, nothing very attractive about going into a venture in competition with enterprises elsewhere in the world, with equivalent technology, which work ores three times as rich, pay one-fifth the wages, and are largely free of environmental restrictions on production.

This brings us to another problem the mineral industries face—and they are not alone in this I would emphasize: namely the problem of technological geriatrics. There is a parallel, I think, between our own case and that of England in the last century. The Industrial Revolution began in England in the latter part of the 18th century as you know, and for a hundred years, more or less, England kept a commanding lead over all other nations in the manufacture of goods.

Whatever it was, the English could make it better and cheaper, and they prospered greatly and dominated the world of trade and finance. But the time finally came when other nations began to close the gap, and as they did so the British power and influence began to wane, and they lost their position as number one, and because they didn't try harder, they didn't even end up as number two.

Something like this, I submit, is happening to us. From the end of World War I to a point somewhere in the early sixties the United States was the undisputed master of the technological revolution. During this period, we were the ones who could make it cheaper and better, and it was our products which dominated international trade channels and our money which became the reserve currency for the world. Now the salad days are behind us, and in item after item—shoes, steel, cameras, radios, automobiles, optical goods—our products are not only outsold in other markets, but beleaguered in our own. The fat surpluses we used to run in our merchandise account have disappeared, and in 1971 for the first time in this century, we had a debit balance in international trade.

It was inevitable, I suppose, that the technological gap between us and our competitors should be narrowed. It was not inevitable that it be closed altogether, or that we should inherit all the difficulties we now have in our commercial relationships with the rest of the world. Somewhere along the way we rested on our oars too long, and failed to give the attention we should to upgrading our technology and the efficiency of our industrial processes. As I have indicated earlier, this is a universal complaint, but because mineral costs and availability lie at the base of our economy, the mineral industries have more than their own share of responsibility to be concerned about. At a time when fundamental research affecting mineral production and use should be expanding rapidly it is being cut back, and this criticism extends not only to the Federal Government but to the mineral industries and to mineral science schools as well. As in the case of skilled manpower, the shortage of basic technology may limit the expansion potential of the mineral industries even if other bottlenecks are cleared. We've got to try harder if we even want to be number two.

A number of other criticisms apply. The Minerals Policy Act needs an organization capable of implementing it. No such organization exists in the fragmented structure of the Federal bureaucracy, although Congress has had President Nixon's proposals to create a Department of Natural Resources for more than a year. The transport system for moving mineral resources is barely adequate to the task of today and pitifully inadequate for that of tomorrow. The particular need here is for large, modern, deepwater terminals to accommodate the supertankers and giant bulk ore carriers that are being built. Sometime, somehow, we are going to have to recognize that our own laws and regulations are seriously handicapping the ability of American companies to deal with competing firms abroad which are under no such regulations. We need a whole new perspective on the role of the American private venture corporation in the multinational environment of the present and the future.

As I mentioned at the outset of my remarks, I have only had time to hit the highlights of the Secretary's first annual report to the Congress on the state of our domestic mineral industries. The Department of the Interior is in the process of developing recommendations aimed at solving some of the problems raised in the report to which I have alluded to this evening.

But the picture I have attempted to sketch for you should be clear. We should not obscure the all-important fact that we face increasing difficulties over the long term in meeting our mineral needs. To illustrate the magnitude of these mineral needs, the report emphasizes the growing reliance on foreign sources of supply and demonstrates that the gap between our supply and our demand has risen from $2 billion in 1950 to $8 billion in 1970, and is projected to increase to $31 billion in 1985 and $64 billion in the year 2000. Nor should we miss the point that although domestic mineral production is carried on by scattered, isolated, relatively little-known operations, it is the basis for all our power and prosperity. Like a great inverted pyramid, our trillion-dollar-a-year economy rests upon a narrow base of raw materials valued at no more than 3 percent of our gross national product. But we need to remember that dollars are the language of accountants, not engineers, and that the relevant counting units are not dollars but tons—billions of tons of stone, sand, gravel, iron ore, coal, copper, oil, zinc, lead, sulfur, potash. The truth is that our entire material existence, and all our hopes for enhancing it, depend upon our mineral wealth, and upon those industries which convert it to our beneficial use. And that is the real message I earnestly hope you receive from what I have said to you this evening.

ABSTRACT: "TOWARD A NEW NATIONAL SCIENCE AND TECHNOLOGY POLICY," REMARKS OF LAWRENCE M. KUSHNER

Any consideration of a materials policy for this country must be consistent with the overall national science policy which is emerging in this administration. Several factors have gone into the shaping of that policy, and I shall describe those factors for you.

The central theme of this science policy was expressed by President Nixon in his State of the Union address in January:

> "In reaching the moon, we demonstrated what miracles American technology is capable of achieving. Now the time has come to move more deliberately toward making full use of that technology here on earth, of harnessing the wonders of science to the service of man."

Two months later, in his science and technology message—the first of its kind by an American President—Mr. Nixon listed the imperatives that he sees for the future:

- Drawing on the great reservoir of technological skills we have created.

- Seeing that the environment for innovation is favorable.
- Maintaining the spirit of curiosity and adventure that has always drawn us to explore the unknown. "Basic research * * * today is essential to our continuing progress tomorrow * * * *"

President Nixon also said:

> "The progress we seek requires a new partnership in science and technology—one which brings together the Federal Government, private enterprise, State and local governments, and our universities and research centers in a coordinated, cooperative effort to serve the national interest."

President Nixon further identified two principal strategies for achieving these goals:

- New Federal incentives to increase private investment in technology development and applications.
- Direct government support for research on projects to improve everyday life.

In the 1973 budget, there are specific programs under these guidelines. Interestingly, they do not show very large expenditures compared to what we usually think of in Federal R. & D. The reason for this effect is twofold: keeping the Federal budget as tight as possible, and getting as much of the new technology development as possible from the private sector. Specific increases are included in the 1973 budget for new ways of generating power without harmful environmental effects; for research into natural hazards such as fires, floods, and earthquakes; for pollution-free transportation; and for those facets of NASA's program which have direct civilian application—weather and resource mapping, communications, aircraft, and research.

In addition to this direct research, the administration is proposing new efforts to stimulate private R. & D. Included are such proposals as cost sharing, liberalized government policies regarding patents resulting from Federal research, and providing Government R. & D. on a cost plus basis.

The transfer of Government R. & D. to the private sector has generally been small. These new programs, all under the close scrutiny of the Office of Management and Budget and the Office of Science and Technology, are intended to make transfer more likely.

Experts disagree on the benefits of many tactics often put forward for encouraging private R. & D. Tax writeoffs for R. & D., for example, are held by some to encourage innovations in accounting and in the definition of R. & D. rather than innovations on the production line. Many believe that accelerated writeoffs for capital investment would be a minor contribution because capital investment is far more related to the general economic climate than to taxes. The Department of Justice maintains that antitrust laws are not a serious inhibition to cooperative research.

So the programs which are being tried will be cast along more innovative lines. They will, for this reason, be rather tentative and exploratory. The notable exception to this principle will be the liberalization of Federal support to small business investment corporations for technological ventures.

One of the more experimental programs is the one in which the National Science Foundation and the National Bureau of Standards are cooperating to identify barriers to private sector technical development and to try to determine what the Government can do to help overcome them. This is a $37.5 million program of experiments in which new forms of cooperation between the Government and the private sector will be explored.

At NBS, this program is called the experimental technology incentives program (ETIP). We will be working with individual companies, groups of companies, trade or industry associations, research institutions, universities, and State and local government agencies on experiments for improving the generation and use of new technology in industry. Criteria for evaluating the proposals for experiments will probably include, but not be limited to:

- Definition of the specific mechanism or incentive to be investigated
- Magnitude of the initial impact
- Probability that the project will become self-sustaining after the Federal involvement ends
- The potential for replication in other industries and institutions
- The likelihood of technical success
- The adequacy of techniques for evaluation
- The time schedule for completion of the project and for realization of the impact

We expect the most valuable result will be not the technology developed, but what we learn about the ways in which the Government can stimulate technology development and use in the private sector. The ETIP program is now getting underway, and we expect to solicit the first proposals in September or October, depending on when Congress acts on our appropriation.

It is appropriate to ask what has stimulated the administration's current thinking on science policy. There are some clearly identifiable influences. Major among them is the report "The United States in the Changing World Economy" done last year by the now Secretary of Commerce, Peter G. Peterson, when he was with the White House staff.

Peterson analyzed the declining U.S. position in the world trade market. He pointed out that the U.S. share of the world GNP is shrinking as is the U.S. share of the world's export trade. Worst of all, the U.S. trade balance has turned negative for the first time in this century. This emphasizes the importance of maintaining our traditional strength in the trade of high technology products; and yet even in these areas, the competition from Japan and Western Europe is increasingly severe. Peterson has traced this decline and the poor performance of the United States in recent years to the low rate of productivity increase in the United States compared with the rest of the world. He focusses on lagging investment in technology development and application in our private sector—not only in manufacturing—but in the service areas as well.

494-649 O—73——5

The result of this thinking in the administration has been the assignment of new responsibilities to the Department of Commerce, including the ETIP program at the National Bureau of Standards. Other new initiatives by the Bureau include a $40 million 5-year program to aid industry in the development of superconducting electrical generators and a significant increase in support of the NBS fire research and safety program.

What do these new directions in administration thinking mean to the development of a national materials policy? It means we must emphasize improving U.S. competitiveness in the world economy. It means that along with stressing materials development for desirable social and economic purposes and materials resource conservation and materials recycling, we must be concerned with the economic impact of proposed programs. We must structure them for maximum participation by the private sector. We must take advantage of the special strengths of the U.S. free-market, competitive system.

REMARKS BY JEROME L. KLAFF, CHAIRMAN, NATIONAL COMMISSION ON MATERIALS POLICY

Our meeting chairman, Dr. Frank Huddle, who has planned and coordinated main topics and work sessions of this conference so expertly, has kindly suggested that I present a philosophical overview of the work of the National Commission on Materials Policy and the materials problems of our Nation. Before proceeding, however, I want to thank you for your contributions to the conference.

Naturally, when one presents an overview, one must also define the vantage point from which these views are formulated. The National Materials Policy Act clearly indicates that national interest comes first, but in making our studies and soliciting information and opinions, our Commission seeks and enlists the aid of the following diversified sectors of the American society.

- The general public as consumers, and those concerned with the environment
- Labor
- All levels of government
- Industry
- Academia
- The science and technology community

From your work thus far, I am sure that you are all aware of how many of these sectors are represented at these sessions. Speaking again of the vantage point, our Commission has to exercise fair judgment in appraisal of inputs by contributing sectors.

We are looking at the life-cycle of materials as they flow through the Nation's economic and ecological systems and we are looking at the energy needs to maintain that flow. If the Commission is going to suggest a coherent and comprehensive policy to the President and the Congress, materials, energy, and the environment cannot be treated

in isolation one from the other. Materials and energy are the driving forces of the Nation's economy. A wise and more efficient use of resources and technology, as our act suggests, can lead us to the type of environmental quality that America is seeking.

While national interests are paramount, we are specifically instructed by law to study international materials requirements, priorities, and objectives in formulating materials policy. The world demand for resources is increasing at a much greater rate than our own.

In defining the vantage point of our overview, we must ask ourselves: What are our goals? What are we shooting for?

During the last 2 years many able men in Government, industry, the academic community, and public groups of various types have testified at Senate and House hearings on future requirements for energy and materials. While a multitude of goals have been specified, major objectives seem to be simplified to four basic targets:

1. Conservation of materials, and preservation of the environment.
2. Adequate materials and energy for national security.
3. Adequate materials and energy for our economy.
4. Materials and energy policies that will stimulate social progress.

In the time that remains, I would like to confine my comments to two subjects that have a bearing on deliberations related to materials:

1. The rapidly changing world in which we find ourselves, and its significance to policy makers.
2. Point 1 of the previously suggested goals—conservation of materials and preservation of the environment.

After World War II America produced goods at the highest rate that the economy would permit using the common goods of air, water, and land without regard to the social costs of these "free" commodities and the pressures that municipal, industrial, and consumer waste were putting on us. Today, when we look at the costs of cleanup, we are amazed at our lack of foresight.

On the international side of the picture, we have become more and more dependent on foreign sources and we have little guarantee that this will not be the case in the future.

Twenty-five years ago, the United States was the preeminent industrial nation in the world. Today, our position is being challenged. Four major industrial areas of the world are nearly as big or rapidly approaching our size industrially: the U.S.S.R., Japan, Western Europe, and China. For the first time in recent history, our steel production has been outpaced—by U.S.S.R. in 1971, and Japan threatens to do so within the next 5 years. These growing industrial areas are now competing with us vigorously for raw materials.

The free flow of energy fuels and metals from foreign sources to our shores which has helped support our economy, can no longer be taken for granted. Developing nations hold a commanding position in petroleum and copper resources and they are exercising an influence on

consumer nations through market restraints, taxation, nationalization, confiscation, and price boosts.

In the words of then Assistant to the President for International Economic Affairs, Peter G. Peterson, "We begin with the premise that the formulation of sound policy must start by asking the right questions. The old policies were based partly on early postwar realities, and sometimes reflected lags between changes in these realities and the world's perception of those changes. The central fact of the past 25 years had been the conviction—ours as much as that of other countries—that the United States was dominant, both in size and competitiveness, in the international economy and that the practices, institutions and rules governing international trade and payments were structured to fit that fact. We as a nation and the world as a whole were too slow to realize that basic structural and competitive changes were occurring; as a result, international policies and practices were too slow in responding."

The exploding range of products required for transportation, communications, defense, and consumer goods has not only increased in volume, but also in number. In the thirties, commercial metals, nonmetals, and fuels required for industry totaled a few dozen. Today, more than 90 mineral materials extracted from the earth are required by industry.

In the thirties, for instance, titanium metal was a laboratory curiosity. Today it's an important metal on every large commercial and military plane that flies. Aluminum has surpassed copper in tonnage as a major nonferrous metal. Add to this the multitude of plastics being developed from petrochemical materials, and the wide range of fibers derived from chemical, forest, and agricultural sources, and we come up with an extremely complex array of materials requirements for industrial society.

The industrial community which was formerly concerned with efficient and profitable production of materials and manufactured products, must now devote a large part of its time to Government involvement in business and industry. Superimposed on this complex, we find ourselves unavoidably involved in problems of consumerism and environment, which leads me to point 2 of my concluding remarks.

Conservation of Materials and Preservation of the Environment

Conservation of materials, and preservation of the environment are intimately involved in the objective and assignments of the Commission as specified in the Resource Recovery Act of 1970. A dozen references in the act specifically mention "environment, air and water pollution, and public health," and the terms "waste, solid waste, recycling, and resources recovery" are mentioned more than 75 times in the act.

Waste and materials production, manufacture, and use are inseparable. The entire cycle of producing materials from the ground,

processing them, manufacturing goods, and using the end products involves waste. Plants producing chemicals, paper, food products, and manufactured goods all produce waste in one form or another.

Statistics released by the President's Council on Environmental Quality and the Office of Consumer Affairs during 1970 and 1971 indicate:

1. Solid wastes piling up in the United States total 4.3 billion tons annually including agricultural.

2. Americans are spending $4.5 billion each year to get rid of waste, and unless we want to wallow in trash we will have to increase this by an additional $835 million annually.

3. Only 40 percent of waste nonferrous metals, 19 percent of waste paper, and 17 percent of available textile wastes are being recycled each year.

Citing statistics such as the foregoing, the Honorable Martha W. Griffiths of Michigan has introduced legislation in Congress to encourage a significant increase in use of recycled solid waste and reduce depletion of critical natural resources.

With growing population, expanding industrialization, limited resources, and world competition for materials, we can no longer afford the luxury of waste to the extent that we have in the past, particularly because waste contributes to the degradation of the environment.

From a philosophical viewpoint, how do we attack this problem? It all boils down to materials management. Basically, we should be conservationists, placing heavy emphasis on recovery of materials from solid waste and recycling materials. If we do that effectively, we will automatically achieve environmental goals to a large extent, and reduce the strain imposed by our requirements of materials from primary sources.

In making this observation, I do not want to imply favored emphasis on the recovery of secondary materials over the production of materials from primary sources, because the secondary industry derives its source materials from the primary industry. However, we must appraise the balance between these two materials sources with greater precision than we have in the past.

Repeating again that we cannot afford the profligate waste levels of yesterday and today, we will have to intensify our efforts to improve technological methods of solid waste recovery; and wrestle with economic underpinning contributing to sporadic shifts in markets and prices that impede the secondary and recycling industries today.

In resolving the problems of balancing production of primary materials with recovery from solid waste; and in equating the aims of those who are concerned about the quality of the environment with the unenviable position of those who have to dig raw materials from the ground, manufacture goods and products, or produce energy, we must avoid polarized and emotional attitudes that result in frozen or uncompromising demands, rather than rationalized solutions.

In conclusion, I would like to relate the observations of a world famous California scientist who speculated that some thousands of

years hence, archaeologists digging into the ruins of civilization would come up with three conclusions:

- Those Americans were always going places—from the thousands of miles of fossil roads, and railway tracks.
- Those Americans must have been awful thirsty—from the myriads of glass and plastic containers encountered.
- Those Americans must have been very wasteful—from the tons of materials unearthed in fossil city dumps.

Let's hope that with respect to the latter observation, we will be able to make a better impression on the archaeologists of the future.

III. TASK FORCE REPORTS PREPARED BY THE CONFEREES

This section of the proceedings consists of 16 brief statements of findings in response to eight sets of problems. The conference, during the second and third days, was divided up into eight task forces and each task force addressed itself to two of the eight problems, one on each day. At the conclusion of the evening session, a clean copy of findings was prepared by each task force chairman, reproduced, and distributed to all conference participants.

On the fourth day, each task force chairman reported to the assembled Conference, giving the highlights of his report, and inviting comments from the floor. On the basis of these comments, some of the statements were further amended before being turned over to the Conference chairman. A general invitation was extended to all task force chairmen and to all participants to communicate further with the Conference chairman if they desired to modify, amplify, or qualify these statements in any way. Some participants availed themselves of this opportunity.

The statements are reproduced here in essentially the form they reached by the close of the Conference. They have been lightly edited to remove minor imperfections, and a few were shortened for conciseness.

The format of the following section is that the eight problem statements are presented in sequence. Each is followed by the two task force reports responding to it. These are then followed by a brief editorial comment that attempts to reflect the tenor of the floor discussion and the extent of apparent consensus arrived at. However, no participant in the Conference need consider himself committed by the editorial addition; it is intended to be tentative and suggestive but neither complete nor definitive.

It should be remembered that the reports each represent a 1-day conference effort by eight or 10 people. The findings and recommendations should be viewed as tentative and preliminary. Some of them are internally inconsistent. The purpose of the exercise was to identify important national issues of materials policy, and to explore their relationships with a selected group of principal problems. It is possible, of course, that some of the recommendations will stand up under further analysis. But it is important that they meet the test of further analysis.

Task One: CENTRAL GOVERNMENT PLANNING AND COORDINATION

Where in the Federal Government should there be a top planning and coordination body for national strategy in materials? What should be the scope of its function?

Rationale.—In 1952, the Paley Commission called for an organization "near the top of the administrative structure" to collect facts and analyses, review them, and "recommend appropriate action for the guidance of the President, the Congress, and the executive agencies." It would devise responses to changes in industrial technology, consumer demands, conditions of overseas supplies, and patterns of conservation, reclamation, and disposal of waste materials. In 1972, the problems are different, but no less important. The question looms as to whether the goal should be an emphasis on self-sufficiency or on positive diplomatic efforts to assure least-cost supplies from abroad; whether to strive for high levels of industrial output or higher quality and longer-lasting products; whether to achieve least-cost disposal of wastes or aim at efficient closed-cycle management of materials with least waste. Nearly 50 Government agencies have functions relating to these issues. How are they to be given leadership, direction, and coordination?

Issues for Consideration

(a) What should be the nature, extent, and limitation of the Federal role in assuring adequate materials supply?

(b) Are there important elements of Government action in the sense of providing public guidance and leadership without invoking sovereign authority, that are important for the implementation of a national materials policy?

(c) How can the executive branch develop and present a complete, balanced, and coordinated strategic plan and program encompassing national materials management as a totality?

(d) What are some possible trends or challenges involving national materials policy to be anticipated in the future, and that might require alterations and adjustments in the national stance?

(e) What are the limitations on feasible and practicable exercise of top leadership in the field of national materials policy?

(f) What would be an appropriate response for the National Commission on Materials Policy to make to the assignment in the act that it make a "determination of"—"(7) which Federal agency or agencies shall be assigned continuing responsibility for the implementation of the national materials policy."?

(g) How should the Commission respond to the charge that it should determine "means to enhance coordination and cooperation among Federal departments and agencies in materials usage so that such usage might best serve the national materials policy"?

Report A

A permanent policymaking body should be established by legislative action within the Federal Government for planning and coordination of national strategy in "materials" as defined by title II of the Resource Recovery Act of 1970. While a Department of Natural Resources would appear to be the ideal solution, more immediate action is required. To insure action in a reasonable period of time, a council or agency with policymaking authority similar to that of the Council on Environmental Quality should be established at the White House level, which would rely on subordinate agencies to carry out its studies and policy directives.

The council or agency should be empowered to require information to acquit its responsibilities and should have funds to pay for the costs incurred in generating the required data. It should be empowered to tap all data banks pertaining to materials and should provide services to the public in the area of information about materials research, materials properties, and materials availability, but without compromising the proprietary interests of individual enterprises.

In view of the major role the council or agency will play in the future economy and in view of the extensive power and expertise the complex must have, the details of its structure, authorities and objectives should be designed by an organization having an indepth expertise and knowledge in the science of government.

Presumably, in the event that a Department of Natural Resources was created, the question could be reviewed as to the desirability of incorporating in it the functions, or the council-agency, discussed above.

Report B

Assumption

A national materials policy which aims at providing a complete and balanced plan for the wise application of materials in the attainment of national goals, and promotes more effective coordination among Federal agencies and departments, industry, academia, and other institutions will serve the public interest.

Findings

No existing Federal agency has the responsibility for developing a national plan and program encompassing national materials management as a totality.

Recommendation

A single new agency should be established in the Federal Government through legislation to:

(1) Administer and implement the national materials policy;

(2) Provide and update the national materials plan for the

494-649 O—73——6

efficient utilization of materials including assurance of a continuing supply of materials, their optimum conservation, recycling, and reuse;

(3) Encourage and support efforts and programs intended to resolve major materials-related problems which are not receiving sufficient attention elsewhere;

(4) Promote effective coordination among Federal agencies and departments, industry, academia, and other institutions concerned with materials;

(5) Gather and analyze data and information while assuring that all institutions and groups with a stake in materials have access to present their views and positions to the Government;

(6) Exert influence on international aspects of materials problems—supply, standards, cooperation on environmental matters, and exchanges of technology.

Editorial Note on Task Force One

In the discussion from the floor on this topic several points were stressed. The question was raised as to whether the proposed Department of Natural Resources could serve the purposes recommended. It appeared to be the sense of the meeting that this prospect was remote because legislative action to create the proposed Department would be complex, difficult, and politically delicate.

Emphasis was placed on the need for centralized aggregation and analysis of data, coupled with planning and the funding of precautionary research and action programs. The organization envisioned would coordinate rather than operate. It would not draw to itself all the present materials functions of government, but would coordinate them from an adequately authoritative level.

Task Two: OPPORTUNITIES AND RESPONSIBILITIES FACING PRIVATE INDUSTRY IN THE MATERIALS FIELD

Is there a need to restructure the traditional role of private enterprise so as to strengthen the national response to the challenges and opportunities of a national materials policy?

Rationale.—The *ad hoc* committee report, Toward a National Materials Policy, in proposing creation of the National Commission, recommended that its objectives should include "[maximizing], to the extent permitted by the constraints essential to the national interest, the opportunities for free enterprise to function efficiently in the materials field." This language was repeated in the Report of the Senate Committee on Public Works on Title II—National Materials Policy Act of 1970, of S. 2005. It is thus a part of the legislative history of the act creating the Commission. It raises questions as to the opportunities and responsibilities of private sectors, national policies toward these sectors, and what the Commission might usefully say about them.

Issues for Consideration

(a) What actions might private industry be stimulated to take in support of a national policy for materials?

(b) What constraints on private enterprise might be anticipated as being "essential to the national interest"?

(c) What other constraints today inhibit or hamper the efficient operation of free enterprise in materials-related activities?

(d) How and in what areas should there be and can there be an expanded view of corporate responsibility vis-a-vis profit motives, capital investment, and national goals? What are the key opportunities and responsibilities facing private industry in the materials field?

(e) Can subsidies, taxes, or "negative taxes" be used effectively to reorient industry toward emerging national goals in materials—as for example to encourage recycling, reduced generation of wastes, recapturing of pollutants, and the like?

(f) In the relations of industry with the various levels of government, are the best opportunities for constructive action offered at the national, State, or municipal level, or perhaps at a regional level, or is perhaps some combination of these necessary?

Report A

Responsibilities of Industry in the Materials Area

1. Develop and apply new technologies which conserve resources, reduce environmental degradation, and increase productivity.
2. Inform the academic community and the Government of its important materials problems.
3. Cooperate in generation of the data base on material supplies and trends in usage.

Policies

1. Changes in Government regulations and controls which affect materials production and usage should be made on time scales compatible with the time needed to comply with those changes.
2. For sections of the materials industry which are highly segmented the Government should encourage joint support of R. & D. to achieve economy of scale (e.g., relief of antitrust action).
3. The Government should use its own purchase and demonstration projects to support the use of new materials and technologies which achieve longer life, make less demand on resources, and minimize undesirable byproducts.

Recommendation

A national institution (probably joint Government-industry) be established for evaluation of new materials, particularly with respect to long-life properties.

What we have in mind here is a mechanism by which an originator or supplier of a new material can furnish to prospective users an impartial authoritative evaluation of that material for certain applications. Submission of material would be voluntary. The proposed institution would have no authority to set specifications or regulations.

Special emphasis should be placed on developing techniques for prediction of long-life performance. Definitive prediction requires detailed understanding of the aging mechanisms and therefore presses sorely on our fundamental understanding of material interaction with its environment and use.

A judicious combination of the Federal Government with private industry aided by the academic community should offset the two most common complaints of evaluation efforts; (a) that industrial associations are self-serving and (b) that Government agencies are interfering with the prerogative of private industry.

Report B

The role of private enterprise is to furnish goods and services for the consumer in such a manner as to receive a reasonable return. If private enterprise assumes the role of promoting self-interests and seeks to take advantage of its position, the Government of necessity will intercede through regulations and controls to protect the rights of the public. In this interface of Government versus industry, some flexibility in the formulation and application of regulations and controls can help to improve implementation of the controls, particularly where existing technology is to be modified or replaced by new technology. The acknowledgement of the above suggests no need to restructure the traditional role of private enterprise.

Positions

(1) Private industry can act to stimulate a national policy for materials by taking action to assist in estimating the future material needs by obtaining information from secondary uses on the projected materials needs. In addition to the industrial requirements for future materials needs, the educational needs of industries, in terms of manpower and areas of specialization, should be formalized and channeled to appropriate agencies and institutions. Consideration should be given by industry to assisting in the setting up of uniform standards and specifications for materials where needed, such specifications to be based upon the intended use (properties) rather than by composition.

(2) Constraints on private enterprise are likely to arise in the areas of mandatory recycling of materials and proper disposal of waste. In addition, constraint on usage to conserve reserves and the placement of industries at geographic locations based upon the nature of the materials being utilized by an industry should be considered.

(3) Other constraints that inhibit or hamper the efficient operation of free enterprise in materials-related activities might include health and safety requirements for employees and the general public. The allocation of materials based upon needs (national interests in brownouts, or materials for the home owners versus industrial applications) is likely to become a constraint on the freedom of action of industry.

(4) Corporate responsibility must include cost accounting that includes the realization that environmental impairments caused by corporate action must be corrected. After an operation has ceased in a locale, the environment must be restored by action that provides clean air, reforesting, and the disposal of acid water wastes, while promoting clean streams, etc. A policy should be evolved whereby technology and knowledge can be transferred within an industry. Thus, in the event that a company makes a breakthrough in the utilization of materials that are strategic or in short supply, this technology should be disseminated to the industry as a whole. Shifts in materials utilization are anticipated based upon changes in present specifications to those based upon properties, thus facilitating the application of substitute materials. There should be encouragement to generate new materials as supplements or alternates for critical materials, and the development of new technologies to increase the recovery of materials not now recovered. Private enterprise should be encouraged to develop new technology for exploration of new and undeveloped areas including the beds of the oceans and ultra-deep mines.

(5) Industry and individuals respond to the opportunity to make a profit; thus, subsidies, taxes, or negative taxes will be most effective in stimulating industry towards the emerging national materials goals. Efforts that are likely to be successful in increasing exports should be encouraged by subsidization of the needed technology. The origin of the subsidies, whether from the consumer or from the Government, should be considered. There should be a tradeoff in incentives that encourage high utilization of a material that can be recycled by incentives that encourage recycling the material. The point was also made that where possible, rather than seeking Government subsidy, industry should permit the market to work. In the encouragement of industry to recycle materials an additional incentive lies in the profit to be derived from the economic utilization of the so-called "waste" byproducts. Where necessary, technology should be developed to assist in the efficient utilization of recycling and the reduction of waste. Industry should also assume a responsibility for educating the public to the need to assist in recycling and the elimination of waste.

(6) Insofar as a national materials policy is concerned, the relation of industry with Government will best serve public purposes on a national level. However, regardless of the level of Government involved, jurisdiction should be clearly established in order that industry, as well as the public and the selected level of Government knows where to look for direction. Where feasible, the use of regulations to control the utilization of resources might be more desirable

and effective than incentives and therefore should be explored as a policy matter. But where solutions to pollution problems are not known or are uneconomical, or where a regulation sets requirements that are too high, industry should acknowledge the lack of technology and work with the appropriate agencies and/or institutions to seek solutions to these barrier problems. Regulations should be practicable in that the time constant must be of sufficient duration to render a feasible solution. That is, industry should not be oppressed by unreasonable regulation to perform according to standards that go beyond the existing state of the art.

Editorial Note on Task Two

Floor discussion of the reports on this task centered on the question of the feasibility of institutionalized quality control, industrial, national, or international. Advantages claimed were that such a service would facilitate user acceptance of new materials, provide a data source for new materials, encourage development of technology for accelerated life testing, and facilitate international trade. However, the sense of the discussion appeared to be that the disadvantages of the concept outweighed the putative advantages. Experiments with the concept had proved unsuccessful because manufacturers of materials resisted governmental evaluation of materials.

It was noted that there was (or might be?) accreditation of materials in the Common Market, and that the United States should be prepared to deal with this exigency to sell successfully abroad.

Several alternative approaches were discussed, such as a mixed public-private institution, or a system for the publication of comparative information provided by private industry.

The plastics industry—including paint and adhesives—was cited as an area in which there had been rapid progress and product acceptance without institutionalized certification of quality.

The damping or arresting effect of building codes on technological progress in the construction industry was also cited.

Then, too, it was suggested that too broad a scope of function had been proposed for the "institution." It would be of decisive importance as to where the testing function would be performed, by whom, and according to what test methods.

In summary, it was agreed that the recommendation was too sweeping, that the matter warranted much more study before reaching any conclusion, and that the discussion should be cited as a part of the record on this problem.

Task Three: INTERNATIONAL COOPERATION AND COMPETITION IN MATERIALS

What U.S. policies are appropriate concerning reliance on overseas supplies of materials in view of rapidly advancing competitors and also the changing policies of developing countries?

Rationale.—European and Japanese demands for materials are rising very rapidly on a per capita basis. Developing countries elsewhere, traditionally the principal suppliers of raw materials, are increasing consumption and also upgrading them at home before export to secure the advantages of adding to their value. Tendencies toward economic nationalism are widely evident and increasing. While the United States is still an important producer of raw materials, it is increasingly dependent on world supplies for materials other than foods, and is almost totally dependent on some of the more important materials (chromium, manganese, nickel, and tin). Potentially, the high level of technological development of the United States affords an opportunity to increase the degree of interchangeability of materials. But competition for materials is growing, supplies from overseas are increasingly in question, and the economic security of the United States, to the extent that it depends on materials from abroad, is thereby in jeopardy.

Issues for Consideration

(a) Which philosophy should the United States pursue toward international efficient development and conservation of materials—one of competition or cooperation? Or should there be a mixed strategy?

(b) Should there be a strong positive effort toward economic autarky in the field of materials, or a strong positive effort toward diplomatic and other bargaining measures to improve the dependence of foreign sources, or some combination of these?

(c) Might some equitable allotting mechanism be evolved among producer and user nations, assuming an international structure of cooperative resource development could be worked out?

(d) In view of the proposition that the profit motive is an important impetus for raw materials exploitation, but not the only one, how can worldwide productive capacity be managed to bear a realistic relation to worldwide demand?

(e) What are the key differences in national policy as between the United States and Japan or Germany; and do the policies of these other countries give them a competitive advantage in the international materials market? What are the implications of the answer to this question for U.S. policy in the future?

(f) What is the role, and what should be the role, of the multinational corporation in the global flow and utilization of materials?

(g) What is and what should be the role of the national stockpile with respect to international competition and cooperation in materials?

Report A

I. Assumption	*Consequence*
National goal is continuation and improvement of quality of life in the United States.	Sustain and increase supply and use of materials and materials technology, at least to match population increase.

Relevant Materials Policy Alternatives (for different international climates)	*Consequences*
1. Move toward complete self-sufficiency in supply	(a) Price increases inevitable—both financial and "external" (environment and energy); (b) Need strong investment in mineral exploration and R. & D. for innovative technology (including alternatives for materials and technologies); and (c) Minimize consumption of materials by optimizing design, minimizing material waste, and maximizing recycling.
2. Strive for self-sufficiency for only those materials whose price is comparable whether obtained domestically or abroad.	(a) Price increase likely, but not inevitable; (b) Some risk of weakening security; (c) Foreign exchange needed for purchases; and (d) Need strong investment in mineral exploration and in R. & D. for innovative technology (including alternatives for materials and technologies).
3. Conserve United States supplies of nonrenewable resources for future needs (beyond the year 2000) by seeking to obtain currently needed materials from abroad, in the open market, and supported by appropriate diplomatic and trade agreements.	(a) Must identify "reserves" in the United States, and *not* exploit (stockpile in the ground); and (b) Price increase likely.

II. Assumption	*Consequence*
World Goal is continuation and improvement of quality of life globally.	Sustain and increase supply and use of materials, and materials technology, for benefit of all people.

Relevant Materials Policy (United States)	*Consequence*
Provide materials and technology to other nations, consonant with achievement of our National Goal, to help them develop their resources and improve their welfare.	Increased international development and interdependence, for mutual benefit and lessened tensions.

Implementation

Primary and continuing responsibility for interpreting and implementing materials policy should be placed in a single agency, which is to work cooperatively with other relevant agencies in carrying out its responsibilities.

Report B

INTRODUCTION

The materials policy of the United States must be based on the fact that we are no longer self-sufficient in material resources and must depend increasingly on other nations for an adequate supply. We believe that material policies must be based on a factual foundation and a total analysis of the impact of the policies on the material as a whole and not just to immediate parties concerned. Where evidence is not clear, the best policy may be to do nothing until a clear course of action is indicated by such a total analysis.

The seven issues for consideration are discussed in sequence. Where a consensus was reached it is indicated. Where the task force could not reach a consensus, several options are described.

(a) Philosophy—Competition or Cooperation

U.S. attitudes towards efficient international development and conservation of materials are conditioned by the agreement that there must be assured sources of materials, particularly of those materials vital to economic and military security.

Whenever there is a widely distributed, adequate, and accessible multiplicity of sources of a material, the United States can rely on the traditional operation of supply and demand through U.S. or international competitive marketplaces for procuring the materials it needs.

Where sources of critical materials are actually or potentially in jeopardy for any reason, the United States will have to enter into friendly, cooperative negotiations and policies rather more than has been the custom hitherto.

Thus, a mixed strategy is called for: traditional competition for the more plentiful materials; more cooperative attitudes for the more critical and sensitive materials. (Oil is a particularly pertinent, sensitive material.)

Cooperation can take many forms, but it seems desirable to try to develop uniform policies rather than preconceived policies for each country. Furthermore, these uniform policies should preferably be exercised through suitable international agencies (e.g. the whaling industry and the "wireless commission"). Specifically, the United States is in a position to offer agricultural and forestry products and high technology products to achieve a better trade balance; technical know-how and managerial know-how in some cases can also help establish local industries and services in return for materials. Unilaterally, the United States can apply import quotas or tariffs if appropriate.

494-649 O—73——7

(b) Economic Autarky or Bargaining

Autarky or self-sufficiency is clearly not possible for the United States in materials. This Nation must therefore attempt to achieve a good bargaining position with other nations that we depend upon for materials through diplomatic or other means. Bargaining measures such as "favored nation" status, favorable loan guarantees, and repayment schedules should be considered. Materials needed for national security should be given high priorities. Even in cases where domestic production is not economic, it may be good policy to subsidize domestic production to avoid complete dependence on foreign sources and to improve our bargaining position.

(c) Allocation of Resources

Worldwide inequalities in the distribution of natural resources have led to a disparity between the needs and the supply of materials from one country to another. Moreover, the production of most materials is becoming more capital-intensive, is of decreasing importance as a source of employment for labor, is often in conflict with environmental programs, and is usually a consumer of large amounts of energy. For these reasons, it may be that the more highly developed countries will find it decreasingly attractive, if not actually impossible, to be materials producers. It may be desirable, therefore, to engage in cooperative resource development on an international basis wherever there appears to be a potential supply and whenever help is needed.

The successful ventures might be capable of producing more than the market demands, thereby causing a surplus supply among the producers. Or, the efforts might be unsuccessful, causing an unsatisfied need among the users. In either situation some method of allocation would be required. In fact, it seems evident that any international program for cooperative resource development would necessarily include means for allocating the benefits to stabilize materials flow and value.

Equitable allocation would require mutual trust and understanding. It should be timed so that reasonable economic planning is possible. It should provide some kind of relief in case of emergency. It might be desirable to give preference to those producing countries which could utilize other local resources, particularly energy, in producing or upgrading their raw materials. It would undoubtedly take into consideration such factors as trade balances and the political climate.

(d) Supply and Demand

If indeed the profit motive is an important impetus for raw materials exploitation, but not the only one, how can worldwide productive capacity be managed to bear a realistic relation to worldwide demand?

Several possibilities exist to control the productive capacity to match it to the needs of the world: (1) Nation-states could regulate their own productive capacity to meet their own needs. (2) A world-

wide federation or regulatory agency could forecast global needs and develop productive capacity to meet these needs. (3) One could depend upon the laws of supply and demand in the world marketplace to bring into the balance the productive capability and demand.

It was the consensus of this task force that supply and demand, using the profit motive, had been effective in the long run in balancing the needs with an efficient productive capacity and there is no obvious reason why this should not continue to be true in the foreseeable future. There is some concern that the Nation might not maximize its activity in a specific materials industry because it is likely that it will be more profitable for a corporation to import certain materials for which it would be possible to develop a domestic source or substitution. While this may be important in the short run by reducing prices to the consumer it may develop dangerous dependences on foreign sources in many areas. It was suggested that if a tax could be placed on these imports, not of a magnitude to discourage imports significantly, but large enough to provide funds specifically directed to development of a domestic source for the given material or as adequate substitute, this would constitute a feedback mechanism that could control over-dependence on outside sources. This would be accomplished without unduly restricting worldwide trade or foregoing the benefits of increased worldwide efficiency in producing a given material.

Dependence upon this type of control would provide ample opportunity and incentive for innovative companies to develop new processes that would increase our reserves of a given material and reduce costs of present reserves.

(e) United States versus Japanese and German Policy

The U.S. Government does not have a practice of furnishing risk capital to industry nor does it have means of investing in joint ventures with industry as a partner in the international materials scene. Until more data can be provided on the success and efficiency of the Japanese and German policies where government joins industry as a partner, regardless of antitrust laws, government-monitored joint research and development on matters of international materials should be supported and sanctioned. In cases where strategic materials are in short supply and no viable substitutes exist, or in emergency situations where national health, safety, or security is jeopardized, the U.S. Government should aid the international materials industry. The Government should aid in combating the stifling price and supply policies of foreign government-subsidized cartels.

(f) Multinational Corporations

There are three types of multinational corporations:

(1) Product—(International Nickel, Honeywell)
(2) Conglomerates (ITT)
(3) Banks (European banks controlling various industries)

Multinational companies in the materials fields extract raw materials in one place, operate processing facilities in another, and sell to

markets in a third; they can thus obtain the lowest cost within the free market, and provide low-cost materials. They can also change their sources of raw materials and their processing methods to obtain most favorable terms. (Kaiser Aluminum has reduction plants with gas, coal, and hydro generated electricity, and they compete within the company.)

In other cases, such as Honeywell (service company), multinationality is needed only because of the size and cost of the business. Such businesses should be regulated by the countries involved.

The role of international conglomerates and bank-controlled industries (which are joined only by management) is not quite clear, and their position should be investigated.

Multinational companies in the materials field are efficient vehicles to handle global material problems and thus should be supported.

However, the question of regulation of multinational companies is outside of our scope.

(g) Stockpiles

Certain stockpiles will be a necessity for strategic reasons, both military and civilian. Retirements for reserves of any materials considered essential for the defense and military safety of the country must be filled without regard to other interests. The second area in which stockpiles should be considered relates to critical needs in peacetime. Such needs could arise with the increasing U.S. dependence on imports of materials. Where supply of a commodity is concentrated in an unreliable area or where transportation by sea could easily be disrupted, the Government should establish some strategic stocks for civilian needs or make provision to do so if an emergency builds up.

At this time the area which comes specifically to mind is petroleum. A number of European countries already maintain reserves to tide their country over possible disruptions in supply. For the United States, maintaining a petroleum stockpile could mean leaving some production in the ground and importing the differential. At one university forum a proposal was made for a mechanism to do this. An oil company participating in the scheme might develop an oil reserve at a U.S. location and then receive an amount of imported oil by quota equivalent to the quantity that could have been produced domestically. The Government would have to pay for the imported oil so as to obtain ownership of the oil left in the ground to become part of a stockpile. The task force believes this suggestion merits careful consideration.

The existence of a stockpile in itself tends to have negative economic effects. If the stockpile overhangs the market with the possibility of a release of mineral or material for sale this will hold down prices and discourage the expansion of productive capacity at home and abroad (mines, oil wells, etc.) to provide for anticipated demand. The actual disposal of material from stockpiles to do away with a surplus will tend to disrupt the existing supply-demand pattern. This can be par-

ticularly serious for some less developed countries which rely heavily on the sale of a single mineral commodity, like Malaya on tin.

It would appear the best policy to undertake stockpile disposals in a manner that gives proper consideration not only to the interests of the United States, but also to the interests of supplier nations with which the United States maintains good relations.

Editorial Note on Task Three

The discussion of this topic centered on the feasibility of national self-sufficiency (autarky) in materials. It appeared to be the sense of the meeting that a flexible strategy was needed—that some extent of effort toward reduced reliance on overseas resources might be warranted. However, there were many uncertainties:

- Costs and feasibility of a policy of autarky;
- Compatibility of autarky with "free enterprise";
- Compatibility of autarky with preservation of "quality of life"; and
- The moral issue of striving for optimal benefits to the United States versus maximizing global benefits.

Thus, it was also the sense of the meeting that policymaking in this area required a great deal more study of the costs and consequences of autarky, the role and extent of domestic and foreign subsidies, the use of U.S. management services as a form of export to balance material imports, and the value of U.S. technology as an exportable commodity in world trade. In essence, an important relationship was perceived between this task and task one.

Task Four: RESEARCH AND EDUCATION

What should be the roles of research and education in improving the national position in materials and materials management?

Rationale.—The National Materials Policy Act of 1970 instructs the Commission to determine "means of exploiting existing scientific knowledge in the supply, use, recovery, and disposal of materials and encouraging further research and education in this field." Emphasis on the need to reverse a deteriorating trend in mineral extraction technology enrollments is offered by Director Osborn of the U.S. Bureau of Mines, and in a report by the National Academy of Sciences. The ad hoc committee report, Toward a National Materials Policy, declared: "Although there are many kinds of operations and programs that would be beneficial in improving the usefulness of materials to man, the changing context of modern society is such that the most immediate task is to develop a national understanding of the facts and their implications. The preservation and restoration of the environment * * * needs to be backed by an understanding that some of the things that must be done are costly. These costs must be met if the goals are to be achieved. A national consensus on this issue must

include a willingness to pay the costs and to distribute them equitably."

Issues for Consideration

RESEARCH

(a) Government R. & D. programs in materials have emphasized enhancing of properties for advanced aerospace, military, and electronic applications; there is some evidence that cutbacks have idled professional people in this work, raising the question as to whether there should be a renewed emphasis on efforts in the field, or perhaps to place emphasis on raising the level of technology in older industries that tend to lag technologically behind their counterparts in Europe and elsewhere. What should be the policy here?

(b) In view of the fact that the services industries employ more workers than do manufacturing, agriculture, and the extractive industries combined, is there room and opportunity for an R. & D. contribution to improve the uses of materials by the services industries as a matter of national policy? (E.g., in maintenance, recycling and disposal, public health, etc.)

(c) Can R. & D. in materials properties contribute to improved flexibility of U.S. posture in materials, in anticipation of future changes in world availability, policies of other nations, and rising consumption?

(d) What should be the national policy respecting the collection, collating, and dissemination of results of research sponsored by the Government? Should it be made self-supporting? Is there a public interest in making every effort to encourage uses of the results of Government-sponsored research?

EDUCATION

(a) Enrollments in materials studies appear to be declining; the trend has been variously attributed to lack of interest in the field, lack of opportunity for employment, and lack of opportunity for advancement. What should be the national policy toward assuring a continuity of education and training in materials-related disciplines?

(b) How might it be possible (and would it be desirable) to increase the scope and intensity of attention to real world problems, materials-related, in the classroom?

(c) What should be the national policy toward combining of research with education at higher academic levels? (There is criticism of the diversion of faculty time from teaching to research; is some extent of academic research effort essential to the enhancing of professional competence of faculties as well as the training of graduate students?)

(d) What national policies would be desirable toward the goal of promoting broad public understanding of the importance of materials to national purposes and well-being?

(e) Can the educational system contribute more effectively (and how?) to social discipline in such matters as waste disposal and litter?

(f) Has advertising of consumer products been an educational experience for the U.S. population, and could it be?

(g) Can the mass media help reorient the U.S. public from a pioneer use-and-abandon culture to a more mature use-and-conserve culture?

(h) Might educational "materials" for educational purposes properly be developed by the Federal Government for classroom use for the purposes indicated above?

Report A

Abstract.—Research and education were the basis of the development of a high living standard in this country. The recent financial cuts, which eliminated fundamental research in a large number of companies and curtailed applied research, and decreased educational and university research funds, may save money in the short term, but be very costly in the long term. This is especially true in the materials area, where the lead times are long.

The country should spend a fixed percentage of its GNP on materials research, and thus eliminate the ups-and-downs. A more even mix should be created between institutional support and project type support of research. A larger research effort should be spent on developing substitute materials.

Education should get a better mix between science and engineering; not all schools should have the same program, diversity is important. A large fraction of graduates (especially with Ph. D. degrees) should enter the production fields, rather than R. & D. and education (in Europe and Japan, Ph. D.'s run steel mills); this will make management more receptive to new technological ideas.

Research.—Government R. & D. programs in materials need to be coordinated more effectively with other Government programs so that cutbacks in aerospace, defense, and electronic applications will not idle professionally trained people. Mission-oriented projects have been found a proven method of accomplishing the reorientation of facing R. & D. programs using the "demand pull" principle instead of the "product push" principle. The substitution of societal missions from the newer departments of Government should be made to reverse this unfavorable trend.

A mixed strategy for redeployment of scientists and engineers appears desirable. In some cases, redeployment should be undertaken in existing Government laboratories; in other cases R. & D. contracts in appropriate industries (e.g., a contract for R. & D. on glass recycling processes should be made with a glass company, provided the company has an R. & D. laboratory effort above critical size).

A variation of redeployment strategy which the Government should consider, drawing on existing facilities wherever possible, is to create Federal research institutes for cooperative research in any of the services or older technologies requiring revitalization.

The task force considered that R. & D. in materials properties could in fact make a significant contribution to improving the flexibility of the U.S. posture in materials. The following areas were named as specific examples:

(1) R. & D. work should aim at the substitution of new materials in specific areas. One such area relates to materials that are likely to create a problem for industry because of anticipated shortages. Another area would be materials for which marked price increases are expected because they will cost more to produce in the required amounts.

(2) It appears important that objectives of research be decided on and the R. & D. work be oriented to the appropriate fields. Much has been said of the value of spinoffs to other areas. Thus research in aerospace has led to results that could be used in social sciences. However, the task force considers it to be more rational to match the R. & D. with the desired activity rather than to rely on spinoffs.

(3) In line with the determination of national objectives, funds must be allocated to the pertinent R. & D. work. For example, a likely objective is the creation of workable advanced energy conversion systems to assure that the growing need for energy can be satisfied. In line with this objective, R. & D. should be earmarked for the development of new advanced materials which are critical items in the successful development of the processes.

The consensus of the task force was that whatever system may be used by the Government to disseminate information on Government-sponsored research, it should not be expected to be self-supporting. In practice it is found that users are greatly reduced as charges are made. The taxpayer has already paid for the research and should have free access to the resultant information.

There is a great need for a system to allow an easy search and selection of the available information. Where users have specific recurring needs, a profile system should be helpful. Overviews by qualified people of new knowledge could also be of considerable use. An example of this type of tool is the publication "Mineral Facts and Figures" by the U.S. Bureau of Mines.

In the United States the chief method for supporting materials R. & D. is the project system. While this has a number of meritorious features, chiefly in productivity, it tends to result in faddish, shallow research coverage to the detriment of deep intensive research that takes many years of continuous effort to develop. The IDL's are an example of institutional type of support with many worthwhile features and may be an ideal mode for the support of pure research. However, insufficient emphasis appears to be given to scoped or topical institutions of the type that are common in Europe. A scoped institute is ideal for intensive coverage of a relatively narrow field, and probably is the best mode for facilitating progress in applied research in a technical field. Efforts should be made to shift the mix of support

more toward scoped institutional support while maintaining a significant level of project support.

Education.—Enrollments in materials studies appear to be declining; the trend has been variously attributed to lack of interest in the field, lack of opportunity for employment, and lack of opportunity for advancement. What should be the national policy toward assuring a continuity of education and training in materials-related disciplines?

The premise that enrollments are decreasing in the materials field was considered in error by this task force. Our impression is that the enrollments in metallurgy and material science programs have increased about 50 percent over the past 10 years in B.S. degree programs, and probably increased by 200 to 300 percent in Ph. D. programs. It was thought that minerals and mining programs have remained relatively constant over this period of time. Recent decreases in enrollments in certain institutions appear to have been incorrectly extrapolated to include schools that have traditionally trained a major fraction of the people in the materials area. It was also the experience of the people in this task force that job opportunities for materials people and opportunity for advancement were superior to that of other engineering disciplines. This appears to be a shift in emphasis in the interest of students and those hiring graduates toward careers that would lead to production and management positions in various industries. We would urge further study to document or refute this premise. If the change in emphasis is valid, it would be in the interest of the Nation to promote increased activity in those areas of major needs. This need not mean a decrease in present areas of activity unless they are found to be overfunded for the number of graduates needed by employers.

It was suggested that some universities should be established as centers of excellence in particular areas with close ties to appropriate industries. Examples are transportation, communication, environmental metallurgy, corrosion, or ferrous metallurgy.

Many industries have found it desirable to study materials problems using interdisciplinary groups with members trained in solid state physics, chemistry, metallurgy, ceramics, and polymer science. But concern was expressed about the advisability of a university's attempting to train a single individual in each of these disciplines at the expense of depth in a particular area. However, there was a consensus that students in materials should be closely aware of the contribution that each discipline could make to the solution of material problems and it may be advisable to increase their awareness to include material processing, extractive metallurgy, and mining principles.

At present, there appears to be a general separation of minerals programs and materials processing programs from the more scientific areas of materials programs in universities. Consideration should be given to methods to promote interaction between these areas of materials since there would appear to be many major contributions that the scientific areas could make to these programs and the problems and

opportunities in the minerals and processing areas appear to be the most pressing materials needs at present.

In general, the universities have pioneered in calling attention to real world problems, particularly those related to society. Unfortunately, most of this attention recently has been against technology, to the point that engineering schools are losing ground as part of the university community. This trend should be reversed, because the interaction between students of technical, scientific, and liberal orientation is an excellent means for promoting better understanding of the problems and of the secondary conditions for the solutions proposed.

Since the prime mover in the classroom is the teacher, he must be sufficiently informed about the problems of the real world, as they relate to materials, to feed this information into the educational process at the appropriate time. The teachers must be encouraged or even be required to keep up to date through research, extra-classroom employment and participation in the activities of civic and professional groups. Paralleling this, there should be more use of persons from industry as teachers. The classroom can be taken off campus through field trips, summer employment, and real-life assignment. Today's students are eager to participate in activities which provide an opportunity for them to draw upon their technical or scientific background, and they should be encouraged to do so.

For the best national interests, research should remain coupled to higher education with teachers employed as teacher-researchers in proportions of 25 to 75 percent, 50 to 50 percent or 75 to 25 percent depending on individuals. Pioneering in research is essential to training graduate students as well as improving the competence of faculties. Coupling of research to higher education affords springboards for new curricula, new courses, new combinations of disciplines, and new research directions.

Professional societies and industrial firms should bear the burden of promoting understanding of national materials policies to the broad general public.

Report B

We believe that R. & D. makes significant contributions to the social, industrial, and economic needs of the Nation. We further believe that in the material sciences, R. & D. has not been effectively applied in many of the mature industries that are experiencing increasing difficulties in competitive world markets. There is little evidence to suggest that this situation will improve in the near future. We believe that action is required and that the Federal Government should actively encourage and support R. & D. to maintain the vitality of our materials industries whenever it is in the national interest to do so.

We recommend that careful analyses be undertaken by appropriate agencies to determine the underlying reasons for the low level of R. & D. activity characteristic of these industries. Among the factors that might be studied are:

(1) Management views of the research and development process

in the mature industries, as contrasted with the modern high technology industries;

(2) Market analysis views of the potential applications of R. & D. in the mature industries;

(3) The spectrum of systems used for the accounting of R. & D. costs;

(4) The mechanisms and criteria used for the accounting of R. & D. benefits and achievements;

(5) The problems associated with coupling of mature industries to the national materials R. & D. community; and

(6) Possible Federal incentives for innovations such as tax writeoffs and depreciation policies, patent policies, antitrust actions, etc.

In considering this broad issue, we find that we can subscribe, in large measure, to the general points made in a recent recommendation of the National Science Board in A National Policy for Technology. The complete text follows:

"Government policy should encourage the injection of basic and applied research activity into mature industries, and the maintenance of a high level of such activity in technologically advanced industries.

"The Federal Government should encourage essential research activity through direct and indirect financial incentives on a trial basis through both traditional and new modes of cooperation among industrial, governmental, nonprofit and academic institutions. Such activities might include, but not be limited to:

"Providing financial incentives for joint applied research activities between academic institutions and industrial associations.

"Providing matching funds for special cooperative efforts for applied research organized within or alongside universities, nonprofit, and governmental installations for those industries so fragmented as to be unable to act effectively alone or in concert."

In our consideration of the educational system, insofar as it relates to materials science, we conclude:

(1) That communication and cooperation between academic and industrial institutions should be encouraged wherever possible without, however, infringing upon the traditional role and responsibility of the academic community to initiate and pursue basic, long-range studies;

(2) That technological obsolescence is a pervasive problem in our scientific and technological society. It is imperative that continuing education programs be encouraged and developed in every sector of our materials science and materials management community. Federal incentives, such as tax deductions, should be broadened to foster continuing education programs in the scientific, technical, economic, and social aspects of materials; and

(3) That the academic community is responsive to the laws of supply and demand in the market place for technical talent. There appears to be no need for attempts to control closely the supply

of trained scientists and engineers in the field of materials through the calculated intervention of the Federal Government.

Finally, in a consideration of policy regarding research information, we concluded that government sponsorship and managment of R. & D. programs should include the publication and dissemination of results as part of the total cost of the R. & D. effort. Wherever possible, efficient mechanisms should be developed to collect, store, assess, and disseminate such information.

Editorial Note on Task Four

Emphasis in the discussion of this topic was on (a) division of resources allocated to in-house governmental research versus Government-sponsored private research, (b) division of educational emphasis as between basic research and "closely coupled" or industrially oriented, problemsolving education in technical fields. There seemed to be considerable sentiment for the proposition that students should be more involved—as one spokesman put it—in "real world problems, large systems courses, and engineering design projects."

Task Five: THE EFFECTIVE APPLICATION AND MANAGEMENT OF KNOWLEDGE

How can information, documents, data, and analytical studies be managed as knowledge resources in support of national materials policy?

Rationale.—Two different subjects are involved—the utilzation or transfer of technological information and the development of useful machine-readable data banks of information. In the act, these two items appear as "means of exploiting existing scientific knowledge in the supply, use, recovery, and disposal of materials" and "the feasibility and desirability of establishing computer inventories of national and international materials requirements, supplies, and alternatives." A system of computerized inventories of materials in the ground was described at the 1970 Henniker conference on materials policy.

Issues for Consideration

(a) It is said that we are suffering from insufficient new output of research information; that we are suffering from insufficient utilization of the good research information already at hand; and also, that we are engulfed in bales of old information of low or diminishing value. What is the truth of the matter? How do we come to grips with this problem?

(b) How much can we reasonably expect the computer to help us? What are its limitations? What are its strong points? Are we using

it fully enough where it is most helpful? Can technology help to make the computer more flexible and useful?

(c) What can we do, in the way of good management, to assure that information is sorted out more quickly and effectively into useful and other; and that we develop open (and low impedance) channels from the source to the users?

(d) One of the ways Japan has been able to move forward rapidly in productivity and industrial-technological sophistication is by an aggressive program of acquisition of the best foreign technology which her own technologists have then improved and applied. In a number of important fields of industry, the United States lags technologically behind the best foreign practice—shipbuilding and rapid transit, to take two examples. Would it make sense to follow the Japanese example, seeking out and improving those fields of materials technology where we lag? What are some examples of these lags? Who should be responsible for stimulating action in the United States and who should take it?

(e) In the field of materials supply data, should we be giving more vigorous support to our own programs? Are there some lessons for us in the Canadian program?

(f) Are we putting the right kind of information and data into our computers? How can we use them better to help us with our management of materials?

Report A

A number of issues were discussed from which three problem areas were delineated and for which three courses of action were formulated. The three areas will be discussed individually with a brief rationale for each.

A. Resources Information

Inadequate and erroneous information now exists on materials reserves; consequently the basis for predicting future needs and utilization of resources is questionable. Better data are required. Existing computer facilities can process and store this information. However, the output of a computer is only as good as the input to it; means for obtaining the requisite input must be established.

Recommendations.—An information gathering system on materials resources should be established. Legislation should be passed to make industrial input mandatory with the stipulation that such company data be proprietary, i.e., that no individual breakdowns be made and that only totals be made available. It is further suggested that a capable and knowledgeable analyst process all input data and have the means by which apparently erroneous input could be rejected and the sources required to supply corrected inputs.

B. Wastes Composition and Sources Data

Recycling of wastes depends largely on availability of markets and a knowledge of the composition in order to process the waste effectively. Little incentive exists for entrepreneurs to create new business for recycling unless adequate information exists on the composition, amount, and sources of waste products. In other words, if someone in a given city wants to build a plant to handle metallic components from municipal dumps, he must know what metals are involved, how much of each to expect, and if these parameters will change.

Recommendation.—A program should be established to collect and disseminate information regarding the composition, amount, and sources of municipal and industrial wastes. The information should be computerized and be made available for creation of new markets for recycled waste.

C. Research Information

The existence of a tremendous quantity of data on materials and their properties, and the difficulty of retrieving such data, implies the need for computerization to utilize available information effectively. Further, the costs in utilizing existing information services as well as the lack of completeness and the time delays in obtaining the data offer strong incentives for systemizing the handling of these data to reduce these costs.

A number of information centers already exist for certain materials, e.g., copper (supported by funds from copper-producing companies and administered by Copper Development Association), but the existence of these groups is generally unknown by others not connected with that particular industry.

Recommendations—A national telephone exchange should be established so that a query could be received, checked with a master index, and connected to the appropriate information agency. Further, a study should be made as to what agencies or groups already exist and what additional ones should be created in order to complete the coverage. For those industries lacking such information groups, an industrial association should be created, such as the Copper Development Association, which would assess the members for funds and administer an information gathering and disseminating group which would become part of the national telephone information system.

Report B

The United States has, over its relatively short existence, exerted outstanding leadership in the management of experience in work, i.e., organizational talent and flexibility. A vast supply of raw materials was available for extraction from the ground, in untapped forests, and in the virgin soil of the country. To settle a virgin continent in so short a time, independence and hard work were the vital and

prized characteristics of most surviving pioneers. (There is a suspicion in some quarters that a modern repercussion of this necessary independence of yesteryear might be the emergence of the NIH (not invented here) syndrome which retards the acceptance of almost anything new. NIH has great importance in technology transfer and will have in the future in the volume acceptance of recycled materials.) Combined with the above was a vigorous working force, almost unlimited markets at home and abroad for its goods, but with a lack of awareness or at least concern, on a broad scale, for social and environmental considerations. However, this situation has drastically changed within the last few years and has brought into clear focus the need for a national materials policy.

The challenge in the years ahead is to learn how to effectively manage knowledge and those who apply knowledge. From a definitional standpoint knowledge, like electricity or money, is a form of energy that exists only when doing work—energy that can be effectively applied for the good of mankind or misapplied and become a detrimental factor on the human race and its environment. Knowledge in this context is not just what is in a book or report. It involves the application of information and data, etc., which are knowledge resources or tools, towards the provision of functional materials, products, systems or objectives towards a performance goal. The computer development starting in the 1940's, the advent of Sputnik and its broad implications, clearly indicated that knowledge in action was no longer only of private but also of public concern.

How then can information, documents, data, and analytical studies be managed as knowledge resources in support of national materials policy? The ASPI states that performance makes the difference between quality and junk. This suggests the importance of quality control as a way of reducing junk.

From the task force rationale it was indicated that two different subjects are involved—the utilization or transfer of technological information and the development of useful machine readable data banks of information. From another view, these pose management problems covering things (information, documents, data, etc.) versus people (application of knowledge, resources, and technology transfer). It is easier to manage things than people.

Recent experience in this country indicates that effective technology transfer occurs only when the people who believe or have confidence in a specific technology are transferred into the new area. This appears to be opposite the Japanese experience where new technology is gratefully sought, bought, and accepted with subsequent innovative improvement and resultant functional quality where performance is a prime prerequisite (cameras, for example). In rationalization of the above, in addition to the NIH syndrome retardation in technology transfer, it should be noted those countries which have suffered the greatest war damage have been most willing, or have been forced, to accept new technologies. This also happens in those areas where there is strong national need or motivation; for example, the U.S. develop-

ment of synthetic rubber based upon prior German experience and its successful production was probably more important than similar concurrent and innovative atomic development during World War II. In each, almost unlimited resources—people and finances—were gambled to attain success. Our space program spun off from earlier Russian efforts after the Russians had duplicated our classified atomic work in the late 1940's. One wag has suggested that if we just apply security classification to any technology we desire to be transferred, voila!

The above suggests that if there is sufficient motivation to create authority and financial backing, the transfer of technology is really no problem; provided that top management in either government or industry understands the need and the ensuing problems, and desires a solution.

Several of us considered that the crux of the problem underlying the needs of a national materials policy relative to the effective application and management of knowledge lies in the noted lack of understanding of the importance of data, etc., as knowledge resources by top management who control the purse strings.

For example, physical properties are among the elements of knowledge resources in describing a material. Specifications are those combinations of properties which are felt by the specification developing groups to determine successful use of application potentials. From a procurement standpoint, specifications and standards are the language by which materials, new or recycled, are described. Further, they are central to any procurement because they state what is to be purchased. It should be noted also that materials are the foundation upon which all products are built. Yet military and Federal specifications are not revised or kept up to date regularly even though established policy states that they must be—primarily because of continued reduction in financial support for such activities. Consensus type specifications usually take an inordinately long time to establish or revise (from 1½ to 5 years). The above supports the statement relative to top management's lack of understanding of crucial importance of these knowledge resources. If they understood, this situation would not be a problem.

If these problems exist for new materials, and they do, they will exist to an even greater degree for recycled materials where little or no credibility relative to properties, cost, or continued availability exists now. Specifications for recycled materials must be established to cover successful applications.

Actually, the scope of the information needed ranges beyond specifications and covers raw materials and their extraction through utilization and recovery or disposal. Thus, education to promote a greater understanding of the problems along with increased financial backing is vital in seeking solutions.

Several specific issues dealing with the subject of efficient application and management of knowledge were raised in the task force rationale:

(a) An expression from one of our academic members indicated that the quality of information available in materials R. & D. is generally excellent; the quantity is increasing at an acceptable rate for current needs. The situation changes as one moves across the spectrum of

materials and materials policy activities from structures and design to management. In the decisionmaking arena, the quantity of information available is immense but much of it is of dubious validity or quality. Major efforts should be made to assess critically the information base that is used for materials management decisions. This can perhaps best be done as part of a continuing R. & D. effort sponsored by the several Government agencies with legitimate interests in the area, such as Commerce, Interior, and DOT. The areas where quantity and quality of research is insufficient lie in newly emphasized fields such as recycling and disposal.

Countering the above statement about the acceptable rate increase came from our information specialist who felt more information is perhaps being generated, but there continue to be restraints on full disclosure and easy availability of materials information so that far less than full measure is being made available. Somewhere we need to make a distinction between research information and its related scientific community where there are incentives to publish—and technology, engineering or applications information and its relative hardware community where we need incentives. Competitive pressures force deliberate constraints of information and protection of proprietary compositions. U.S. Government procurement is an example. Within our Government, constraints exist because of security ghosts, and overworked zeal to have data perfect before release, and minimum dissemination of certain types of information such as company I.R. & D. reports. In England, industry must disclose full composition to continue to be qualified to supply Government requirements.

(b) There is insufficient utilization of good research information already at hand. In a production-oriented society, the pressure to produce quickly forces the engineer to find answers without delay. He will use whatever is at hand rather than to make time consuming searches. The NIH syndrome also exists as a cause of insufficient utilization. We need better ways to give engineers fingertip access to data and knowledgeable peers.

(c) We are not engulfed in bales of old information of low or diminishing value. What is of paramount importance, whether the information is old or new, is the credibility of the data and if they are relevant to the problem under consideration.

(d) The value of the computer was questioned in the rationale for this task force. It was agreed that several important considerations are involved in its use. Selectivity of the information fed into the computer was necessary in order that credibility be established in the output. Personnel involved in the operation of the computer should be highly trained. And, finally, it should be understood that the computer is a remarkable tool but is in itself not infallible (good information in results in good solutions out). We need to watch out that the computer remains as a tool but not our master.

The value of the computer is in its large storage capability, rapid retrieval, and the ability to solve complex equations and situations. The recent development of computer capability in the field of design

or "computer aided design" provides a new extension, thus integrating materials and design.

Another value of the computer is its ability to present information rapidly in a wide variety of formats and arrangements. For example, the computer can rank materials in order of any desired property, etc.

(e) The statement was made in the rationale that Japan, for example, acquires the best of foreign technology and then its own technologists improve and apply it effectively. Should the United States adopt a similar practice since it apparently has worked very successfully for Japan? The basic reason for Japan's success appears to be: They established national objectives; they restructured industry to respond to these objectives; they provided risk capital to establish the industry; provided continuous training and a lifetime job; however, there is little flexibility for employees to change their occupation; also, because of their insular position they have arranged for economic stockpiling (or availability) of materials.

In contrast, the United States has no uniform national goals or objectives; industry is highly responsive to profit and loss with very little social consideration; capital for industry is normally raised through the private sector; and voluntary training is quite available with considerable flexibility to change one's occupation or profession.

It should be noted that in our most successful trading partners or competitor countries (Japan and West Germany), government and industry work very closely together—in some cases with joint industry ownerships. This contrasts with the often antagonistic situation between the U.S. Government and U.S. industry.

It would be beneficial to examine in detail the Japanese economy and consider the incorporation into the U.S. system of those facets beneficial to our economy. It is recognized that certain changes would have to be made in existing laws and regulations to implement such actions.

It may be concluded that some actions are in order to improve the present materials situation:

(a) Top management education to create better understanding of existing problems and their solutions.

(b) The establishment of a national materials policy, now underway.

(c) The establishment of national needs, goals, or objectives.

(d) Reexamination of laws and regulations governing industry, e.g., taxes, depreciation, full employment, antitrust laws, balance of payments, pricing, incentives, etc.

(e) Integration of the existing and future-planned computers.

(f) Better communication and understanding between government, industry, and universities, perhaps by the establishment of an institute consisting of representatives of each to coordinate, finance, and seek solutions to national materials problems.

(g) Evaluation of foreign competition and its impact on the U.S. economy.

Editorial Note on Task Five

The conferees did not reach any firm conclusions regarding the need for legislation to strengthen the management of technical information. There appeared to be a consensus that the use of technical information was of increasing importance, and that in fact it was a significant determinant of the value of technological innovation itself. Technical information was an important and insufficiently used national resource. The need to strengthen it was generally conceded. However, the proposal that some form of national center of technical information—computer-based and telephone-linked—was not generally agreed to. Clearly, the subject required further study.

Task Six: THE CLOSED-CYCLE FLOW OF MATERIALS

How can improved management of materials be reflected in enhanced value of the materials flow throughout the cycle and reduced volume of wastes that deplete the flow throughout the cycle?

Rationale.—Apart from the fact that the National Commission on Materials Policy was created as one feature of the Resource Recovery Act, three of the assignments to the Commission are concerned with the feature of resource recovery:

> "recommended means for the extraction, development, and use of materials which are susceptible to recycling, reuse, or self-destruction, in order to enhance environmental quality and conserve materials;"
>
> "means of exploiting existing scientific knowledge in the * * * recovery and disposal of materials and encouraging further research and education in this field;" [and]
>
> "means to enhance coordination and cooperation among Federal departments and agencies in materials usage * * *."

Issues for Consideration

(a) What should be the objectives and constraints in the design of a system for the effective and efficient, total, sustained management of materials?

(b) What social controls and motivations might be employed to channel the flow of materials to maximize effective closed cycling?

(c) What are the obstacles to a closed materials system?

(d) What are the implications of the interaction of materials and energy, for the achievement of a closed materials system? (For example, the different energy budget for one-way versus recycled aluminum containers.)

(e) Should a closed-cycle materials system be designed on a national or regional basis? Should materials flow be approached as a local social problem or as a national resource problem?

(f) What are the international aspects,of materials recycling, and environmental preservations standards; what policy issues are implied by differences in national standards?

Report A

Part I—Background: Current Recycling Practices

The task force reviewed major features of the recycling of various materials as it is carried out currently or may be carried out in the future. The following materials were considered: steel, copper, aluminum, lead, zinc, precious metals, paper, rubber, textiles, plastics, glass, and municipal waste.

Recycling of materials serves two functions: (1) the conservation of resources and (2) the reduction of wastes. The conservation of resources results from the business activities of the secondary materials industries and of other industries involved in recycling. Their activities are stimulated by market forces, follow the laws of traditional economics, and are part of the private sector. Various materials are recycled in this manner.

These recycling activities contribute to the disposal of wastes, especially auto hulks and containers. The reduction of wastes by recycling would be increased, however, if other materials could be recycled. In the absence of private profit, the required driving forces are environmental: the activities must be assessed from the viewpoint of welfare economies and are part of the public sector. The recycling of ingredients of the mixed municipal waste stream is the main example, but other materials may also fall in this category.

Recycling can start on three levels: (1) in the plants of primary producers of materials, (2) in the plants of manufacturers, and (3) at the point of discard after use. The recycled materials in the case of metals are home scrap (revert scrap), prompt industrial scrap (new scrap), and post-user scrap (old scrap). The same three categories as a rule apply to other materials, in particular paper.

The recycling of home scrap and prompt industrial scrap (or their non-metallic equivalents) improves process yields, reduces costs, and helps to conserve raw materials and energy. It is standard industrial practice and poses no major problems. By contrast the recycling of post-user scrap depends sensitively on such factors as economic conditions, location, and the type of material. It represents a dynamic element and is the area of recycling in which policy is most likely to be effective.

Major facts and problems of recycling for 12 materials and muncipal waste are summarized in the attached table.

Part II—Issues for Consideration

(a) Possible systems for the management of materials will be greatly different for different materials. In particular, they will differ in the degree to which they can be "effective, efficient, total, and sustained."

Recycling—Facts and problems

Materials	Supply of secondary	Demand for secondary	Collection and sorting	Processing	Energy	Pollution	Institutional	International
Steel	Imbalance	May increase	Auto hulks	No insurmountable problems	(+)	+	T, Tr, Z	(Steel imports).
Copper	Relatively balanced		dto		+	+	dto	(Quotas).
Aluminum	Probably no long-term imbalance.			New refining processes needed.	+	+	dto	Reduces dependence.
Lead	Balanced			No insurmountable problems	(+)	(+)	dto	
Zinc	Available	May increase				+		
Precious metals	Balanced							
Paper				Limited capacity for secondary.	+	(+)	T, Tr, Z, S	
Rubber		None developed	Possible	New technology needed				
Textiles	Marked imbalance			dto			S?	
Plastics		None developed		dto				
Glass	Marked imbalance							
Mixed muncipal waste.	Markets needed	None developed		New technology needed		+	Incentives needed.	

Legend: +=recycling has advantages over primary production; (+)=dto but to lesser extent; T, Tr, Z=taxation (depletion allowance, capital gains treatment), transportation (freight rates, coast-wide shipping), zoning regulations unfavorable to recycling; and S=specifications unfavorable to recycling.

The differences result from the physical and economic characteristics of the materials to be managed and from special considerations (e.g., management of mercury as a toxic material).

All systems of materials management must take into account the costs of recycling which increase with increasing extent of recycling (the law of diminishing returns). In most cases it will be desirable to take recycling into account in the original use (design for recyclability). Increased durability of products will not affect recycling adversely. The management of several materials must be approached in a coordinated manner: for example, the most abundant material should be assigned to dissipative uses.

(b) Social controls and motivations aimed at maximizing closed cycling must change public attitudes from those of a "throw-away society" to attitudes favoring conservation of resources and minimizing wastes. This will require publicity, consumer education, and securing support for such practices as the segregation of household wastes.

(c) Quality deterioration creates obstacles to a closed system for some materials. For example, the cellulose fibers in paper are degraded physically by recycling and move downward rather than in a circle. In some metals harmful impurities build up and need to be eliminated in a vent stream.

All materials can only approach closed cycling because of the effects of dissipation and dispersion (both geographically in space and chemically in other materials). These effects can be overcome only by the expenditure of energy and other materials; the resulting costs of total closed cycle management would make such recycling uneconomic.

For a few materials, required recycling technology is lacking even to make a start. The most important example is plastics.

(d) A closed materials system inevitably leads to expenditure of energy. The energy required for production from secondary sources, however, is generally less than that required in the corresponding primary production of the same material: this is particularly true of aluminum, magnesium, and titanium. See the column headed "energy" in the attached table. The energy requirements of collection processes must not be excessive—see (c) above.

(e) A closed-cycle materials system must be designed on a national, rather than a regional, scale because its chances of success are likely to increase with scale. Materials flow considered with regard to waste disposal and resource conservation is both a local and a national problem.

(f) Recycling reduces the demand for imports of scarce materials. Domestic recycling also cuts potential exports of secondary materials (the case of copper).

Recycling tends to reduce pollution. See the column headed "pollution" in the accompanying table.

The policy issues implied by differences in national antipollution standards were considered by this task force as outside its scope.

Report B

Introduction

Our national objectives in the context of the concept of the closed-cycle flow of materials should embrace, among others, the conservation of our material resources (considering also its impact on energy conservation), the protection of the environment, facilitation of the recovery or disposal of processing and product wastes, and a maximization of the service of materials to society. The attainment of these objectives requires the optimization of the total system depicted by the diagram in the accompanying illustration.

Briefly, it represents the life cycle of a material, including the impact of environmental controls and energy requirements during successive steps in the cycle. The interdependence of the producer and consumer circles on the production economics, together with those external factors that affect each, is illustrated by overlapping rectangles.

It should be recognized that recycling, like conservation, energy minimization, or environmental control, is not an ultimate goal to be achieved irrespective of cost. Paramount is the optimization of the overall well-being of the citizens of the country. The intrinsic value of the material in a particular product may be such as to make its recovery impractical, in which case disposal as efficiently and unobtrusively as possible may be the most reasonable solution.

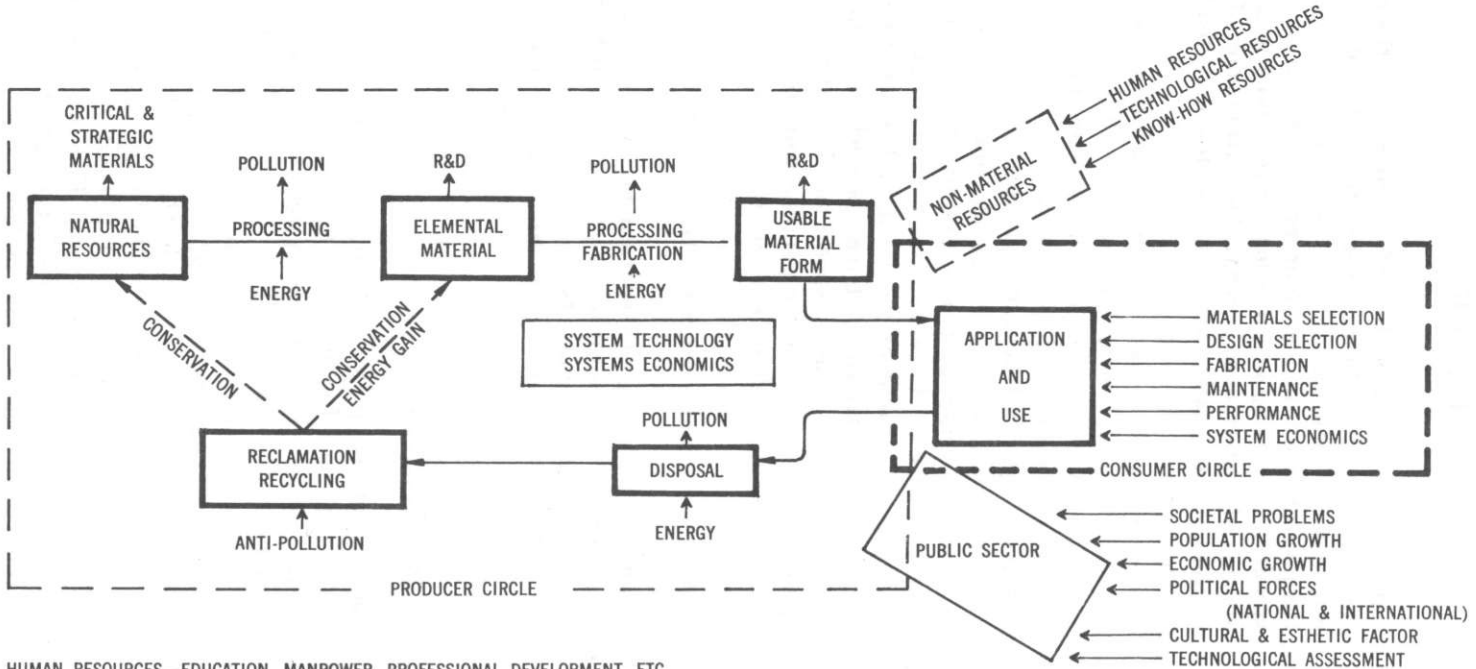
Some of the obstacles to the closed systems approach at the present time are:

(1) Relative discrimination against the use of waste process material.
(2) Difficulties in collecting and separating the waste components.
(3) Current lack of consideration in product design to the recovery of materials components.
(4) Lack of individual, corporate, and Government responsibility.
(5) Vested interests.

Recommended Policy Statement

We recommend a national policy that would provide incentives and disincentives as appropriate for the use of materials in products that would be more durable, recyclable, or readily disposable, commensurate with the costs and benefits of such policies to society. As a first step, measures must be taken to eliminate discrimination against waste materials as compared with virgin materials provided they meet performance requirements. Incentives for the exploration or development of virgin materials may or may not be necesary but adequate incentives for the reuse of waste materials or other possibly useful residuals should also be promoted through State and Federal governmental policy. (Note: The group gave little consideration to the export-import aspects of the "closed cycle" of material flow.)

THE LIFE CYCLE OF MATERIALS



HUMAN RESOURCES—EDUCATION, MANPOWER, PROFESSIONAL DEVELOPMENT, ETC.
TECHNOLOGICAL RESOURCES—CAPABILITY, EQUIPMENT, FACILITIES
KNOW-HOW RESOURCES—
RECORDED INFORMATION: STORAGE, RETRIEVAL
EXPERTISE
} TRANSFER

Limitations or Constraints

Some of the constraints under which such a policy might operate are:

(1) No lowering of the standard of living of our individual citizens.
(2) No serious impact on employment.
(3) Favorable balance of payments.
(4) Maintenance of our national security.
(5) No arbitrary curtailment of the use of a material or elimination of a particular industry.

Implementation of Policy

The incentives and disincentives that may be used to bring about greater application of the closed-cycle principle are:

(1) *Economic*, for example, taxes and subsidies, Government procurement policies.
(2) *Technological*, for example, design of product with ease of recycling in mind, greater standardization of materials, research, and development.
(3) *Psychological and social*, for example, education, greater public awareness to achieve a sense of personal responsibility.
(4) *Legal*, for example, class action suits and other legal mechanisms.

National vs. Regional Solution

The main impetus for the recycling of waste materials has been that of local social problems associated with waste disposal. However, the Federal Government and the materials profession should also view it as a national resource problem and promote the closed-cycle concept, where possible, as a national goal.

Application of the closed-cycle principle to the flow of materials lies at both the national and local or regional levels. Uniform and stable standards or controls should be national in scope lest business or industry in one State or region be placed at a competitive disadvantage by local or State regulations, although this is a judgmental issue which should be decided by those directly involved. However, the actual application of standards and controls to the recycling process will undoubtedly be handled on a regional or local basis. Whether it should be by Government or the private sector depends on the local situation although it is the opinion of this task force that private industry is best equipped to carry this out.

International Aspects

We cannot impose a national policy on materials that will penalize our own economic well-being, and yet our past laissez faire policy in the production and use of materials is now under reexamination. The

Federal Government must play an active and aggressive role in the establishment of international product and materials standards, environmental controls, and insuring the availability of critical raw materials. We recognize that because the balance of payments issue is an underlying consideration in all this, we must strive toward attainment of the same level of standards in all industrialized countries, thereby removing the possibility of placing our industries at a disadvantage relative to those of the other countries.

Editorial Note on Task Six

This task elicited considerable floor discussion. It seemed to be agreed that there was a significant, perhaps basic, distinction between the concept of the "closed cycle of materials" and the "recycling of materials." There was in the former concept a greater emphasis on (a) the use of all scrap, (b) the constructive use of effluents, (c) design attention to the ultimate fate of materials contained in products for the consumer, (d) the relation of the closed cycle to the national (or regional) energy balance, (e) definition of technological goals, (f) restriction of dissipative uses of nonabundant materials, (g) rates of degradation of materials repeatedly recycled, and (h) the economics of the closed cycle.

A total or ideal closed cycle was recognized as practically unattainable. The role of scrap export needed analysis. The question of whether the closed cycle should be attempted on a regional or a national basis was undecided. Also, it was suggested that the time frame was important and that changes in the pattern—or degree of comprehensiveness—of the closed cycle should be defined in terms of when necessary and for what materials.

From those conferees familiar with the secondary materials industry, the point was strongly made that the creation of markets for recoverable materials was the first requirement of any recycling or closed-cycle system.

Task Seven: DEMANDS, RIGHTS, AND RESPONSIBILITIES OF THE CONSUMER

What burdens on the consumer are implicit in the concept of improved management of materials, altered patterns of materials availability, and internationalization of environmental costs?

Rationale.—The ultimate purpose of all uses of materials is to improve the environment of the consumer; however, at various points in the process of converting materials into useful products, and their subsequent use by consumers, there occur adverse impacts on the human environment. In a sense, therefore, the "consumer" is the ultimate cause of the environmental effects of which the "consumer" complains.

(a) How is the consumer to be identified? For policy purposes, would it be desirable to distinguish among classes of consumers such as individuals, groups, companies, industries, governmental institutions, etc.?

(b) Are the requirements of the consumer elastic or amenable to modification for either materials-based products or environmental quality?

(c) What standards of product performance and environmental quality should the consumer expect, and how might these be achieved?

(d) Do U.S. and world consumers have access now or prospectively to a workable mechanism through which to impact on policy?

(e) What is the implied impact on materials costs of an individual's right to enter class action law suits against alleged violations of environmental quality legislation?

(f) What are the implications for the consumer of the conflicting consequences of demands for electric power for air conditioning his environment and demands that electric power generation not be permitted to inject heat into his environment?

(g) To what extent are these problems of the consumer a matter of regulation, resource allocation, frugality and waste reduction and education? Where should the Government as ultimate allocator of values place the principal program emphasis?

Report A

The consumer has demands, and is conscious of his rights, but is not always aware of his responsibilities. The average public consumer is not concerned with the materials in the final product but with performance and price. However, the one consumer who has real clout to make decisions regarding more effective and efficient use of materials is the manufacturer. His is the responsibility for product design that will facilitate more effective and efficient utilization of materials. There are examples to show that the ultimate consumer has some impact upon these decisions, especially when the product causes widespread environmental damage and has an ill effect upon his personal well-being.

The term "user" provides a clearer concept than that of "consumer," in the sense that there are users in every step of the materials cycle. Consuming may also imply "using up" or "destroying" (consuming fuel to produce heat). Consumer, therefore, is not synonymous with user. It is not desirable for general policy purposes to distinguish among classes of consumers—individuals, groups, companies, industries, institutions, etc.

The major requirements of the consumer are elastic and amenable to modifications in materials-based products. His requirements may be modified by increased price of materials and by fluctuations in income. There may be long-term effects, depending upon how high the price rises.

A second aspect is technological: there is a wide degree of elasticity in a technological sense. In case of transient inelasticity, the answer

is technology, research, and development (e.g. there is no basic problem in using aluminum for automobile radiators if we had practical methods of joining aluminum).

The subject of standards of product performance may be considered from two viewpoints. First, the standards may be tightened to improve durability and life of the product, the efficiency and efficacy of operation, other aspects resulting in conservation of materials and energy, and the achievement of other desiderata. On the other hand, on some occasions standards may have to be relaxed to permit trade-offs where the resultant compromise contributes to the optimization of the overall objectives. The kind of degree of trade-off depends upon the homogeneity of consumers and the specific situation.

Consumers should have the right to seek their individual goals with the least amount of Government interference necessary. Therefore, to that end, policies should be sought that maximize the freedom of consumer choice, subject, of course, to the constraints imposed by environmental and other external (nonmarket, nonpriced) costs.

What are the mechanics to achieve standards of product performance and environmental quality? In addition to Government agencies, there exist means through which consumer interests are partially protected. Among these are organizations such as the Underwriters' Lab, American Society for Testing Materials, SAE, Consumers' Union, etc. Roles of such groups should be expanded to take into consideration product design for recyclability and disposability, in addition to other aspects currently examined—durability, reliability, repairability, and safety. In order to enable these organizations to function effectively, the Government must assume a greater role in developing the standards from which the tests are conducted.

Class action suits against violations of environmental legislation are one means of emphasizing to the manufacturer the importance of meeting standards. Such suits will increase costs. Undoubtedly, other means should be investigated to bring about desirable actions.

Selection of appropriate policies regarding regulations, resource allocation, frugality, and waste reduction depend upon specific situations. Sound policy must be founded on a firm data base. Such a base is currently lacking in materials data and it is imperative that this be corrected.

Clearly the consumer, the user at various stages of the life-cycle of materials, is a vital factor in materials policy formation and implementation; that is, there is a "people's factor." On the one hand, as indicated above, probably every aspect of materials policy will impact on the well-being of the consumer. Conversely, the consumer's needs and rights influence some aspects of national policy. Accordingly, during the formulation of the policy, consumer opinion must be determined insofar as practicable. The national policy must be exposed to and explained to the consuming public at every stage of the life cycle of materials. It is imperative that there be a continuing dialog among all segments of society (the public, industry, Government) for mutual education and moral obligations. These activities must be considered and implemented in terms of both short- and long-range programs.

Report B

(1) *Who is a consumer?* We recognize several types: individuals, Government, companies, and institutions. Some are final users of a product, others may modify or utilize materials to produce a product. We recognize needs, rights, and responsibilities of all the groups, but point out that they cannot be considered the same in regulation, education, and economic freedom and constraint. In particular, the vote of the individual in our political scene does give a certain clout, but the aloneness of an individual compared with the strength of large groups, such as corporations, the military, institutions, and Government itself produces weakness.

(2) *Recognizing differences between classes, how is wise allocation of scarce resources made?* By ability to pay? By an agency? By a czar? Whatever the decision, a focus needs to be given to the extent of establishment of an active arm of Government to oversee allocation of specific materials when that is necessary.

(3) *How does an individual consumer exercise his desires for quality?* Through selective purchasing. Through complaint over faulty products. Through suits in court. Through newspaper and radio. Alone, the individual may seem to have little total power, but joint action adds to that power. We believe the power of the individual is increasing and, fully as important, the awareness of power is increasing.

(4) *When substitutes are desirable or necessary, what features need to be considered?* Performance of the product is important, but also the safety of the user and lack of further degradation of the environment are important. We emphasize that the capacity of the professional community of this Nation to solve technical problems is high. We acknowledge the existence of problems in the present and future, but we should not despair of their solution. We have a great deal of confidence in the inventive capability of the Nation.

(5) *Overuse of materials.* Beyond doubt, many materials applications result in overuse, either in quality or quantity. This may be called the "profligate century." To control use of critical materials, a tax might be levied on use of critical materials. To emphasize to the individual the importance of specific materials or practices, we believe more attention should be given to incorporation of the real cost of materials in the price of actual products. Subsidies in specific instances spread the cost of a given material or practice. Putting the cost where it occurs could affect the use of specific materials and products. Example: the Federal reimbursement for black lung does not put the cost where it actually occurred—on coal.

(6) *Consumer responsibility.* All of us know many examples of individual overuse of materials in an affluent society. All of us are guilty, some more than others. Evidence exists that difficulty will come in use of all materials sooner or later, but we seem collectively heedless

of warnings of trouble. Because of population increase and per capita increase in materials use, we must plan to alleviate these problems.

Three courses of action seem available:

(a) *Education:* We see in ourselves the feeble results of education. And who can deny the request of free people to enjoy the fruits of affluence if they wish to and can afford them financially? Appeal through education will not be sufficient.

(b) *Regulation:* The limitation of freedom by regulation of use of materials seems inevitable. Yet such regulation will have to come slowly because we are not yet conditioned to accept the need for control. In fact, through advertising, through merchandising practice, through our everyday experience, we are led to expect an endless plenty. If controls should be necessary, the information trend will have to change.

(c) *Real cost:* To what extent should the price of objects and energy reflect their real costs? How should the consumer be made aware of real costs? Consideration should be given to letting materials find their natural price—for example, natural gas.

(7) *Problems of regulation.* The Nation operates on the basis of meeting crises as they come. The next crisis in materials seems to be in fuels, not minerals. Our group can think of no metal whose use demands regulation in terms of worldwide availability of ore. In terms of U.S. needs, the problem is political and financial. In iron, the worldwide reserves of ore are so great that no need exists for recycling all of our scrap on the basis of ore needs alone. Esthetics, control of waste disposal, and maintenance of quality of life are more valid reasons for recovery of iron scrap.

Summarizing Statements

The complexity of the materials problem in its technological, political, and financial ramifications makes understanding of the problems of worldwide use of materials difficult for the individual. Indeed, advertising, pricing schedules, substitutions, and inventiveness of manufacturing practice tend to mask present or potential problems. The ability of the individual to pursue perceived goals is further complicated by an inherent desire to satisfy his own individual needs even as he pursues the common goal. An active arm of the Government should be established to focus the collective perception of the Nation on allocation, regulation, education, and pricing of materials.

Editorial Note on Task Seven

The Conference appeared to have reservations about the possibility of a constructive role for the ultimate consumer in the management of materials. The view was general that the buying public did not recognize the materials content of purchased products—either as a potential shortage or as a recoverable value. The consumer's interest lay more in product performance, safety, and cost.

Although the free market system was seen as the principal and preferred mechanism for allocation of materials in industry, the system was not offered as an equally effective way to make consumer choice compatible with good management of materials. The pricing system did not educate the public in this way because political intervention in the form of subsidies and various forms of preferential treatment tended to obscure real costs.

The conferees saw some possibility of a future change in consumer attitudes but mainly in response to serious or widespread environmental damage or personal hazard. The complex sociological problem of motivating concerted public programs to segregate trash or to abstain from littering was passed over.

Task Eight: ECONOMIC OPPORTUNITIES AND CONSTRAINTS IN MATERIALS

Rationale.—Apart from their physical role, conferring properties that enable man to control and manipulate his environment, materials also have an economic role. Apart from the precious metals which have intrinsic value, most materials are assigned value in proportion to their utility and inversely to their abundance, within a lower limit of out-of-pocket cost to produce and an upper limit of the industrial and the ultimate consumer's willingness to buy.

In extracting materials from nature, the motivation is price. Yet making them abundant drives down the price. Conversely, making them scarce pushes prices up; but when price rises too high, the consumer is diverted to alternates. The classical picture of materials economics is one of fluctuations in price, with each producer and each consumer trying to outguess his competitor in determining when and how much to buy. Above-ground inventories and recovered scrap become a part of the puzzle.

Superimposed on this classical picture are many social constraints: antitrust laws, taxes (including taxes on proved reserves in the ground), tariffs and export/import regulations, embargoes, price regulation, and many others.

In recent years, an additional regulatory feature has been concern for the environment. It has resulted in many kinds of regulatory actions, with more in prospect: against pollution of waterways, against pollution of the air, against siting of powerplants in some localities, against dumping of tailings and waste materials, against dangerous health and safety conditions, and many more. The end is not yet in sight.

Discoveries of small, rich deposits of minerals are becoming less frequent and also less important. As world demand rises, attention of producers focuses on large, low-grade deposits. But these require heavy capital investment. Tax laws prevent these investments from being rapidly amortized; interest rates require them to be carefully discounted over future years; the impact of national and international

regulations and environmental regulations combine to force these large producers into ultraconservative patterns of behavior. These built-in inflexibilities in corporate structure tend to have the effect of reducing the quickness of response to the market and intensifying the fluctuations in price.

Issues for Consideration

(a) Should national policy aim to restore the flexibility of the marketplace in materials, or conversely should it recognize that the pricing system must be replaced by an institutional structure to stabilize prices and supply?

(b) If other nations act to stabilize their own supply and demand in materials, while the United States opts for a strategy of free market flexibility, will this country be compelled toward a costly and production-limiting policy of autarky—of materials self-sufficiency?

(c) If the impact of laws and regulations threatens to reduce available supply, should the United States turn to supplies from abroad where laws and regulations may be less stringent?

(d) Or what happens when large foreign sources of production are nationalized and their products tend increasingly to be upgraded to semi-finished and finished goods at home?

(e) What can be done in the United States to improve the economic prospects of large and stable producers of materials?

(f) How can a more dynamic and flexible response be built into the large corporations whose behavior tends—by all these circumstances—to be forced today into ultraconservative patterns?

(g) To what extent can these problems of materials balance be minimized by a national policy of R. & D. to enhance the properties and extend the utility-per-pound of materials?

(h) To what extent can these problems of materials balance be minimized by a national policy to intensify the re-use of materials, recovery of byproducts, and a more frugal use of energy?

(i) What actions and policies by the Federal Government are appropriate to design and stimulate corrective measures in the face of this dilemma?

Report A

General Goal

To provide economic and regulatory policies that will insure adequate established reserves of materials into the future consistent with environmental quality.

The specific policies listed below will help attain the above goal:

(1) The most economical domestic resources should be used initially because any other priorities would be unworkable in our society. However, the social cost (pollution, environmental impact) must be included in the price of the material marketed.

(2) Research on abundant resource materials should be encouraged and supported to make them functionally and economically substitutable for both potentially scarce materials and materials that we must import. Such research should include both the extractive processing and property development.

(3) National objectives for recycling of materials should be formulated. For a given material, such objectives should specify a percentage recycling target to be attained in a definite number of years. The recycling programs should be addressed to problems with materials in the following categories:

(a) Materials in short supply—a proper recycling program will develop an ever-increasing, circulating inventory of these scarce commodities.

(b) Materials in which primary production damages the ecology.

(c) Materials for which disposal results in a health hazard.

(d) Materials for which disposal creates a land use problem.

(4) Historically, this country has imported raw materials and exported the products of technology and management. In the future, it should be our policy to resolve balance of trade problems by improvement in such export areas and not by restriction of raw materials imports.

(5) Raw materials should be bought on the world market in accordance with market prices. However, in order to provide adequate protection against major interruption of foreign supplies of these materials, mechanisms such as stockpiling, development of substitute materials, and standby facilities for processing indigenous resources should be employed.

(6) Investment in production-scale facilities that utilize new improved technologies for processing materials should be encouraged by the Government through appropriate fiscal incentives.

Report B

Issues Considered

(a) Should national policy aim to restore the feasibility of the marketplace in materials, or conversely should it recognize that the pricing system must be replaced by an institutional structure to stabilize prices and supply?

A country can influence prices only when it is a major purchaser or supplier. There are few materials falling within this category, and one example is steel scrap of which one-third of our production is exported to Japan. It should be supply and demand which fixes the price. However, the first part of this question admits that flexibility does not exist. It was concluded that the problems are not technological but are due to self-interest groups, economics, and international trade. Therefore, recommendations of a national materials policy to control

prices artificially would probably not be accepted by Congress and would therefore have only a marginal effect. A group formed predominantly of engineers cannot influence this complex situation.

Considerations of prices must be made on a global scale and must include effects of nationalization in other countries.

Efforts should be directed to liberalize constraints that hinder U.S. industries from reacting rapidly to world market challenges. Among the constraints mentioned were antitrust laws limiting the ability to collaborate, and the very high cost of innovation in the primary metals industry in that companies sometimes duplicate efforts and investments are made at company risk. In other countries, the efforts of government, universities, and industries are often well coordinated and are subsidized by the governments concerned. Our industry often competes with nationalized conglomerates.

Institutional standards must be of international scope as the United States as a whole no longer has the capacity to influence the market and price structure.

(b) If other nations act to stabilize their own supply and demand in materials, while the United States opts for a strategy of free market flexibility, will this country be compelled toward a costly and production-limiting policy of autarky—of materials self-sufficiency?

It is not necessarily always a threat when other nations stabilize their supply in relation to their own internal demands, as is the case with Russia's achieving a smooth growth curve for steel production.

Problems are encountered, however, when a foreign country goes after the same source of materials as does the United States. A competitor in this regard is Japan, looking for material sources as a whole, and not as separate companies as in the United States. The economic theorists contend, however, that this is not a problem as these materials result in cheaper products than those available in the United States, and that the imports, in turn, stimulate our economy.

It was generally felt that we should not strive for autarky, but for a situation in which a company can compete fairly in the international marketplace.

We should, however, avoid becoming dependent for high-technology materials and products, particularly, when they relate to our national defense.

(c) If the impact of laws and regulations threatens to reduce available supply, should the United States turn to supplies from abroad where laws and regulations may be less stringent?

This question can also be worded as follows: "Do we want the pollution here or abroad?" Turning to other countries with less stringent laws and regulations is only a temporary solution. Even though this situation does exist today between some industrialized countries, it is not a lasting one.

International labor rates are analogous to this problem. For example, in a decade or so, Japan will not be the cheapest labor source.

Concerning laws and regulations, it was felt by some members of the task force that the burden, or cost, of pollution control could be equalized throughout the United States for a particular industry, for example, copper. In the long run, the environmentalists would not accept this, because of the different ecosystems at different geographical locations. However, it would be a less disruptive approach for employment and the economy.

It is likely that initially the emerging countries will accept environmental pollution, but they will hopefully and rapidly learn from the mistakes of Japan which has apparently sacrificed environmental standards for industrial growth.

(d) Or what happens when large foreign sources of production are nationalized and their products tend increasingly to be upgraded to semifinished and finished goods at home?

There is little that can be done with respect to this problem which, however, is not as severe as is sometimes claimed. The value-added approach of some emerging countries is a gradual development. It gives the United States time to "feel" and plan the response. Some members of the task force expressed the opinion that although in 5 to 10 years, we will be importing alumina instead of bauxite, alloys may not be available from these emerging countries in the foreseeable future.

Examples were discussed where U.S. companies develop foreign resources. For example, United States Steel has built a plant in Venezuela producing metalized ore. This approach is important. It enables other countries to bring their own troubles under control, and it is, therefore, desirable that the United States supplies technology to achieve this. As plants in emerging countries move further along the applications engineering process, the facilities become capital intensive, the equipment must be purchased at higher prices, and these new industries will begin operation at higher initial costs. The production costs will increase accordingly and the price-differential will decrease.

The potential market in emerging countries for semifinished products will stimulate the above trend. Such a market is the building industry.

An area which should concern the National Commission on Materials Policy is high-technology R. & D. This should be continued vigorously. In the past, progress was often the result of emergency or constraint situations. Planned, long-range, high-technology R. & D. is necessary.

(e) What can be done in the United States to improve the economic prospects of large and stable producers of materials?

To address this question, it is necessary to consider some examples of primary materials. Those selected for this purpose are: (1) copper, (2) steel, and (3) aluminum.

Recycled materials and forest products are not considered. However, some of the considerations for metals are also applicable to the problem of improving the economics and conserving resources in the forest products industry, for example, innovative design concepts for industrialized housing.

(1) The Copper Industry

The major problems identified for this industry are:

(a) That copper ores are becoming increasingly lean.
(b) Water and air pollution.
(c) Land use and vast solid-waste disposal.
(d) New markets are needed for recycled copper.
(e) Substitution of aluminum for copper for electrical applications is becoming more extensive.

The cost of mining and milling copper ore is roughly 80 percent of the cost of the mill product. The remaining 20 percent is contributed by the smelting and refining operations and marketing. In the discussions of the task force, the emphasis was therefore on the mining operation.

It was concluded that new mining technology is urgently needed. An example is in situ leaching, first, to enable underground mining, and, second, to avoid the immense solid-waste pollution problem.

The increasing costs of pollution control will aid recycled copper and generate markets for this grade.

(2) The Steel Industry

It was agreed that the economic prospects for the steel industry are not bleak. At this time, only 20 percent of the steel used in the United States is imported.

A problem is, however, that restraints are placed on wages and prices, yet steel companies are expected to compete with foreign countries whose prices are moulded in a different manner, as briefly discussed earlier (consideration "b").

To improve the economic prospects of the steel industry, productivity needs to be improved. This can be accomplished as follows:

(a) Through management talent,
(b) Automation, and
(c) Innovation of processes.

A change in attitude of labor will be required. Labor must understand it is in an international market.

An effective way to achieve quantum jumps is to reduce production steps, for example, translate directly from ore to sheet, continuous casting, etc. This should be achieved by a cooperative R. & D. and investments, rather than competitive efforts. Cooperative research is advantageous for the entire industry.

It was felt that industry has concentrated on major markets. Of these markets, road and tracked transportation of people and freight is included.

It is necessary for the steel industry to stimulate utilization of its materials more efficiently in this market through the aggressive generation of innovative design concepts, for example, multilayered, automatically welded configurations, meeting needs of light weight, low maintenance, and repairability. If such innovations do not take place and soon, aluminum, low-cost fibrous composites, foams, etc., will make significant inroads in the transportation market for steel.

(3) The Aluminum Industry

The development of technology to extract alumina from domestic materials was emphasized as a means to improve the economic prospects of the aluminum industry.

The ease with which aluminum alloys can be machined, formed, drilled, and adhesive-bonded is a reason, besides its light weight, why this category of material is making inroads in land and sea transportation and capturing markets previously held by steel.

The ease of fabricating products from aluminum sheet and extrusions may favor its selection in the future because of considerations of minimized energy requirements for well-known reasons.

An increase in emphasis on the opportunities of engineering design, employing aerospace design philosophies to improve fatigue lives of installed structures in transportation, for example, the development of crack-propagation tolerant structures, will improve the economic outlook for the aluminum industry.

It was also concluded that experience shows that the return-on-investment on R. & D. in these three primary industries is low.

The future impact of layoffs of highly-qualified scientific personnel at major laboratories of primary metal fabricators should be of concern to the National Commission on Materials Policy and should therefore be evaluated. The pool of R. & D. resources and Government-sponsored projects possibly related to high technology materials critical to our national defense should receive consideration as mentioned in the remarks for steel earlier.

Zinc is a textbook example of what can happen. In the last 3 years, eight smelters have been closed because the facilities were not competitive.

(f) How can a more dynamic and flexible response be built into the large corporations whose behavior tends—by all these circumstances—to be forced today into ultraconservative patterns?

The suggestions of pooled R. & D., etc., referred to earlier will enable more dynamic and flexible response to market opportunities.

(g) To what extent can these problems of materials balance be minimized by a national material policy of R. & D. to enhance the properties and extend the utility-per-pound of materials?

It is possible for a national materials policy to be developed recommending and justifying higher performance, lighter weight products of longer life than present products, but is there a mechanism of implementation?

Concern was expressed as to how such a policy could be policed. Also, how will incentives be provided? Should the Government support the R. & D. in this area, for example, using matching funds? It is recommended that the National Commission on Materials Policy define such goals.

A question which the task force could not resolve is how do we

change the economy from planned obsolescence to products with considerably extended life. There are now three types of obsolescence. These are:

1. Technological
2. Deterioration (inferior quality)
3. Stylistic (due to changing tastes and advertising created "wants")

Many different customer requirements are motivated by different psychological and behavioral needs and characterized by many subpopulation groups. It is, therefore, unlikely without an extensive educational and advertising program, that longer life products, such as automobiles, will be acceptable by everyone. Do poor people want expensive automobiles that last 10 years? There are no simple solutions.

We can, with adequate R. & D. and creative approaches to engineering design, develop products of longer life-conserving materials of construction and reducing power requirements, but can and will the subpopulation groups representing the U.S. public pay the price? The task force could not determine this.

To provide some information to enable judgments to be made in this complex area, it was suggested that a historical study might be made of products, costs, life-times, and quality, for example, 20 years ago compared with today's products.

In this vast and urgent area of new product development, enhancing properties and extending the utility of materials, a number of complex and broad questions must be answered. Typical of these are:

(1) What will the population growth rates be in the future?

(2) Will there be growth or will we move sideways generating new markets?

(3) Is the economic situation favorable to stimulate growth?

(4) Are the major opportunities for material resources open to underprivileged population groups?

(5) Will there be greater emphasis in the future on satisfying needs instead of creating "wants"?

From these five questions, and there are certainly others, two broad questions can be recognized related to national materials policy:

(a) What R. & D. do we need for present materials and short-range market needs?

(b) What R. & D. do we need for future products involving materials emerging from the laboratories employed in structural systems?

Research on materials and design developments in the future will require a different emphasis than in the past. Materials will not be developed to meet simpler requirements of the past, for example, strength or stiffness requirements at a high temperature. Similarly, design will not involve simply minimized weight. More complex institutional standards and customer needs must obviously be met.

We, therefore, conclude that this is an important R. & D. area and many subordinate areas involving enhancement of materials utilization can be proposed.

Increased durability will not make inroads in recycling, but will extend the product life cycle.

(h) To what extent can these problems of materials balance be minimized by a national policy to intensify the reuse of materials, recovery of byproducts, and a more frugal use of energy?

Recycling can be mechanized through innovative designs, for example, easily removable auto electrical harnesses and pop-out bearings.

An emerging problem, exemplified by the automobile, is that when the engineering designer has to employ materials systems, modularized construction, and other design refinements to meet DOT and EPA requirements, the process dissipates more elements and complicates the recycling process and distribution. It can cease to remain a volume proposition for the recycling plants. Scrap contamination can also occur. However, the trend to materials and structural systems is already with us. The systems can enhance the desirable properties of materials and avoid the undesirable properties.

Progress is being made in separating materials and reference was made to a cryogenic (liquid nitrogen) technique developed in Belgium or Holland for removing plastics from metals.

Besides the design goals of satisfying human and aesthetic factors; minimized weight and cost; improved safety, reliability, and repairability; the engineering designer must achieve a product that is amenable to recycling.

It is necessary to conduct R. & D. on low-cost disintegration techniques, achievable both at the design stage and for use in the recycling process. It is not, however, possible to estimate the impact of such research programs on the materials balance.

(i) What actions and policies by the Federal Government are appropriate to design and stimulate corrective measures in the face of this dilemma?

The foregoing questions are all interrelated.

It is recommended that R. & D. on life cycles should be initiated on high-volume items. Examples of such products are:

(1) Household appliances (freezers, washing machines, dishwashers, air conditioners, and dryers).

(2) Automobiles, trucks, tires, and batteries.

(3) Railroad equipment (75,000 box cars dismantled annually).

(4) Television sets, radios, computers, electronic tubes (containing high-value metals intricately utilized and difficult to extract).

(5) Containers and packaging (involving many combinations of materials).

(6) Manufacturing equipment.

(7) Communications equipment, including telephones (containing 15 percent copper removed only with difficulty).

An excellent model for studying the complete life cycle process is the composite tire which cannot be recycled today.

Extensive R. & D. is required on recycling plastics.

Editorial Note on Task Eight

The discussion of this topic reflected the ambivalence of the title—"problems and opportunities."

The problems discussed centered on an asserted rigidity or lack of flexibility of American industrial management and other decision-makers in meeting serious domestic and foreign challenges. The latter received more of the attention of the conference in the discussion of this task.

There appeared to be a consensus that the U.S. economic position in the global framework was deteriorating. Factors in this trend included the difficulty of competing with large developed countries, with countries embarked on planned and vigorous programs of concerted export effort, and with nations employing a system of "state trading." The Common Market posed special but important problems.

Several issues could be foreseen as needing attention. The "export of pollution" was one of these—the transfer of "dirty" industries to other countries to comply with increasingly stringent U.S. regulation for environmental protection. Another was the question of whether to rely mainly on domestic sources of materials, or on foreign supplies, or some mix of both of these. A third issue was the question of whether U.S. antitrust policy really placed American industry at a competitive disadvantage vis-a-vis foreign industry in the effective management of materials. (The pooling of research and the sharing of technology were cited as examples.)

Some conferees suggested that a national strategy in materials appeared to have been pursued by the United States, more or less by happenstance. It was, as one participant expressed it, a strategy of being the "high technology and service manager of the world while importing materials and products." However, this strategy did not appear to be adequate; at a minimum, it should—another speaker proposed—be supplemented by the further national role for the United States of "designers to the world."

There was a consensus that a purposeful national strategy in materials management was needed, and that it should be designed consciously rather than evolved by default.

Among the illustrative questions to be resolved in the formulation of the national strategy were (a) whether to expand the capability, quality, and scope of design for export, (b) whether to maintain or expand the level of research and development—especially the latter; (c) whether to accelerate the internal exchange of technology and its application (even at the cost of some modification of antitrust regulation); and (d) whether to expand and intensify the use of materials (such as glass and wood) that are not subject to supply or import constraints.

IV. SUMMARIZING STATEMENT OF THE CONFERENCE

Two years ago, while the National Materials Policy Act of 1970 was pending in the Congress, we held a conference here to develop the themes that would be of concern to the proposed Commission on National Materials Policy. The papers delivered at that conference were collected and published, and have been useful to the Commission as we had hoped. Some of this gathering participated in that session.

Since then, as the prospectus for this conference has indicated, there have been a number of important developments in materials policy. There is no need to tabulate them all. As Jerry Klaff has suggested, they can be quickly summed up as a growing national awareness that materials, energy, and environment make a triad of interlocking problems. Unless we deal systematically and comprehensively with these three closely related sets of problems as really a single problem, the consequences may be undesirable at best and at worst catastrophic.

The format for this Henniker Conference on National Materials Policy has differed from the last one. This time, the participants were asked to make their own input. The product of the conference comes mainly from you. It is my task in this final session to gather together the themes that have been expressed here, to indicate—as best I can—the points on which you appear to agree, and the points still at issue.

Before turning to the reports of the task forces, let me quickly run over the proceedings of our first day. The purpose of that session was to set the stage, provide some elaboration of the problems the task forces would handle, and provide emphasis as to the importance of these problems.

In starting out, Charlie Ryan sumarized the university forums. He said there emerged a clear call for a stated, comprehensive national policy for materials. Laws and regulations should be responsive to this policy instead of the other way around.

The policy should take explicit account of the fact that natural resources and the environmental consequences of their mismanagement are not merely a national concern but a global concern. Subsidiary policies are required to reconcile the U.S. concept of free markets with the fact that much of the world's resources are nationalized, as is a great deal of foreign trade. How does the individual businessman compete with governments for the sale or purchase of materials?

The necessity to deal with the national issue of growth versus the achievement of a steady state was clear, but there was little consensus on the issue or how the policy—however decided upon—would be implemented. It appeared to involve the questions of how to change or preserve a free market pricing system, whether and how to achieve a more equitable distribution of materials goods, whether to concentrate on tax policy to restrict use or on technology to achieve more intensive use of resources. Some optimists still called for a policy of unlimited growth.

All parties seemed in agreement that there should be more Federal support for research, development, and education in materials-related science and engineering. But there was no consensus as to the goals of research and engineering, or as to the tasks that the newly educated scientists and engineers would perform for the public whose taxes would pay the costs of the expanded research and education.

It was well established that policy cannot be made in a vacuum, it must be based on factual information. Charlie listed many needed categories of facts:

Impact of minerals on environment.
Monitoring of the environment.
Special ecosystems.
The individual materials cycles.
Special problems of toxic metals.
Land use inventory.
Forecasting of needs for technology.
Forecasting effects of new technology.
Facts about who pays for and who benefits from clean-up of the environment.
(Or conversely, who benefits from and who pays for dirtying the environment?)

The principle of recycling was everywhere endorsed, but the reasons appear to have been taken for granted. Mention was made, but more emphasis could have been given, concerning the enormous effect of recycling on conservation of electrical energy, achievement of steady state reduction in the consumption of space, as well as the often mentioned conservation of materials.

Charlie's paper offered a host of detailed recommendations that seemed important to those who offered them, but must be judged in the broader context of total national concerns and approaches.

For example, many techniques of materials conservation were offered, such as substitution, miniaturization, use of replenishable resources such as wood and manganese modules or inexhaustible resources like magnesium and perhaps iron. During my Pentagon stint, I developed something like 30 classes of conservation techniques for military purposes, and all of these would be applicable here. But the broad policy calls simply for measures to encourage more intensive use of materials, with the designation of appropriate instruments of government to implement this policy.

Charlie's report dealt also with an array of current constraints on private enterprise in meeting present or foreseeable needs. Clearly

there was ambivalence as to whether primarily reliance could or should be placed on private commerce or government regulations. This is a fundamental policy issue. Either course has many adherents, but both courses will need to be followed, and whichever is emphasized, the costs of that choice will be heavy and unpleasant to many people. Ultimately, the decision will be made on a political basis. Technology is the art of the possible. But politics is the art of the acceptable.

Harry Paxton, who followed the Commission talks, described the research program of the NSF. He made clear that his primary mission was to identify and find opportunities for good research, and that the basic research orientation of NSF might make it an awkward instrumentality of government for sponsoring mission research.

SUMMARY OF PRINCIPAL POINTS IN TOPICS RELATED TO MATERIALS SCIENCE AND ENGINEERING

Vic Radcliffe: During the past several decades, materials science and engineering has become recognized as both a broad field and a specialized new concept. The field involves recognition of a commonality of features underlying properties and behavior, and draws on activities and contributions from several established disciplines (solid state physics and chemistry; electrical, mechanical, and chemical engineering; as well as metallurgy, ceramics, polymer science, materials science, and materials engineering). The new concept couples the science and engineering of materials to the functional needs of engineering design or problems. The field occupies a key position in the total materials cycle.

The COSMAT study is concerned with the nature of the field, its institutions, its relationships to national needs and materials policy, and its ability to provide options to assist in meeting these needs.

Dick Claassen: The MSE concept of "purposefully coupled materials science and engineering" has been shown to operate successfully in a significant region of the total materials cycle. He described case histories of materials development in both high and low technologies to illustrate its operation and applicability.

Walter Hibbard: Addressed himself to the subject of materials institutions. Other than in communications and electronics, functional characteristics predominate rather than structure-properties. The MSE concept is not used.

During recent years of austerity, industrial R. & D. in materials has been severely reduced with respect to long-range research and strongly focused to product and time schedule marketing. At the same time, industry is facing a variety of challenges from environmental organizations, and successful foreign competition in technology. The Federal Government has developed a substantial regulatory role that is affecting the effectiveness of industry as "the engineering arm of society." In the universities, there are some 30 materials research centers and no shortage of trained people. But the research has not con-

nected effectively to industrial application. A new approach is needed to stimulate industry to face and deal with these new challenges and needs.

Dr. Wells: Speaking on materials and national goals, decried the tendency in developing policy by obtaining a consensus of majority opinions of practitioners. Their opinion is often based on inadequate facts. Many problems relevant to materials and national goals are researchable and policy developments should be undertaken only after such research (e.g., the problem of long-range scarcity) by independent research organizations to achieve maximum objectivity.

Nate Promisel: International activities: he dealt with seven major activities: general policy, long-range planning, R. & D. programs of new technology, natural resources, education, communication and standardization.

He described the evolution of the Materials Research Advisory Group in OECD—which is now exploring a reorientation towards resources and recycling; he also touched on the AGARD group in NATO, primarily concerned with specific technical topics related to military technology. He offered some general conclusions:

(1) National science and engineering are in transition in both character and organization,

(2) There is a major interest in resources supply; this leads him to conclude that the United States can expect supply problems,

(3) New technologies are generating new materials R. & D. needs—e.g., high-speed transportation,

(4) Foreign government-encouraged high technology is increasing their advantages versus the United States,

(5) Very effective means for utilization of research results exist, for example, the Max Planck Institute,

(6) Much of U.S. materials technology is purchased from abroad, especially in process innovation,

(7) U.S. ahead in development of university centers for materials research,

(8) Materials information disseminates rapidly abroad to all who can use it,

(9) Government risk capital is available in these countries to help create new industries and strengthen old ones.

The closing session on Monday developed some of the themes stressed in the policy discussion by Secretary Dole last night. Earl Hayes provided extensive documentation of the need for strengthening the domestic minerals industry—looking toward a closed cycle in the total management of materials by society. He also warned of the coming power and fuel crisis as emerging nations compete for the world's dwindling reserves of fossil fuels.

Secretary Dole translated the findings of the minerals report into policy imperatives. He said: The Minerals Policy Act needs an organization capable of implementing this policy which we do not now have.

We should reduce the uncertainties that keep industry from investing, modernizing, and keeping up with the rest of the modern nations of the world. These include: the impatience of environmentalists to clean up everything at once, the eagerness of ecologists to reserve public lands free from mining, the problem of finding people willing to work the mines, also, tax laws, exploration laws, and uncertainties over stockpile releases.

He said: "There is * * * nothing very attractive about going into a venture in competition with enterprises elsewhere in the world, with equivalent technology, which work ores three times as rich, pay one-fifth the wages, and are largely free of environmental restrictions on production."

We suffered from technological arteriosclerosis. Our need to import materials from overseas would generate a supply/demand gap that might reach $31 billion by 1985.

Larry Kushner described the strategy of the President's new technologies program. He identified an increase by $2.1 billion in technology development expenditures 1969–73, including programs in energy systems, natural hazards control, cancer research, transplant, and NASA civil systems research.

The strategy called for new Federal incentives to increase investment in technology development and application and direct Government support for research on projects to improve everyday life.

The cooperative program of NSF and NBS, called "experimental technology incentives program," was a program open to companies and groups of companies, various research institutions, trade and industry associations, and others. The experimental aspect was in fact a search for incentives that work. Among its aims of interest to the materials community was the design of government programs to assist (as he said) the normal competitive market mechanism in providing incentives for needed technological developments.

Jerry Klaff described the task of the National Commission on Materials Policy. He saw four goals:

(1) Conservation of materials, and preservation of the environment.

(2) Adequate materials and energy for national security.

(3) Adequate materials and energy for our economy.

(4) Materials and energy policies that will stimulate social progress.

He offered one general principle:

"Materials, energy, and the environment cannot be treated in isolation one from the other. Materials and energy are the driving forces of the Nation's economy. A wise and more efficient use of resources and technology as our act suggests, can lead us to the type of environmental quality that America is seeking."

Like Hollis Dole, he took note of the changing U.S. position in a developing world, quoting Secretary Peterson on the need for a more dynamic response to change. He called for plans for conservation of materials as a statutory obligation, referred to 4.3 billion tons of wastes

generated annually, and costing $4.5 billion just to get rid of it. What to do? It boiled down to a question of better management of the total materials cycle.

Our speakers this morning dealt with three topics that had not received attention earlier in the week. I suggest that these topics are all important ingredients of our national materials policy, and of the means for its implementation.

Jerry Persh described a detailed methodology for translating technological needs into highly specific programs of research and development. This technique, employed in the Department of Defense, would seem to offer opportunities for application in the newer Departments—particularly in transportation, housing, and urban development. The technique also has implications for the transfer of technology to nongovernmental users. On both counts, it warrants consideration as an element of national policy.

Dr. Pfeffer, from the Canadian Department of Industry, Trade, and Commerce, gave us, I think, some useful new insights into the role of the multinational corporation as a trade bridge between and among nations. By calling attention to the differences in structure of such corporations, and by relating these differences to the sociological impact of the corporation on the local community, he has enlarged our understanding of this still-evolving institution. More consideration should indeed be given to the importance of combining imported skills with local leadership.

Philip B. Yeager, counsel to the House of Representatives Committee on Science and Astronautics, provided us with a welcome assurance that the Congress is closely attentive to the problems and opportunities of the materials community. Also of value to us was his caution that the need of Congress was for facts. Legislation is seldom responsive to mere say-so. The materials community and the technical societies should document their needs and the needs of the public to strengthen the U.S. position in materials and materials technology. But if the materials community is prepared to do this, a strong partnership for purposes beneficial to the public is in prospect.

As I turn to our eight tasks, and your comments on them, I do so with a sense that there is much more here than meets the eye, more than I can hope to do justice to in the brief time I am willing to subject you—and myself—to. I want to study your contributions at greater length. I propose also to communicate with the 16 chairmen to refine and polish these statements further, to reflect more precisely the views of the panels and the sense of the meeting yesterday.

Instead of attempting to summarize the individual papers and your comments on these papers, let me run through the eight topics and see if I can present on each a summary statement you can all subscribe to.

On topic one, the question of central government planning and coordination, I think you indicated a general agreement that the very numerous materials functions and impacts of the Federal Government should be coordinated by one policy agency, not an operating agency, but a high-level council or board supported by a flow of reliable information, and able to transfer funds to support programs and activities

it saw as necessary to strengthen the future of U.S. posture in materials.

Furthermore, I think it was the sense of the meeting that this central coordinating and materials planning body was needed soon, and not at some long term future period.

Topic two concerned the opportunities and responsibilities of industry in the materials area. The purpose of this question was to open up a dialogue on ways in which the free enterprise system might be purged of avoidable constraints and provided with reasonable incentives in its relations with the Federal Government. I would judge that the kinds of questions asked under this heading were too searching to be manageable in the context of 1-day study.

Nevertheless, some principles emerged that I am inclined to treat with respect. For example:

The traditional role of private industry as the main engine of commerce to produce and distribute goods and services does not require restructuring.

Government regulation should avoid arbitrary impacts and should strive for flexible accommodation to changes in technology and changes in public needs.

The undesirable side effects of free enterprise are capable of reasonable control and warrant it.

It is preferable to achieve social advance through incentives rather than through disincentives.

Regulations should not impose unreasonable time constraints.

Highly segmented industries and local governmental institutions need special treatment to achieve economy of scale in R. & D.

Government standards should aim toward improvement of product rather than toward cheeseparing frugality.

Improvement is needed in present procedures for establishing the performance and reliability of materials in design and service.

Topic three, international competition and cooperation in materials. This topic posed squarely the issue of national self-sufficiency versus global cooperation. The response was not unequivocal. There was some sentiment for a policy of interdependency and cooperation, if only because of the enormous costs in dollars and lowered living standards resulting from the alternative.

The concept of reduced dependency was also attractive but raised questions as to its compatibility with the principle of free enterprise. Naturally, total self-sufficiency would vastly disrupt free enterprise patterns.

One conclusion seemed clear: that study of the implications of the alternatives, and various mixes of strategy required much more study and that there should be an agency charged with responsibility for keeping an eye on this problem in the future as world conditions continued to change.

On topic four, research and education, it was rather notable that the sentiment seemed more in the direction of doing better than doing more.

Stability of research level was viewed as important. Improved coupling of research and engineering was called for, particularly involving real world problems in the academic classroom or by taking the students out of it.

One study proposed a kind of stockpile of technology to enable a flexible response to all kinds of emerging situations in which substitutes and emerging conservation measures might be useful.

The question as to division of government resources between inhouse and contract research remained unresolved.

More attention should be given to the preparation of research reports and their dissemination. Information management should not be a separate and self-supporting activity. Funds should be allocated not only to long range and good research but to goal-oriented pertinent research.

The "mature industries" need more and better R. & D. and the reasons why should be studied.

The question of technological obsolescence inspired me to speculate whether there was a different half-life of technology in low- and high-technology industries and if so, whether it might not be to our advantage to invest more heavily in raising the technological level of low technology (and perhaps also the service) industries.

On topic five I heard no consensus. The problem of information management was technically too difficult to resolve, although many interesting ideas were broached.

I believe we can all agree that knowledge management in the materials field is a pervasive and vitally important subject, one that must be dealt with, one requiring positive action, but also a subject that does not lead itself to facile and simple solution. It is a subject calling for hard study by the Commission and others.

On the question of the "closed-cycle flow of materials," topic six, there appeared to be agreement that the "closed-cycle" concept was preferable to the idea of recycling. It involved more explicitly the idea of total management of materials as a system or flow.

Although discussion brought out some of the limitations of the concept, it clearly offered great economies of electric power, as well as better control of wastes—a matter to which Jerry Klaff assigned high importance.

The question of closed cycling of plastics, it was agreed, should be given further study because it posed many technical problems.

On topic seven, the consumer, there appeared to be agreement that it was extremely difficult to exact from the consumer any systematic and sustained acceptance of responsibility. However, he was recognized to have rights. To help him enjoy (or enforce) these rights, it was suggested that Government action might be taken to "focus the collective perception of the Nation on allocation, regulation, education, and pricing of specific materials."

However, a more generally accepted proposition was that the consumer was interested in products, not materials. In general, he saw no

necessary connection between the products he used and the periodic table and other tabulations.

Topic eight, economic opportunities and constraints. Suggested goals included: reserves of materials for the future; improved ability to export rather than curtailed material imports; and Government support of process development. The question was raised again as to whether to opt for autarky (self-sufficiency) or trade: Should the United States export its pollution? In sum, it was difficult to find an area in which technological development does not offer opportunity for improvement.

In conclusion, may I suggest to my fellow conferees—or perhaps we can refer to ourselves as the "friends of the frog in the beaker"—that a number of general axioms have been repeatedly stressed here. The list could be considerably expanded, but for openers (and closers) I suggest the following—

Axioms

Flexibility of stance.

Capability for vigorous positive action.

Fact finding and analysis on a continuous basis to anticipate the storms ahead and hopefully avoid them.

Pragmatic approach—seeking to learn what works rather than clinging to arbitrary folklore.

Investigating rather than accepting facile excuses for failure.

Strengthening U.S. capabilities where we are weak but not relinquishing leadership where we are strongest.

Applying good management principles to the totality of our materials flow, recognizing the triad of materials, energy, and environment; the triad of research coupled with engineering practice, coupled with strong corporate management; and the triad of government, industry, and academia, where in the last analysis most of our materials problems must be solved.

APPENDIX

A NOTE ON WHAT POLICY IS

In the first session, it was suggested that there was a good deal of uncertainty and imprecision in the understanding of the world "policy" and that a note should be circulated to the conferees to elaborate and clarify the term.

The Glossary of Science Policy Terms defines "policy" in the following words:

> A general course or method of operation adopted or proposed for the achievement or maintenance of a condition or (less frequently) the winning of an objective. The term is customarily employed with respect to social, public, administrative, and business institutions, and particularly to characterize the general principles guiding the operational decisions of their principal executives, to achieve coherence and consistency of management.
>
> "Policy means * * * intelligently directed action toward consciously determined goals—as distinct from aimless drift and blind faith." [1]
>
> A respondent suggests that an administrative hierarchy of procedure should be identified. It begins with policy (as defined above), leading to program ("an ordered set of interrelated actions"). Program, in turn, may be further subdivided into projects or tasks, each contributing coherently to a program in support of a policy.

With reference to the tasks being studied by the conference, the following were offered as policy alternatives; either one of the following pairs of policy statements would represent a broad course or policy and each would be capable of being "shredded out" into program statements and projects or tasks.

I. Policy Alternatives.

Central Federal Government planning and coordination.

(1) There should be a national strategy in materials, planned, coordinated, and stimulated by a central organization of government

[1] "Resources for Freedom," A Report to the President by the President's Materials Policy Commission (Washington, D.C.: U.S. Government Printing Office, June 1952), p. 17; (The "Paley Commission").

close to the President, (OR) Government actions, programs, and legislation concerning materials should be coordinated or directed without reference to the conditions and constraints of materials but in accordance with social, economic, or political needs.

(2) The Federal Government should assume responsibility for taking appropriate action to insure that industries consuming materials have dependable and economically stable sources of supply of the materials they require. (OR) The responsibility of assuring materials supplies is exclusively the responsibility of private industry irrespective of whether the sources are domestic or foreign; no domestic encouragement of production or intervention to smooth the way to procurement of foreign supplies should be undertaken by the Federal Government.

(3) The Federal Government should adopt a constant long-range strategy of eliminating all dangerous and costly dependence on foreign sources of essential materials. (OR) The Federal Government should undertake positive diplomatic and other actions relating to foreign governments to strengthen the assured reliance of U.S. industries on sources of materials not produced in the United States.

(4) The Federal Government should accept the proposition that continued growth of industry, economic expansion, and enlarging consumer satisfactions is a continuing and necessary prospect for the future and should take no measures to inhibit this expansion. (OR) The Federal Government should recognize the ultimate inescapability of a "steady state" in economic, industrial levels of activity and should take positive measures to facilitate the orderly transition into this "steady state".

II. Illustrations of the "Shredding Out" Process.

Policy was defined above as a general statement capable of being translated into programs and further subdivisions into tasks or operations. An example is offered below of one such policy and its subdivisions. It should be stressed that the material is illustrative only and does not indicate a prejudice or bias for the points discussed:

(1) *Policy Issue.*—The Federal Government should recognize the importance of full and reliable availability of useful technological information to those who can use it effectively in industry or other activities to serve the public.

(2) *Programs derived from the policy.*—(a) information centers should be established by the Department of Defense serving all contractors and potential contractors of the Department making free available information generated under defense contractors; (b) a repository of all technical documents, reports of scientific investigations, studies and the like should be centrally maintained by the Department of Defense with appropriate access granted to all persons who would be able to make use of the information for military or commercial purposes within the United States; (c) a systematic program of translation of all scientific literature identified as useful by appro-

priate U.S. authorities should be carried on with the results made available to repository libraries through the United States; (d) a program of scientific information exchanges should be promoted with other technologically advanced nations through the establishment of an International Clearing House of Scientific and Technological Information cooperatively with such nations as United States, Canada, United Kingdom, France, Germany, Scandinavian countries, Japan, and the like.

III. Illustrative Tasks.

Under these broad programs, a specific task might be set up, for example: (1) under the proposed program of translations, a list of publications might be selected from a particular country and arrangements made for their translation as a set; (2) or, under the assignment to the Department of Defense to establish information or technical evaluation centers, a single center might be set up to handle ceramics and graphite type materials; (3) in the area of international exchanges, a task might be the establishment of an international conference on technology of composite materials looking toward the establishment of a continuing body to translate and maintain information resources in this area.

Program for Engineering Foundation Conference
on
"RESOLVING SOME SELECTED ISSUES OF NATIONAL MATERIALS POLICY"

New England College, Henniker, N.H.
July 30–August 4, 1972

Date	*Program*
Sunday, July 30	REGISTRATION
Monday, July 31	CONFERENCE CONVENES

Session No. 1—*Chairman:* F. P. Huddle

GENERAL INTRODUCTORY

James Boyd: Activities and Plans of the National Commission on Materials Policy

Charles Ryan: The NCMP University Forums Discussion

Harold Paxton: The Materials Research Program of the National Science Foundation Discussion

Session No. 2—*Chairman:* N. E. Promisel

Morris Cohen: The General Concept of Materials Science and Engineering

Richard Claassen: A Model Concept of Materials Science and Engineering

Walter Hibbard: The Institutional Framewok of Materials Science and Engineering

F. J. Wells: National Goals and Contributions of Materials Science and Engineering

N. E. Promisel: OECD Studies of Materials Science and Engineering
Discussion

Earl Hayes: National Minerals Policy; Educational Resources to Support a National Minerals Policy

Meeting of Executive Committee
Chairman: Reed Powell
Selection of Task Forces and Task Force Chairmen

Tuesday, August 1

Briefing of Task Force Chairmen
Session No. 3—*General Chairman:* Reed Powell
Meeting of Eight Task Forces
Session No. 4—*General Chairman:* Reed Powell
Meeting of Eight Task Forces

Wednesday, August 2

Session No. 5—*General Chairman:* Reed Powell
Meeting of Eight Task Forces
Session No. 6—*General Chairman:* Reed Powell
Meeting of Eight Task Forces

Task Titles

1. Central Government Planning and Coordination
2. Materials Opportunities and Responsibilities Facing Private Industry
3. International Competition and Cooperation in Materials
4. Research and Education
5. The Effective Application and Management of Knowledge
6. The Closed Cycle Flow of Materials
7. Demands, Rights, and Responsibilities of the Consumer
8. Economic Opportunities and Constraints in Materials

Task Force One: Will handle titles 3 and 1 above
Task Force Two: Will handle titles 5 and 1 above
Task Force Three: Will handle titles 2 and 7 above
Task Force Four: Will handle titles 8 and 2 above
Task Force Five: Will handle titles 3 and 4 above
Task Force Six: Will handle titles 5 and 4 above
Task Force Seven: Will handle titles 6 and 7 above
Task Force Eight: Will handle titles 8 and 6 above

(Handle first item on Tuesday, and second on Wednesday)

Thursday, August 3

Session No. 7—Chairman: Earl Hayes
Task Force Reports (in the following order):
Task Force Four: Topic No. 8
Task Force Eight: Topic No. 8

Task Force One : Topic No. 3
Task Force Five : Topic No. 3
Task Force Two : Topic No. 5
Task Force Six : Topic No. 5
Task Force Five : Topic No. 4
Task Force Six : Topic No. 4
Task Force Seven : Topic No. 6
Task Force Eight : Topic No. 6

Session No. 8—Chairman : Harold Paxton
Task Force Three : Topic No. 2
Task Force Four : Topic No. 2
Task Force Three : Topic No. 7
Task Force Seven : Topic No. 7
Task Force One : Topic No. 1
Task Force Two : Topic No. 1

GENERAL DISCUSSION

Session No. 9—Chairman : James Boyd
Speakers : Lawrence M. Kushner, Acting Director, National Bureau of Standards; Hollis M. Dole, Assistant Secretary of Interior; Jerome Klaff, Chairman, National Commission on Materials Policy

Friday, August 4

Session No. 10—Chairman : Frank Huddle
Presentation and Discussion of Issues Resolved and Unresolved

CONFERENCE ADJOURNS

MEMBERSHIP OF THE TASK FORCES

Task One.

Report A.—Don Stevens (chairman), Ron Slinn, Keith Buck, Gordon Powell, Morie Steinberg, John Zerbe, and Jim Boyd.
Report B.—Manny Horowitz (chairman), John Moller, Don Colby, Dave Swan, W. Meinecke, Vic Radcliffe, and Jim Bryant.

Task Two.

Report A.—Dick Claassen (chairman), Gene Nixon, Al Shilepsky, Don Kedzie, Tom Leontis, Jack Wachtman, and Bob Kaplan.
Report B.—John Brittain (chairman), Charles Wert, John Wilkinson, Diane Deland, Earl Hayes, Bob Holliday, Jim Trayers, Ad Watts, and Ron Slinn.

Task Three.

Report A.—Lefty Leverenz (chairman), Jim Bryant, Don Colby, Dave Swan, Bruce Hannay, Amy Horowitz, Manny Horowitz, Vic Radcliffe, and Eberhard Meinecke.

Report B.—Bob Jaffee (chairman), Paul Forsyth, Michael Hoch, Bill Pfeffer, Alan Chynoweth, Sam Ellison, Ken Rose, and Dale Stein.

Task Four.

Report A.—Michael Hoch (chairman), Bob Jaffee, Bill Pfeffer, Ken Rose, Alan Chynoweth, Sam Ellison, Paul Forsyth, and Dale Stein.

Report B.—Bob Hughes (chairman), Don Smyth, John Burke, Harry Callaway, Harry Pebly, Ray Putnam, and Ed Owens.

Task Five.

Report A.—Dave Douglass (chairman), Don Stevens, Ron Slinn, Keith Buck, Gordon Powell, Morie Steinberg, John Zerbe, and Jim Boyd.

Report B.—Dick Harmon (chairman), Bob Hughes, Don Smyth, John Burke, Harry Callaway, Harry Pebly, Ray Putnam, and Ed Owens.

Task Six.

Report A.—Michael Bever (chairman), Bryan Noton, Bill Philbrook, Gary Timm, Boyd Outman, Fred Perbix, and Dick Cambridge.

Report B.—Norm Carlson (chairman), T. Cromwell, Fred Wells, Jim Owens, Erwin Bulgrin, Clyde Dial, and Nate Promisel.

Task Seven.

Report A.—Treva Cromwell (chairman), E. Bulgrin, Norm Carlson, Clyde Dial, Jim Owens, Nate Promisel, and Fred Wells.

Report B.—Charles Wert (chairman), John Brittain, John Wilkinson, Diane Deland, Earl Hayes, Bob Holliday, Jim Trayers, and Ad Watts.

Task Eight.

Report A.—Bev Clark (chairman), Dick Claassen, Gene Nixon, Bob Kaplan, Al Shilepsky, Don Kenzie, Tom Leontis, and Jack Wachtman.

Report B.—Bryan Noton (chairman), Michael Bever, Dick Cambridge, Boyd Outman, Fred Perbix, Gary Timm, and Bill Philbrook.

ENGINEERING FOUNDATION CONFERENCES
NATIONAL MATERIALS POLICY

New England College, Henniker, New Hampshire/July 30–August 4, 1972

Participants List

Mrs. Gloria A. Adams
Administrative Assistant
National Commission on Materials Policy
2025 M Street, NW., Room 3002
Washington, D.C. 20506

Dr. Michael B. Bever
Professor of Metallurgy
Massachusetts Institute of Technology
Room 13–5066
Cambridge, Mass. 02139

Dr. James Boyd
Executive Director
National Commission on Materials Policy
Apt. 1405
700 New Hampshire Avenue, NW.
Washington, D.C. 20037

Dr. John O. Brittain
Professor and Chairman
Northwestern University
Materials Science Department
Evanston, Ill. 60201

Dr. James I. Bryant
Staff Officer
Department of the Army
Office of the Chief of Research and Development
DARD–ARP–T
Washington, D.C. 20310

Mr. W. Keith Buck
Director, Mineral Resources Branch
Department of Energy, Mines and Resources
Ottawa, Ontario, Canada

Dr. Erwin H. Bulgrin
USDA, FS, Forest Products Lab.
Post Office Box 5130
Madison, Wis. 53705

Dr. John J. Burke
Planning Director
Army Materials and Mechanics Research Center
Watertown, Mass. 01905

Mr. Harry M. Callaway
Physical Scientist
U.S. Department of Commerce
Washington, D.C.

Mr. Richard Cambridge
Research Assistant
National Commission on Materials Policy
2025 M Street, NW.
Washington, D.C. 20506

Dr. O. Norman Carlson
Professor of Metallurgy
Iowa State University
125 Metals Development Building
Ames, Iowa 50010

Dr. A. G. Chynoweth
Assistant Director, Materials Research Laboratory
Bell Telephone Laboratories
Murray Hill, N.J. 07974

Dr. R. S. Claassen
Director, Electronic Component Development
Sandia Laboratories
Albuquerque, N. Mex. 87115

Dr. J. Beverly Clark
Associate Program Director
National Science Foundation
Division of Materials Research
Washington, D.C. 20550

Mr. Donald S. Colby
Research Coordinator
U.S. Bureau of Mines
4015 Wilson Boulevard, Room 417
Arlington, Va. 22203

Dr. Sanford S. Cole, Director
Engineering Foundation Conferences
345 East 47th Street
New York, N.Y. 10017

Mrs. Treva Cromwell
Environmental Program and Projects Coordinator
League of Women Voters of the United States
2000 Spruce Drive
Lafayette, Ind. 47904

Ms. Diane DeLand
Economist
Environmental Protection Agency
5600 Fishers Lane
Rockville, Md.

Mr. Clyde J. Dial
Director, Systems Management Division
OSWMP
Environmental Protection Agency
5555 Ridge Avenue
Cincinnati, Ohio 45268

Mr. Hollis Dole
Assistant Secretary of the Interior
U.S. Government
Department of the Interior
Washington, D.C. 20450

Dr. David L. Douglass
Professor and Vice Chairman
Materials Department
University of California
6531 Boelter Hall
Los Angeles, Calif. 90024

Dr. Samuel P. Ellison, Jr.
Professor, Geological Sciences and Dean of College of Natural Sciences
University of Texas
5948 Highland Hills Drive
Austin, Tex. 78731

Dr. Paul S. Forsyth
Financial and Technical Consultant
3418 Quesada Street, NW.
Washington, D.C. 20015

Dr. A. E. Gorum
U.S. Army
17 Stone Drive
Watertown, Mass. 01532

Dr. N. B. Hannay
Executive Director, Research—Materials Science & Engineering
Bell Laboratories
600 Mountain Avenue
Murray Hill, N.J. 07974

Mr. Richard E. Harmon
Manager, Government Products
PPG Industries, Fiber Glass Division
7801 Norfolk Avenue, Room 201
Bethesda, Md. 20014

Dr. Earl T. Hayes
Chief Scientist
U.S. Bureau of Mines
Department of the Interior
Washington, D.C. 20240

Dr. Michael Hoch
Professor and Head
University of Cincinnati
Department of Materials Science and Metallurgical Engineering
Cincinnati, Ohio 45221

Dr. Emanuel Horowitz
Department Director, Institute for Materials Research
National Bureau of Standards
Washington, D.C. 20234

Mr. Robert W. Holliday
Liaison Officer—Maine
U.S. Bureau of Mines
Federal Building, Post Office
Augusta, Maine 04330

Dr. Frank Huddle
Science Policy Research Division
Congressional Research Service
Library of Congress
Washington, D.C. 20540

Dr. Robert E. Hughes
Director, Materials Science Center
Cornell University
627 Clark Hall
Ithaca, N.Y. 14850

Dr. Robert Jaffee
Senior Fellow
Battelle Memorial Institute
505 King Avenue
Columbus, Ohio 43201

Dr. Robert S. Kaplan
Staff Metallurgist
U.S. Bureau of Mines
1800 E Street, NW.
Washington, D.C. 20240

Dr. Donald P. Kedzie
Professor and Head
Department of Metallurgical Engineering
The University of Texas at El Paso
El Paso, Tex. 79968

Mr. Jerome L. Klaff
Chairman
National Commission on Materials Policy
2025 M Street, NW.
Washington, D.C. 20506

Dr. L. M. Kushner
Deputy Director
National Bureau of Standards
Washington, D.C. 20234

Mr. Thomas E. Leontis
Associate Director, Magnesium Research Center
Battelle Memorial Institute
505 King Avenue
Columbus, Ohio 43201

Mr. H. W. Leverenz
Staff Vice President
RCA
Sarnoff Research Center
Princeton, N.J. 08540

Dr. E. A. Meinecke
University of Akron
302 East Buchtel Avenue
Akron, Ohio 44325

Mr. Harry Moffett
Deputy Assistant Secretary, Minerals
Department of the Interior
Washington, D.C. 20450

Mr. John U. Moller
Commission Staff—IR Analyst
National Commission on Materials Policy
2025 M Street, NW.
Washington, D.C. 20506

Dr. Eugene R. Nixon
Professor of Chemistry
University of Pennsylvania
Philadelphia, Pa. 19104

Mr. Bryan R. Noton
Professor, Engineering Design Laboratory
Washington University
Box 1185
St. Louis, Mo. 63130

Mr. Boyd Outman
Industrial Consultant
5831 Osceola Road
Washington, D.C. 20016

Dr. Edwin L. Owen
Assistant Professor of Metallurgy
The Pennsylvania State University
305 Mineral Industries Building
University Park, Pa. 16802

Mr. James M. Owens
National Commission on Materials Policy
1016 16th Street, NW.
Washington, D.C. 20036

Dr. Harold W. Paxton
Division Director, Materials Research
National Science Foundation
Washington, D.C. 20550

Mr. Harry E. Pebly
Director
Plastics Technology Evaluation Center (PLASTEC)
Picatinny Arsenal
Dover, N.H. 07801

Dr. G. W. Perbix
National Commission on Materials Policy
1016 16th Street, NW.
Washington, D.C. 20036

Mr. Jerome Persh
Department of Defense
Washington, D.C.

Dr. H. W. Pfeffer
Special Assistant to the General Director
Materials Branch, Department of Industry, Trade and Commerce
112 Kent Street
Ottawa KIA OH5, Ontario, Canada

Mr. W. O. Philbrook
Professor of Metallurgy and Materials Science
Carnegie-Mellon University
Pittsburgh, Pa. 15213

Dr. Gordon W. Powell
Ohio State University
490 Watts Hall
Columbus, Ohio 43210

Dr. Reed M. Powell
Associate Dean and Director, Division of Research
Ohio State University
1775 College Road
Columbus, Ohio 43210

Mr. Nathan E. Promisel
Executive Director
National Materials Advisory Board
National Academy of Sciences
2101 Constitution Avenue, NW.
Washington, D.C. 20418

Mr. Allan Ray Putnam
Managing Director
American Society of Metals
Metals Park, Ohio 44073

Dr. S. Victor Radcliffe
Professor and Head
Metallurgy and Materials Science
Case Western Reserve University
University Circle
Cleveland, Ohio 44106

Mr. Kenneth E. Rose
Associate Dean, Engineering
University of Kansas
Lawrence, Kans. 66044

Mr. C. J. Ryan
Asst. Director of Policy Development
National Commission on Materials Policy
4462 Greenwich Parkway, NW.
Washington, D.C.

Mr. Alan Shilepsky
Policy Research Assistant
National Commission on Materials Policy
1731 Church Street, NW.
Washington, D.C. 20036

Dr. Ronald J. Slinn
Vice President
American Paper Institute
260 Madison Avenue
New York, 10016

Dr. Donald M. Smyth
Director, Materials Research Center
Lehigh University
Bethlehem, Pa. 18015

Dr. Dale F. Stein
Professor and Head, Metallurgical Engineering
Michigan Technological University
Houghton, Mich. 49931

Dr. M. A. Steinberg
Director of Technology Applications
Lockheed Aircraft Corp.
Post Office Box 551
Burbank, Calif. 91503

Dr. Donald K. Stevens
Asst. Director of Metallurgy and Materials Programs
Division of Physical Research
U.S. Atomic Energy Commission
Washington, D.C. 20545

Mr. David Swan
Vice President, Technology
Kennecott Copper Corp.
161 E. 42d Street.
New York, N.Y. 10017

Mr. Gary E. Timm
National Commission on Materials Policy
1765 R Street, NW.
Washington, D.C. 20009

Col. James L. Trayers
Staff Member
Council on Environmental Quality
722 Jackson Place
Washington, D.C. 20006

Dr. John B. Wachtman, Jr.
Chief, Inorganic Materials Division
National Bureau of Standards
Room B308, Building 223
Washington, D.C. 20234

Dr. A. A. Watts
Director, Materials Research
Bell Aerospace Co.
Post Office Box 1
Buffalo, N.Y. 14240

Dr. Fred J. Wells
Research Associate
Resources for the Future, Inc.
1755 Massachusetts Avenue, NW
Washington, D.C. 20036

Dr. Charles A. Wert
Professor of Metallurgy
University of Illinois
201 Metallurgy and Mining Building
Urbana, Ill. 61801

Mr. John J. Wilkinson, Jr.
Vice President, Connecticut Labor Council
51 Maple Drive
Groton, Conn. 06340

Mr. Philip B. Yeager
Counsel
House Science Committee
Rayburn Building
Washington, D.C. 20515

Dr. John I. Zerbe
Director, Forest Products Engineering Research
Forest Service, USDA
14th and Independence Avenue
Washington, D.C. 20250

U. S. GOVERNMENT PRINTING OFFICE : 1973 O - 494-649