# I. Introductory Sessions

## CALL TO ORDER

by John B. Wachtman, Jr.
Chief, Inorganic Materials Division
National Bureau of Standards
Chairman of the Conference

Good Morning! I am Jack Wachtman, substituting for Frank Huddle, who is at work in Washington and about whom I will tell you more later.

This conference is the result of the work of many people. It is important to take a few minutes not only to recognize them, but to understand the broad base of interest in the issues to be considered here, and to listen to the written expressions of interest by several people who are in a position to use the products of this conference.

Before describing the general background of the whole series of Henniker conferences on National Materials Policy and explaining the perspective for this conference, I would like to introduce the conference co-chairman, Mr. Nathan Promisel, whom most of you know,

This conference began over a year ago with the agreement between the Engineering Foundation Conference and the Federation of Materials Societies to hold the fourth in the series of Conferences on National Materials Policy. The federation appointed a committee chaired by Frank Huddle and co-chaired by Nate Promisel to organize the conference. A tentative program was developed with the assistance of a steering committee consisting of Cornelius Cosman, Anthony DiBenedetto, George Eads, Richard Harmon, Sheldon Isakoff, Robert Johnson, Ben Kornhauser, Jerry Kruger, Walter Moen, Dana Moran, John Morgan, Albert Paladino, Jerry Persh, Allen Gray, and Robert Vaughn. Contributions toward the cost of printing the proceedings were made by the Office of Technology Assessment, the National Commission on Supplies and Shortages, the Bureau of Mines, and the Federation of Materials Societies.

In May, when Frank Huddle became ill, he asked me to form and chair an Executive Committee to complete the arrangements and manage the conference. This committee consists of Nate Promisel, George Eads, Curry Ford, Allen Gray, and Albert Paladino. Frank is recuperating and has been back at work for

several weeks. He has continually provided help and moral support to the Executive Committee. Although many other people have contributed, this is largely Frank's conference and I would like to read a message from him to the conference.

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The Library of Congress
Congressional Research Service

Washington, D, C., August 2, 1976

Dr. John B. Wachtman, jr. Chairman
Fourth Henniker Conference on National Materials Policy
New England College
Henniker, New Hampshire 03242

Dear jack:

I am writing to express my hope and confident belief that the fourth Henniker conference on national materiaJs poJicy will be the best and most rewarding of the series. If thoughtful planning, hard work, outstanding speakers, and superior attendance count for anything, it will be.

The theory underlying these conferences is that we bring together a group of diversified and knowledgeable conferees; we put before them a collection of important public problems and issues; we explain and clarify the circumstances that surround these matters; and then we look to the conferees to advise the conference, and subsequently the interested public and its representatives, on possible ways to approach these national problems and issues.

What happens at these conferences is important precisely because the conferees, taken together, are behoIden to no group interest, There is no special pleading. The concern shared by all conferees here is the public interest. The quality of thought is both high and objective, It is important and necessary, of course, that the interests of the different groups in our national society be expressed and considered. But the final product ought to be a consensus that represents a total collective judgment as to the best interests of us all,

There is another aspect of these conferences that I hope will grow. That is the introduction of interests and views on behalf of two constituencies that cannot be adequately represented at this time, One of these is future generations of Americans, whose needs ought to be voiced today. The other is the citizens of the world, our fellow passengers on spaceship Earth, whose views and attitudes transcend national boundaries in the effort to achieve wise, effective management of our total global pattern of resources.

in the future, increasingly, the needs of our own nationaJ community should be reconciled and harmonized with those of the totality of globaJ society, present and future. It will be constructive if the proceedings of Henniker W show some of this scope and direction.

In conclusion, let me wish you and the conferees a profitable week, exciting ideas, thoughtful discussions, new friendships, and a lasting contribution to the body of literature of national materials policy. 1 am sorry that I cannot share the experience with you. May it be a great one!

Sincerely yours,
Franklin P. Huddle.

An important feature of this series of conferences on National Materials Policy is the interest shown by leaders in science, technology, and public policy, I would like to read you three messages to this conference. The first is from Cortland Perkins, the President of the National Academy of Engineering.

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NATIONAL ACADEMY OF ENGINEERING
2101 Constitution Avenue, N. W.,
Washington, D.C. 20418

Office of the President — july 27, 1976

Dr. Franklin P. Huddle
Congressional Research Service
Library of Congress
Washington, D,C. 20540

Dear Dr. Huddle:

I have read the Program and the Terms of Reference for the IVth Henniker Conference on National Materials Policy with interest. The program appears to address important areas relating materials technology to questions of national policy. As you know, the NAE and the NAS co-sponsored a recent symposium on "Materials and the Development of Nations: The Role of Technology." Currently, we are considering a follow-up program on issues identified by participants in that symposium.

1 am looking forward to seeing the proceedings of the Conference, which I am sure will be both interesting and informative,

Sincerely,
Courtland D. Perkins
President

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The next is from Dr. Guyford Stever, Director of the National Science Foundation, who has been nominated by President Ford as Science Adviser and Director of the new White House Office of Science and Technology Policy.

NATIONAL SCIENCE FOUNDATION
Washington, D.C. 20550

Office of the Science Adviser

July 30, 1976

Dr. Franklin P. Huddle
Congressional Research Service
Science Policy Research Division
Library of Congress
Washington, D.C, 20540

Dear Dr. Huddle:

The Program of the IVth Henniker Conference on National Materials Policy addresses a series of issues which are important to materials science and technology and through them to the national economy and security.

I wish the conferees success in their work and I look forward to the Conference proceedings as useful contributions to national policy considerations.

Sincerely yours,
H, Guyford Stever
Science Adviser

The third message is jointly from Senator Frank Moss, Chairman of the Senate Committee on Aeronautical and Space Sciences and Representative Olin Teague, Chairman of the House Committee on Science and Technology.

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COMMITTEE ON SCIENCE AND TECHNOLOGY
U.S. House of Representatives
Suite 2321 Rayburn House Office Building
Washington, D.C. 20515

August 5, 1976

To Participants of the Engineering Foundation
Conference on Materials Policy, Henniker, N.H.

It is with genuine concern for the significant issues with which this conference will be contending, and with much hope for equally significant results, that we take the occasion to extend to you the high interest and best wishes of your national legislature.

We do not presume to suggest to knowledgeable people such as yourselves a list of reasons why materials policy and materials research and development are vital to the nation—and thus to the Congress of the United States. You are far more familiar with such reasons than we. Nonetheless, we do wish to impress upon you that materials problems and materials sciences and technology are now infiltrating the collective consciousness of the Congress to a degree that we believe has not heretofore existed.

Some of you, we are sure, are familiar with the companion bills (HR 14439 and S 3637) now pending in the House and Senate. Entitled "The

National Materials Policy, Research and Organization Act of 1976," these bills have been introduced recently by Senator Moss and Representatives Symington and Mosher. While we hold no particular brief for the precise format of the bill as it presently stands, we believe it will stimulate thought and discussion— and hopefully will provoke some manner of observation, criticism, recommendations or whatever, from this conference. Your constructive reaction would be of great utility to us.

No one expects that we will have good enough answers to basic materials problems, or have them soon enough, to warrant serious consideration of this kind of legislation in the immediate future. On the other hand, we as a nation (perhaps as a species) will not be able to go our traditional, unstructured, exploitive way much longer without creating disastrous materials situations which may prove irreversible.

Your findings can help us– and can do so in time to be effective. We trust you will keep us current and, to the extent your rules permit, make the proceedings of the 1976 conference available to our Committees.

With best wishes for your success,

FRANK MOSS, Chairman
Senate Committee on Aeronautical and Space Sciences

OLIN E, TEAGUE, Chairman
House Committee on Science and Technology

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Copies of both the companion bills are available; the text is the same. Also, we have copies of the statements by Mr. Moss and Mr. Symington with which the bills were introduced. It is important to read these statements to understand the purposes of the bills, I believe Mr. Daddario will also discuss them later today. Many of the issues to be treated by our task forces are pertinent to the bills. Also, we plan to discuss some of their features at the Panel Meeting on Friday morning. The conference results pertinent to these bills will receive appropriate attention by personnel of the legislation branch. Ms. Gail Pesyna of the staff of the House Committee on Science and Technology is here today.

The plan for the conference will follow roughly the same format as in 1974. Following the keynote and other introductory statements will be tutorial papers addressing the five tasks before the conference. This evening we will hear a technical paper from a foreign guest, Professor Pick from Birmingham, England. Tomorrow and Wednesday, the conference will be divided into task forces to work on the matters of concern to our sponsors. Thursday, the chairmen of the task forces will report, and then we will hear a lecture from a distinguished speaker from private industry in the United States. The Conference will conclude Friday morning with several papers on other materials issues, a

general plenary discussion of national materials policy, and a consideration of proposed means to implement it.

The next speaker this morning will be Curry Ford, President of the Federation of Materials Societies. He will be followed by the keynote message to the conference. Let me mention the keynote address because it has several novel features about it. Several months ago, Frank Huddle and I met for lunch at the Cosmos Club with Dr. McKelvey and Dr. Falkie to discuss the keynote address for this conference, We wanted to stress the importance of the functional relationship between the US. Geological Survey, that helps to discover minerals in the ground, and the U.S. Bureau of Mines, that helps to dig them out and bring them to the market for industry to use, Accordingly we agreed upon the device of a joint keynote address, in which the directors of these two great institutions would share the spotlight.

# WELCOMING REMARKS ON BEHALF OF THE FEDERATION OF MATERIALS SOCIETIES

by Curry E. Ford
President
Federation of Materials Societies

On behalf of the Board of Trustees of the Federation of Materials Societies, I welcome you to this fourth Henniker Conference on National Materials Policy, The federation is honored to again have the privilege of organizing and managing this conference for the Engineering Foundation.

The findings and recommendations of the conferences of 1970, 1972, and 1974 have had a very significant impact on materials policy legislation, This 1976 conference has the opportunity to generate new insight and thoughtful recommendations that can affect actions on the critical problems of chronic materials scarcity. I am confident we will exercise this opportunity,

Much of the success of the past three conferences was the result of the leadership, knowledge and dedication of the conference chairman, Dr. Franklin P. Huddle. You can appreciate our concern when Dr. Huddle became seriously ill this past spring, just as detailed planning for this conference was getting underway. We were most fortunate when Dr. John B. Wachtman, Jr., Past-President of the Federation, promptly agreed to assume Dr. Huddle's responsibilities. The Federation and alI of us here today are deeply indebted to Dr. Wachtman and his conference executive committee for their outstanding effort which has made this conference possible.

This is not the time and place to review the activities and plans of the Federation. We do feel, however, that your attendance at this conference confirms your interest in materials issues, and we are placing your names on the mailing list for the Federation's Quarterly newsletter, "Materials and Resources News." You may find this publication of help in informing you of Federation activities and other materials matters of interest.

We have a busy week ahead, We hope you will find it pleasant and rewarding.

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## JOINT KEYNOTE ADDRESS–PART I

by V. E. McKelvey
Director, Geological Survey
U.S. Department of the Interior

In discussing our roles in this conference, Frank Huddle suggested to Dr. Falkie and me that it would be useful to tell you something about the activities of our respective organizations and the way they articulate with each other and with other organizations concerned with materials problems. This I am glad to do, but just to be sure I don't get into a level of descriptive detail that might be of little interest to you, I plan also to discuss findings as they relate to the conference theme, namely the Engineering Implications of Chronic Materials Scarcity.

The Geological Survey was established by an Act of Congress in 1879, and charged with responsibility for ". ., the classification of the public lands and examination of the geological structure, mineral resources and products of the national domain. . . ." Taken in their broadest sense, those terms still describe our responsibilities pretty well. In its larger part, the Survey is a research and fact-finding organization directed toward acquiring information and knowledge about the configuration and use of the land surface; the composition and structure of the rocks that underlie the United States; the distribution and character of our water, mineral, and mineral fuel resources; and geologic processes that relate to the discovery and use of our physical resources, including the land itself, The Survey is also responsible for the mineral classification of Federal land, the classification of water power sites, and the supervision of operations on Federal lands authorized by leases issued by the Bureau of Land Management. This regulatory activity has been growing in recent years, but even so it makes up not quite **zo** percent of our total activity.

Through its topographic and geologic mapping, its mineral and hydrologic assessments, and its studies of geologic processes, the Survey is the principal public source of information about the distribution, magnitude, and quality of the nation's physical resources; the mineral values ot federally owned lands; the physical characteristics of the natural environment; and the nature of geologic hazards that may affect us or may attend our use of the land in engineering developments, In celebrating the 50th anniversary of the Geological Survey in 1929, George Otis Smith, then Director, said, "The one-hundredth report of the Director of the United States Geological Survey may be expected to be simply a report of progress. " With our centennial less than three

years off, I can fully confirm Smith's prediction, for the task of acquiring sufficient knowledge of the Earth and its resources to guide and underpin resource development and conservation is a never-ending one, The results in hand, in fact, are inadequate to allow us to cope with many of the problems we are now facing. For example, we don't yet have much capability for defining prospects for the occurrence of concealed ore bodies that have no surface manifestation or for estimating the extent of undiscovered resources. In spite of such deficiencies, we have acquired extensive knowledge of the subjects for which we have responsibility— enough, as I'll indicate shortly, to provide guidance and assistance on resource-related problems.

**Agency Cooperation**

A word now about how we articulate with other organizations. First, as a public service agency we consider that our first responsibility is to make the results of our work public. In 1975, for example, we issued about 2,900 reports and nearly 9,000 maps. We have come to recognize that it isn't enough simply to publish results— we must publish them in a form in which they can be understood and used by those who need the information, and in recent years we have been striving to improve the public utility of our reports and maps.

With respect to the mineral industry, we do not ourselves search for mineral deposits, except under emergency circumstances, but instead, attempt to develop information that will help us assess resources, and in addition help industry to identify targets for exploration.

This is a good point to mention our interface with the Bureau of Mines, which can be described in terms of the distinction between reserves and resources—a distinction which the Bureau and the Survey have helped to develop in recent years by agreement on a set of definitions that seem to be coming into wide use. We define reserves as identified deposits that can be extracted profitably with existing technology under current economic conditions. Resources in the broad sense include reserves but also encompass known deposits that are currently not profitable to produce, as well as undiscovered deposits that may or may not be economically producible if and when they are found. Whereas reserves represent the inventory on hand for production, resources include the potential that may come from additional exploration or technological advance or price increases.

In the general area of resource assessment, the Bureau of Mines is responsible for developing information on reserves; the Survey, for information on the remainder. Following that general

distinction, we work jointly in the appraisal of the mineral resource potential of lands nominated for withdrawal in the wilderness systems. In other areas, our work diverges, with the Bureau focusing on studies related to mineral and materials production, along lines that Dr. Falkie will describe,

We have a somewhat similar relationship with the Energy Research and Development Administration, with which the Department of the Interior is currently in the process of developing a memorandum of agreement, and in other areas we have close working relationships also with several other Federal agencies, such as the Bureau of Land Management; the National Oceanic and Atmospheric Administration; the Soil Conservation Service; the Nuclear Regulatory Commission; and the National Aeronautics and Space Administration, A good indication of the extent to which the Survey's expertise is utilized by other public organizations may be seen in the fact that in fiscal year 1975, we were reimbursed for services performed on behalf of 103 Federal agencies, more than 550 State and local organizations, 16 foreign governments, and the United Nations, These agencies call on the Survey mainly because of its expertise in Earth sciences research and fact-finding, but a supporting reason for many of them to do so is that traditionally the Survey does not enter into policy issues, It can be counted on, therefore, for objective, impartial data and interpretations not influenced by a predetermined position favoring, for example, resource development, environmental protection, or land withdrawal.

**Problems and Solutions of Chronic Materials Scarcity**

Let me move now to some of the problems that relate to the theme of this conference—Engineering Implications of Chronic Materials Scarcity. As a geologist representing an organization concerned mainly with Earth sciences research and fact-finding, I don't have much to contribute to the engineering side of the problem; perhaps some comments on our mineral, fuel and water resource position would help provide a useful base for conference discussion of the broader problems.

To the best of m y knowledge, there is no mineral, fuel, or water scarcity now in the market place, except locally, either in the United States or the world at large. Two obvious questions, then, are: (1) could we have chronic resource scarcity, and (2) should we take defensive actions to prepare for, and if possible prevent, such an eventuality? It doesn't take a crystal ball to answer those questions, and I am sure it was the realization that the answers to both questions were in the affirmative that led those responsible

for planning this conference to decide to explore some of the implications of resource scarcity.

The problem of potential resource scarcity results from the interaction between an exponentially increasing demand and the depletion of supply sources that were easy to find and cheap to produce, The result of this collision between our ever-rising demands and our dwindling supplies of low-cost resources had been a growth in our reliance upon other countries for minerals and fuels to make up the deficit in our own production. For a very long period of time, we were a net exporter of mineral fuels, including petroleum. Beginning in 1948, we became a net importer of oil–by choice, not necessity–and through 1970, oil imports never exceeded 25 percent of out total supply. In that year, however, our domestic production reached its peak and began a decline which has continued until now. Currently, imports average 43 percent of our supply and the outlook, even with the production from the Alaskan North Slope, is for our dependence on foreign oil to rise still further as demand continues to increase and production from the older fields continues to decline.

In general, our experience with non-fuel minerals parallels that of oil, although the growth of our dependence on foreign sources has been much less precipitate. We have always been dependent on other countries for certain minerals; but across the board, our net imports were rather modest–almost nominal–until after World War II. We now import, by value, about 15 percent of our total non-fuel mineral supply, but this general statistic obscures the fact that we are dependent on foreign sources for more than half our supply of 20 important minerals, a number of which are critical to some of our basic industries. So our dependence is not nearly so modest as the general-average figure might suggest.

I do not consider it at all likely that we shall ever be fully self-sufficient in all minerals. The random nature of their distribution and the fact that we occupy only seven percent of the Earth's land area, (while consuming 30 percent of its mineral production), is enough to convince me that we shall always be dependent on other countries for part of our mineral supply. The real problem is how to avoid becoming even more dependent than we now are as we continue to deplete our known domestic sources. Nothing suggests that this will be an easy matter.

The Geological Survey in 1973 published a review of the long-term U.S. position for potential resources of 65 mineral commodities. The sense of the document is that, aside from a

relatively few cases, we shall face extensive shortages by the end of this century unless prompt and effective actions are taken to avoid them.

What are the actions? If we can visualize resources as natural substances useful or potentially useful to man, then a number of things that we can do become apparent.

Immense volumes of known discovered resources await the development of technology that will allow their profitable extraction. This is a remedy which we have pursued with much success for 50 years or more, and it still has much potential. Dr. Falkie will have more to say about this approach.

Another important way by which we can stretch our resources is to find new uses for materials not previously usable. At the turn of the 20th century, only about 30 of the chemical elements were in commercial use. Now there are about 80. Finding a use for many of these made it possible to do something that could not be done before, but some minerals have served as substitutes for scarcer and more costly materials in established uses. Aluminum, for example, which was only a laboratory curiosity a century ago, has displaced wood and other metals in hundreds of uses. The substitution of abundant materials for scarcer ones is an avenue to future mineral supply that is well worth pursuing, and it is encouraging to see the developments in ceramics and composite materials that go in this direction.

A serious constraint in both the improved technology and the substitution approaches is that they often involve an increased consumption of energy. Just the opposite is the case with a third approach, namely recycling used materials, especially metals. Recycling not only saves energy; it also reduces the amount of trash that must be disposed of at the taxpayer's expense and with some risk of environmental damage as well. The Bureau of Mines has been doing some outstanding work in the field of recycling, and I'm sure Dr. Falkie will tell you more about that.

Then, of course, there is the fundamental approach of discovering new deposits of minerals, which entails not only new tools and concepts for exploration, but also new places to look. It may be hard to imagine, but there are still areas of the United States that have not yet been adequately explored, even with existing tools and techniques. These areas, including most of Alaska and the Continental Shelves, certainly merit closer inspection.

But the great challenge to minerals exploration remains the hidden deposit. Most of the mines operating in the world today were located on evidence visible at the surface. Until this century, mining was in many ways a cottage industry, Anyone with

determination and a strong back could go into the mining business, and thousands did, to the point where most of the deposits that could be found by the human eye have already been discovered over large areas of the Earth. Now, the need is for the sophisticated instruments, expanded knowledge of the geology of the subsurface, and exhaustive detective work that will lead to the discovery of deposits that cannot be seen. The petroleum industry has been highly successful in its ability to locate structural traps at great depth, but the mining industry to date has been nowhere nearly as successful in discerning environments where ore bodies may be found.

Nevertheless, progress is being made, While I mentioned earlier that the Geological Survey concerned itself mainly with delineating targets for private exploration, our scientists have done some important work in advancing geologic knowledge of the origin and environment of deposition of mineral deposits, and knowledge of the regional and local geologic relationships to which sound principles and effective methods can be applied in the search for concealed deposits.

Research on the geology of mineral occurrence is of particular importance in the search for blind deposits, for if we can ascertain how mineral deposits are formed, we have at least some clue as to where to look for them. Every piece of knowledge is important. For example, most minerals are more soluble at high temperatures than at low temperatures. Recent research, however, has shown that molybdenite (the most important source of molybdenum) and chalcopyrite (an important copper mineral) may show an opposite behavior under certain conditions. If this is the case, then we may expect copper and molybdenum deposits to form earlier and deeper than ores of other metals such as lead and silver, so that the occurrence of these latter minerals at the surface may indicate deep underlying deposits of copper and molybdenum. Information like this is useful in constructing models of ore deposits and greatly expedites assessment of regions for new deposits by limiting the search to a few well-defined geologic targets. Many such hypotheses turn out to be invalid on further investigation, but some do not, and furnish the basis for further progress in the difficult art and science of mineral exploration. It was such a novel concept (about gold mineralization) that led to the discovery of the disseminated gold deposits at Carlin, Nevada, in 1965–the most important gold discovery in the United States in 50 years.

New and more sophisticated techniques have helped greatly in both geochemical and geophysical investigations. One such geochemical approach involves the chemical separation and

analysis of manganese and iron-rich fractions of stream sediments and soils, The manganese and iron oxides are very sensitive scavengers, and concentrate metals such as copper, zinc, and silver, allowing the detection of subtle geochemical anomalies that may indicate hidden ore bodies nearby. This method has been successfully applied to outline metal anomalies in regions of thick rock cover in New Mexico. Here, minute amounts of metallic oxides have migrated through hundreds of feet of barren volcanic rock. Such trace indicators of mineral deposits cannot be detected by the usual geochemical surveys.

Geochemical halos in the soil may give surface evidence of deeply buried deposits. Volatile elements and compounds such as helium, sulfur gases, carbon dioxide, mercury, and light hydrocarbons frequently appear in the air trapped between particles of soil at or just below the surface, and they can be detected and measured by new techniques. Soil moisture conditions may complicate the analysis of soil gas, but the anomalous concentrations of these minute traces of elements and compounds can point to deposits which may lie deep beneath the surface.

In geophysics, considerable research is being concentrated on borehole techniques using electrical and seismic measuring devices. The borehole measurements, which are made from one hole to a second hole or to the ground surface, are expected to extend the range of subsurface probing to as much as 300 meters from the test hole. Obviously, this is a vast improvement over previous well-logging techniques, which had **a** range of only a few meters from the borehole, and would permit a great reduction in the amount of drilling needed to discover and delineate ore bodies. Another borehole measurement technique of great interest is our neutron activation probe, which can detect the presence of copper, nickel, and numerous other metallic elements in the rock section penetrated by the test hole.

Images of the Earth's surface, recorded by satellite and aircraft, are being processed by recently developed techniques to provide new information on potentially mineralized areas and geologic structures in Nevada, Wyoming, Mexico, and Brazil. Landsat (formerly ERTS) imagery, which is computer-enhanced, has been used successfully to detect and map hydrothermally altered areas that are related to ore districts in south-central Nevada. Thermal infrared images of the Colorado Front Range, near Denver, have revealed anomalous textural patterns that correspond to known mining districts.

These achievements represent gradual improvements over our past capabilities. There are no miracles, no magic, and no break-

throughs in prospect. But we do keep getting better at the job of finding mineral concentrations that were too elusive to be discovered in earlier times, and that is important,

Finally, there is the need for conservation in use. I mentioned earlier that we could not view shortages as merely a problem of supply. Without a sane and sensible policy toward consumption, it is impossible to balance the supply-demand equation, no matter how much emphasis is given to supply, Consider, for a moment, the impact of a steady increase in consumption at the relatively modest rate of 3 percent (anything that increases at only 3 percent a year is modest these days), At that rate of increase, a billion years' stock of anything, computed at this year's consumption rates, would be exhausted in 582 years. Two billion years' supply would be consumed within 23 years after that,

There's a bit of hyperbole in this example, of course, but it is sufficient to show that we cannot go on indefinitely increasing our consumption. Some economic growth is desirable in our society, and some growth in consumption is probably inevitable until we can stabilize our population. But much of what passed for "growth" in the last few decades in this country might more properly be labeled "waste" — waste in the sense that energy and minerals have been used for what are in essence frivolous, nonproductive purposes, Who needs a 5,000 pound car that can go 120 miles an hour, for example? In our development of highway transportation and all that goes with it, how much represents the socially efficient use of energy and minerals, and how much has been unnecessary use for purposes that could have been accomplished just as well in less consumptive ways? Recent reflection on this and many other examples of the frivolous use of energy and raw materials in our society has led me to conclude that we have been wasting our resource capital on a massive scale,

In conclusion, with our current dependence on imports for many commodities, we face the potential for at least intermittent shortages well in advance of true world scarcity. If recent rates of growth in consumption continue to outstrip our development of new sources of supply, we can be certain that true resource scarcities will develop in a few decades for some minerals. We can readily identify ways to add to and extend our supplies — through exploration; through gains in extractive, processing, and materials technology; through the wider practice of recycling; and through conservation in use. As some of you here know, I am optimistic that if we devote searching, imaginative, and driving effort to the task, we can succeed in satisfying our resource needs

far into the future. Accelerated research is an important part of the effort required, but research alone cannot long stand up to the buzz saw of exponential growth in consumption. Conservation in use by choice must become a national effort if the time when it becomes a necessity is to be put off for long.

## JOINT KEYNOTE ADDRESS–PART II

by Thomas V. Falkie, Director
Bureau of Mines, U.S. Department of the Interior

Good morning ladies and gentlemen. Thank you for inviting me here to share with Dr. McKelvey the honor of keynoting this important Conference,

Vince has given you a very complete picture of what the U.S. Geological Survey is doing to assist in the discovery of our mineral resources and to define our resource base. Since the programs of the Survey and the Bureau of Mines mesh to form a competence encompassing the entire mineral resource field, I will take it from there and discuss the role of the Bureau in helping, through its factfinding and its research and development programs, to convert our mineral resources into mineral reserves, Clearly, these programs, among others, have contributed greatly to minerals and materials technology, and information will continue to be part of our country's mineral posture.

First, let's remind ourselves briefly just how important the wise development and use of our mineral resources are to our domestic economy. In 1975, the output of such extractive operations as mining, quarrying, and oil production was valued at about $62 billion, excIuding exports, If you take that output through the mineral processing industries—smelting, refining, energy generation —the resulting production is valued at over $270 billion, which is a sizable portion of our $1.5 trillion Gross National Product.

Underlying the issues that will be addressed by this Conference is one of our Nation's biggest current materials problems: the dollar value of our imports has been exceeding that of our exports at a growing rate, except during the recession year of 1975. A substantial part of the reason, of course, is related to petroleum imports, which are costly and are also, unfortunately, still increasing. The possibility that the same pattern could well develop with other mineral materials is your primary concern at this meeting. At the same time, the impediments to increasing domestic production are growing.

As Vince noted earlier, the United States depends heavily on imports for such essential commodities as manganese, chromium, bauxite, platinum, and many other important minerals and metals.

To reduce this dependency– in fact, just to keep it from growing — it will be necessary to make real engineering innovations, to take major steps forward in the technology of exploration, min-

ing methods and ore transport, processing of low-grade resources, materials development, substitution and use, and scrap recovery, Only through genuine progress in each of these critical areas can we hope to assure an adequate supply of mineral raw materials in the future.

**Bureau of Mines and Chronic Materials Scarcity**

Commodity situations are constantly changing, and if we are to plan realistically for the future we must do it on the basis of up-to-date information. Recognizing that both industry and Government need timely statistical and economic information on mineral developments at home and abroad, the Bureau of Mines decades ago began building a system to provide it. The system has been modified many times over the years, and we are still improving it, It has made the Bureau of Mines the primary authoritative source within the Federal Government of the latest available data on mineral developments throughout the world, and is the basis for publications ranging from periodic statistical surveys of roughly a hundred individual mineral commodities, to such well known general references as "Mineral Facts and Problems," which will soon appear in a bicentennial edition. This information system, coupled with our wide-ranging technological expertise, has also made the Bureau a respected and much-consulted source of facts, advice, and opinion on mineral legislation and mineral policy for all branches and all levels of Government.

I think you can see how this factfinding and informational program of the Bureau relates to the theme of this year's Henniker Conference. We can best deal with material scarcities by being well-enough informed to anticipate them and, once forewarned, knowledgeable enough to avoid them,

I don't claim that the Bureau of Mines, or any other part of Government for that matter, has yet achieved the kind of capability required to foresee and avoid every problem or shortage that might one day confront us. But despite budgetary and manpower constraints, we are working hard to strengthen the Bureau's capability in that direction, and we are making progress. On the domestic front we maintain a continual surveillance for situations—such as strikes in basic mineral producing industries or in parts of the infrastructure that supports them—that could cause disruptions of mineral supply, When they occur, we monitor them carefully to assure that appropriate government actions can be taken in time to avert serious shortages.

Right now, we are far better equipped than we were a few years ago to deal with materials crises as they arise, Interagency

commodity committees, 95 of them in all, have been formed to provide a quick mechanism for obtaining the latest coordinated information available within Government on any commodity to help in developing recommendations for dealing with actual or foreseeable supply problems, Every concerned department and independent agency of the Government is represented on each committee. In the minerals field, Bureau of Mines commodity experts serve as the executive secretaries of the interagency committees dealing with their respective commodity areas, In this way, the government has achieved a capability for quickly gathering and coordinating all the significant input available on any particular problem,

As we all know, world demand for minerals is increasing. With it, competition among nations for the limited supplies that are available is rapidly intensifying, We have witnessed the formation of cartels, first in oil and then, with the success of the OPEC actions as an example, in such vitaIly important raw materials as copper, bauxite, and iron ore. While it seems unlikely that cartel actions affecting those materials could have the forceful impact of an oil embargo, they could nevertheless cause short-term disruptions in material price or supply and those disruptions, in turn, could have repercussions in various sectors of our economy, In such a situation the ability to be able to turn quickly to a domestic source of supply, to have on-the-shelf technology, so to speak, would be distinctly advantageous. Both the Geological Survey and the Bureau of Mines are working–usually together–to make that possible.

In the Bureau we are developing two fully automated data banks. Into one–our Minerals Availability System (MAS)–we are putting every scrap of information we can get on domestic mineral deposits. Data on location, ownership, history, production, reserves, grade of ore, mining, economics . . . everything we can learn about a potential domestic source is being computerized so it will be at the Government's fingertips in any future emergency. We're doing the same thing for deposits of coal, petroleum, natural gas, and other energy sources with our Fuels Availability System (FAS). MAS and FAS represent relatively new Bureau initiatives, and some of the information we are seeking isn't the kind that property owners are anxious to divulge, Nevertheless, our data banks are growing qualitatively and quantitatively, and we are convinced that they will serve the Nation well in years to come. One key to these information systems is the ability to apply experienced technical expertise to the data collection and interpretation process.

Most of the information collected in the programs I've been describing is widely disseminated throughout Government and to

the private sector where it is a reliable basis for policymaking and planning decisions, In addition, it enables the Bureau to comment knowledgeably and helpfully on proposed legislation and environmental impact studies and to serve effectively in a consultant capacity to numerous other agencies.

As I've already intimated, the information also guides us in planning our mission-oriented research and development in mining and metallurgy. Mining research is one of the principal avenues through which our objective of avoiding shortages is pursued. I think all of us will agree that, given plentiful supplies of low-cost energy, we need fear no shortages. With abundant cheap energy we could produce just about anything we might need out of common sand, Energy, as we learned the hard way in the fall of 1973, is the key to everything else. To the extent that the United States can again become self sufficient in energy, it will be insured against the political decisions of foreign governments insofar as they relate to material supplies.

That, in brief, is what most of the Bureau's mining research is about, In the fiscal year that just ended, roughly two-thirds of the Bureau's total budget of $158.8 million was earmarked for mining research and most of that (some $92.7 million) was for research in coal mining and preparation (table 1). Our goal, as you no

TABLE I.–Fiscal Year 1977 Budget Request
(thousands)

| | FY 1976 | FY 1977 | Increase (+) or Decrease (-) |
|---|---|---|---|
| Metallurgy Research | $ 27,022 | $ 25,802 | -$1,220 |
| Mining Research | 102,873 | 107,504 | +4,631 |
| Data Collection and Analysis | 14,465 | 14,705 | +240 |
| Engineering, Evaluation, and Demonstration | 13,056 | 15,247 | +2,191 |
| Program Administration | 1,402 | 1,486 | +84 |
| Total, Mines and Minerals | $158,818 | $164,465 | +$5,647 |

doubt know, is to help advance the technology of coal so that abundant fuel can supply a greater share of the Nation's energy requirements and thereby reduce our dependence on foreign sources. To achieve that goal, we must resolve some of the problems associated with the mining and use of coal. We must find ways to minimize the health and safety hazards of mining, and ways to make both coal mining and coal use more compatible

with our demands for a quality environment. At the same time we must provide the kind of technology that can improve a dangerously declining productivity in coal mining and increase the percentage of the resource that is typically recovered.

The Bureau's mining research program has been planned to attack all of these problems simultaneously, because, as you know, it is not practical to attack them separately (table 2), Although an important part of the total program is conducted in our

TABLE 2, –Fiscal Year 1977 Budget Request
Mining Research and Engineering Programs
(millions)

| Program | FY 1976 | FY 1977 |
|---|---|---|
| HEALTH & SAFETY RESEARCH | | |
| Coal Health & Safety Research | $ 29.4 | $30.0 |
| Metal & Nonmetal Health & Safety Research | 5.7 | 5.7 |
| ADVANCING MINING TECHNOLOGY | | |
| Coal Mining | $ 56.2 | 59.6 |
| Oil Shale Mining | 5.6 | 5.6 |
| Metal & Nonmetal Mining & Explosives | 6.0 | 6.0 |
| ENVIRONMENTAL CONTROL DEMONSTRATIONS | | |
| Mined Land Investigations & Demonstrations-Anthracite Area | 5.8 | 5.8 |
| Anthracite Conversion Demonstrations Plant | – | 3.0 |
| Rock Springs Subsidence Control | 1.5 | – |
| Mined Land Investigations & Demonstrations-Bituminous Area (Illinois) | – | 1.0 |
| Fire Control in Coal Deposits | 0.2 | 0.2 |
| PAY AND SPACE INCREASES | – | 0.6 |
| Total | $110.4 | $117.5 |

own facilities, it is predominantly a contract effort, with industry increasingly participating now through cost-sharing and other types of cooperative arrangements. Such cooperation not only strengthens the effort, but also speeds transfer of the developed technology into industrial practice.

The program is yielding important dividends. Some of the most promising developments so far in terms of increased safety and health protection for miners have come from our work in methane drainage, which was begun several years ago as a means of giving miners added protection against the explosive gas by degasifying coal seams in advance of mining. Degasification already has been accomplished profitably in West Virginia, where methane drained from a coal seam has been commercially pipelined to thousands of homes in the State, Other products of

Bureau research are now in the mines helping to assure greater safety for those who operate coal mining equipment, aiding in the control of mine roof, and improving efficiency and accuracy in the monitoring of noise and dust,

To combat the sharp downtrend in coal mining productivity that began in 1969, we are emphasizing research to speed up the development phase of mining (giving the industry faster access to coal reserves), along with adaptation of highly automated longwall and shortwall systems which, where they can be applied, offer higher productivity and greater recovery of the resource.

On the environmental side, the Bureau has pioneered for years in the development of improved methods for reclaiming surface-mined land; for controlling subsidence and acid mine water; and for minimizing the environmental hazards associated with mine refuse banks. That work continues today, but with greater emphasis than ever before on the design of mining methods and systems that can prevent the environmental disturbances so long associated with coal mining. On the surface, we are looking at innovations like the cross-pit conveyor, which makes it easier for reclamation to proceed at the same pace as mining. Underground, we are developing a new generation of continuous miners that provide their own roof support, along with other features that can help to make the underground mining process truly continuous and, at the same time, environmentally compatible.

All of this effort is aimed at providing the essential key to material abundance: low-cost energy. We are convinced that if the United States is to have that key in the foreseeable future, we will have to get it from coal.

But, while coal represents the largest share of the Bureau's mining research program, it is not the entire program by any means. If I limited my discussion to potential sources of energy supply, I would still have to mention that we are conducting important research on the mining of oil shale and tar sands. We're interested in mining oil sands as well, that is, mining energy-depleted, near-surface reservoirs to recover the 60 percent of the oil, on-the-average, that primary production methods do not get. We are also investigating the possibility of borehole mining as an economic means of tapping small, localized uranium deposits.

The Bureau is making progress, too, in research related to minerals other than fuels, This is loosely called "hard rock" research, and some of it is indeed like our work on developing a continuous drill-blast process for hard rock mining. One approach involves a tunneling machine that detonates frequent small blasts in the face as it drills holes in a spiral pattern, loading

the broken rock as it goes. Another uses small charges of high explosives in shallow holes—about 18 inches deep. Other areas of research include studies of airblast and ground vibration from surface operations to develop ways of minimizing the disturbance to neighbors, and development of an emergency hoist communication system, for deep shaft mines, that uses the hoist cable to carry voice messages.

Regardless of how successful our mining research may be, it will surely be a long time before the United States is once again blessed with an abundance of low-cost energy. In fact, if we limit our goals to what seems feasible right now, we will do well within the next decade simply to stop increasing our dependence on foreign energy sources. If we don't want to find ourselves one day in the same position with regard to other essential commodities, we must find ways now to increase our reliance on our own resources (table 3).

TABLE 3.–Fiscal Year 1977 Budget Request
Metallurgy Research Programs
(millions)

| Program | FY 1976 | FY 1977 |
|---|---|---|
| Advancing Minerals Technology | $13,9 | $12.6 |
| Effecting Pollution Abatement | 7.5 | 3.7 |
| Secondary Resource Recovery | 2.1 | 2.4 |
| Mlnimizing Mineral and Metal Needs | 3.5 | 3.8 |
| College Park Laboratory Replacement | – | 2.8 |
| Pay and Space Increases | – | 0.4 |
| Total | $27.0 | $25.8 |

That is a major aim of the Bureau's metallurgy research. The abundant nonmagnetic taconites of Minnesota, plentiful domestic deposits of anorthosite and clay, and significant resources of low-grade laterite and gabbro material , , , all of these and others are targets of Bureau metallurgy research. We have had one recent dramatic success with the nonmagnetic taconites, as is evidenced by the existence of a major new commercial mine and processing plant at Tilden, Michigan. The success of the process used at the Tilden plant results from research conducted by the Bureau. Now, we are experimentally applying the same technology, along with alternative approaches, to convert more of the vast nonmagnetic taconite resource into an economic iron ore reserve,



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Although bauxite cannot be said to be in short supply throughout the world, we have little of it here in the United States, and we are increasingly forced to compete with other industrialized countries in seeking reliable sources of bauxite at acceptable prices. Recent trends toward nationalization by bauxite-producing nations point up the need for a technology that will permit us to use our own ample resources of anorthosite, clay, and other alumina-bearing materials as a raw materials base for aluminum production. In cooperation with major aluminum producers, the Bureau of Mines is doing just that. As you probably know, there are several processes that will extract alumina from the kinds of material I've mentioned. The difficulty is that no single one stands out clearly as the best bet for doing it on a commercial scale. So, with financial support from the industry, the Bureau is testing each process on a miniplant scale, about 25 pounds of alumina production per hour. Such a procedure will allow us to judge which particular procedures, or combinations of procedures, offer the most promise for scale up.

An important source of encouragement in this enterprise has been our past success in extracting gold from carbonaceous ores once thought impossible to treat by conventional cyanidation, Nevada's Carlin gold mine exists today as testimony to the ingenuity of Bureau metallurgists in overcoming such obstacles.

Nickel, cobalt, and chromium are all essential metals for which the United States depends heavily on foreign sources of supply. But, both nickel and cobalt occur along with copper in the Duluth, Minn., gabbro deposits, and both chromium and nickel are found in the low-grade laterites in Oregon and California. Bureau researchers are seeking ways of treating these materials, which today can at best be termed a submarginal resource, and in the process improving our self-sufficiency in metals that we cannot do without.

As Vince noted earlier, we still waste a high percentage of our minerals in this country and, again as he indicated, the Bureau of Mines is working to reduce that percentage, Right now, better than half of the antimony scrap generated in the United States is recycled, but it is the only one of ten major metals for which anything like that kind of a record can be claimed. We recycle 25 percent of our iron and copper scrap, roughly 20 percent of our nickel and tin, and from 5 percent to 10 percent of our aluminum, zinc, and chromium. Thirty percent of our scrap lead is recycled, but less than 5 percent of magnesium scrap is reclaimed.

The Bureau has pioneered in application of metallurgical technology to reclaim valuable metals and minerals from urban refuse, and the procedures it has devised are now being adopted by several communities in various parts of the country. Now, we

are going after metal values being lost every day in such industrial wastes as flue dust, mill scale grinding swarf, and the solutions used for electroplating, etching, and pickling, Automobile recycling is a good example of a technology area that was given great impetus by Government (Bureau of Mines) R&D. We pioneered technology that makes possible the smokeless incineration of the nonmetallic components of old auto hulks, and our studies have also pointed the way to more efficient procedures for stripping junk cars before the bodies are shredded. We also developed air classification as an effective means of recovering the nonferrous fraction of shredded auto bodies.

Substitution is still another way in which Bureau research is seeking to provide the kind of technology that can help forestall material shortages, by substituting relatively abundant materials for scarce ones, For example, substitution of molybdenum for imported chromium in certain alloys, substitution of rare earths for platinum in catalysts, and substitution of ceramics for metals.

We also can extend our limited supplies of materials with processes like ion implantation, making what are, in effect, new materials. We can give a plentiful material the properties it needs to supplant a scarce one, and give the scarce one qualities that enable it to stand up longer in use. Ion implantation may give us the answer to the problems of scale and corrosion that shorten the life of metals used in casing geothermal wells, If so, it can make our access to geothermal energy significantly less costly.

I've tried to give you a broad picture of the Bureau's activities, particularly as they relate to the problem of material shortages. While the examples I've chosen are typical, they are by no means all-inclusive. The time available did not permit any such review. We are making increased effort to tie economics to R&D and to use this to plan and evaluate our R&D programs (table 4).

**Solutions to Chronic Materials Scarcity**

Because the Bureau is the kind of Federal agency it is, the questions to be pondered by Task Forces at this Conference are of natural concern to us. While we don't pretend to have all the answers, we do have some thoughts that bear on some of your questions, and before stepping down, I'd like to share a few of them with you.

The question of how conservation should be defined, for example, is one that has interested the Bureau throughout its history. Our first director, Joseph A. Holmes, defined conservation as "the wise and efficient use of natural resources," and for most of the years of the Bureau's existence, that definition has seemed adequate enough. In any case, one definition postulated

TABLE 4.–Fiscal Year 1977 Budget Request
Mineral and Materials Supply/Demand Analysis Programs
(millions)

| Program | FY 1976 | FY 1977 |
|---|---|---|
| Data Collection and Verification | $5.1 | $4.9 |
| Evaluation and Analysis | 3.8 | 3.8 |
| Information Dissemination | 3.3 | 3.3 |
| State Liaison | 2.3 | 2.3 |
| Wilderness and Engineering Investigations | 5.5 | 5.0 |
| Pay and Space Increases | | 0.6 |
| Total | $20.0 | $19.9 |

for **a** Task Force seems to me somewhat narrow, even though I realize that the Task Force's immediate concern is the conservation of energy in materials processing.

The definition proposed, "continual progress in reducing the energy consumed per unit of output (or GNP)," states a laudable-enough goal. But, I believe that the output itself, the mix of products, must also be taken into consideration. I think Americans are beginning to realize that the phrases "standard of living" and "quality of life" are not synonymous, The word "wise" in Dr. Holmes' definition of conservation becomes more and more meaningful for me as I consider the difficulties of the choices that we, and future generations, will have to make. Do we want to pursue a lifestyle that is essentially wasteful, or are we willing to husband our resources so that all of us, and our progeny, can be assured the necessities of life? Do we want a sound economy, or will we choose to remain at the mercy of foreign powers with objectives quite distinct from our own? If I seem to be echoing my fellow keynoter, I guess I am. Like him, I'm convinced that the choices we make today will determine whether we have any choice at all tomorrow.

With regard to the recommendations being made on materials information systems, we have—as might be expected—some definite views. We concur heartily in the stated need for monitoring the Nation's vulnerability and dependence on foreign sources, for materials, and for conducting research, that can be expected to reduce such vulnerability and dependence. But we cannot concede that additional Federal authorities are needed to accomplish those functions. (Incidentally, in Washington, there is often confusion about the difference between data and inter-

pretation on the one hand, and either commodity supply/demand information or information on technology on the other hand.) In fact, the programs and activities that Vince McKelvey and I have described to you embrace those functions and more. The Survey's Computerized Resource Information Bank, coupled with the Bureau's Minerals and Fuels Availability Systems and its worldwide reporting of mineral information, provides a highly effective monitoring capability, and that capability guides the R&D efforts of both agencies.

Mineral and material policy is shaped by many different forces, including markets, international relations and trade, strategic and military considerations, tax laws, state of the economy, financial and monetary situations, government regulations, public land policies, labor/management attitudes, social attitudes, congressional committee structures, checks and balances among Government agencies, and politics. It's relatively easy to create "laundry lists" of necessary or desirable mineral policy needs, For the most part, the Government already has adequate authority in the mineral technology information and policy area. We cannot ignore the growing Government and other impediments to our own domestic supply situation. However, it seems unlikely that we will have a comprehensive mineral policy in the near future, just as it seems unlikely that we will have a comprehensive policy in any area, unless we have a controlled economy, which I don't advocate.

There are, however, several contemporary principles upon which mineral policy should be based:

1. We should not become over-dependent on foreign sources for our mineral supplies; over-dependence can lead to economic and political problems. However, international trade in minerals is important to us and to the world.
2. We should depend on the private sector to find, produce, and supply our minerals. We must maintain a favorable economic climate in order to allow for reasonable recovery of risk capital.
3. Mineral deposits must be available to be mined, especially those on the public lands, which are generally the most geologically favorable for mineral occurrences. The concept of multiple use has served this country well, and should be maintained.
4. Mineral authorities within the Federal Government should not be overly fragmented to the proverbial 67 different agencies.
5. Governmental laws and regulations must be based on scientific and engineering fact; they must not be punitive;

and they must allow for physical, geological, and geographical differences.

6. International mineral policy must be made with a complete understanding of our free-enterprise economy, By the same token, we must recognize the growing needs of the developing countries. Economic stockpiles and commodity agreements could lead to more Government control of domestic prices and production; however, we should be willing to discuss commodity arrangements on an individual basis. We should maintain our basic free trade position.
7, The Federal Government (Bureau of Mines) has a limited, but important, role in advancing the technology for:
   - finding, mining, and processing ores from lower grade deposits;
   - substituting more plentiful minerals for those which are scarce;
   - conserving consumption of mineral materials, i.e., using less, increasing recovery, and extending useful life;
   - decreasing the environmental effects and the health/safety risks in mining and processing of minerals; and
   - recovering valuable mineral materials from municipal, industrial, and other wastes.
8. Strategic minerals for defense purposes deserve special consideration. The concept of a strategic stockpile, if properly designed and controlled, is a good one.
9. The basic laws governing mining and leasing of public land minerals are fundamentally sound. Perhaps it would be desirable to improve the diligence requirements and environmental safeguards, but the location-patent system for locatable minerals is a good principle and should be retained.
10. The oceans represent a major potential source of some of our critical minerals. Ocean mining policy must carefully weigh the interests of our domestic mineral economy and our domestic mineral needs.
11. In order to maintain our mineral position, we need the assurance of a secure and stable energy supply. (Thus, industry is part of the problem and part of the solution—a good example of the complexity of these problems.)
12. Mineral information systems must be adequate for public and private planning and policy purposes. However, it is not necessary to collect everything, and in many cases, voluntary systems work better than mandatory ones.

The final thought I would like to leave with you is this. There seems a pervasive belief today that the one best answer to every problem is more Government action. Even the agendas for your task forces and the dominance of Government representation here today reflect what seem to me a little too much readiness to "turn the whole thing over to Government." Some persons are apparently unable, or unwilling, to remember that we have a dynamic private sector with intelligence, energy, and talent, and that it has a capability for dealing effectively with a wide range of problems.

Government action is necessary, of course, where the overriding factors are other than economic, as in the case of national defense. But, wherever possible, Government should use the forces of the marketplace to achieve its goal. In fact, there seem to be developing trends to indicate that increased Government interference with the marketplace has contributed more to the problem of mineral and material shortages than to its solution. as in the 1973-74 shortage situation so prominently discussed at these meetings,

Moreover, those Government actions that must be taken should be continually evaluated on a cost-effectiveness basis. When circumstances change, or if the actions do not achieve their intended effect, they should then be rescinded or modified to accomplish the legitimate policy aim. Otherwise, we will continue to see what already is increasingly evident: too much Government, in too many places.

I've been asked to say a few words about the Committee on Materials (COMAT), of the Federal Council for Science and Technology (FCST), and its significance to this Conference. COMAT was established in February 1975, by H. Guyford Stever, FCST Director, as an interagency materials R&D coordinating committee, Jack Carlson, Assistant Secretary, Department of the Interior, was its first Chairman, succeeded in February 1976, by William L, Fisher, its new Assistant Secretary. Three task forces were formed with the following charges:

- To inventory and analyze materials R&D funded by the Federal Government and industry;
- To determine materials requirements and Government-sponsored materials R&D for a national energy program: and
- To develop a governmental perspective between materials production. environment, and health.

As Chairman of the Inventory Task Force, I am pleased to distribute advance draft copies of the first report on materials R&D funding in the Federal Government. As noted by its title "Materials Life Cycle R& D," COMAT'S definition of materials is

very broad, including everything other than food and drugs, from exploration to extraction, processing, manufacturing, application, and recovery or disposal. Approximately $1 billion of FY 76 funding by 18 Federal agencies is identified in its computerized inventory. It can easily be searched to analyze the adequacy of programs in relation to national goals, specific missions. functions or stages in the materials life cycle, and materials categories, The excellent help provided by Battelle Columbus Laboratories in this pioneering effort is gratefully acknowledged.

Time does not permit my presenting the inventory data in greater detail. However, the COMAT report, which you now have, can be effectively utilized in identifying the breadth and depth of the Government's current materials R&D program, and relating that information to the issues before this Conference, This factual data base, on the Government's materials R&D spending as identified by specific areas, provides us with the means of analyzing and authoritatively recommending courses of action. The Phase 11 part of this inventory on industry's materials R&D, when completed, will provide us with the total national activity. We recommend that the COMAT inventory be used as widely as possible for effective and productive planning purposes.

# CONGRESS AND THE ENGINEERING FOUNDATION CONFERENCES

by Emilio Q. Daddario, Director
Office of Technology Assessment
US. Congress

Ladies and gentlemen, it is an honor and a pleasure to be with you today at this fourth Henniker Conference on National Materials Policy, The title of this Conference, "Engineering Implications of Chronic Materials Scarcity," highlights our concern for the best use of the world's materials supplies and the developing need for a US. national materials policy.

The need for an early warning mechanism, not only for materials but for other problems as well, was realized by Congress and a large part of the public some time ago. Technology could no longer be applied without an understanding of its ramifications—both good and bad. This realization was the motivating force behind the creation of the Office of Technology Assessment.

This same need for an early warning mechanism to develop and focus a national materials policy has helped to shape the work of past I-Ienniker conferences, and hopefully will continue to be the backbone of future Henniker conferences. It is quite fair to say, due to the scope of these conferences and the development of a dialog among experts in the materials field, that the result of previous Henniker conferences has been a wider participation and a better understanding between the public and private sectors.

As you know, some of OTA's initial assessments are concerned with the problem of materials supply and the availability of natural resources. One of these, a program in the area of material resources, will be discussed shortly by the OTA Program Manager for Materials, Dr. Albert Paladino. Other OTA assessments are in the important areas of world food supplies, ocean technologies, and the overall energy situation. The selection of these assessment topics by OTA's governing congressional body, the Technology Assessment Board, is responsive to the priorities set by Congress in expressing its need for legislative assistance.

## Congressional Use of Henniker Conference Findings

During the 94th Congress, approximately 150 bills have been introduced dealing with materials subjects. These bills range from specific topics of materials durability, solid waste disposal, and the authorization to dispose of materials from the national

stockpile to the broader, more sweeping subjects of the need for a national materials policy or the establishment of a "Commission on Materials Research and Operations. " Before looking at one of these bills in detail, I'd like to touch on the role Henniker has played and the response Congress has shown to the findings and results of past Henniker sessions.

The first Henniker Conference on National Materials Policy, held in 1970, discussed the topic of "Materials Problems and Issues," The proceedings of this conference were published by the Senate Committee on Public Works. This Committee was instrumental in drafting the bill that created the National Commission on Materials Policy, which was signed into law approximately two months after the first Henniker Conference.

The second Henniker Conference on National Materials Policy, held in 1972, was entitled "Resolving Some Selected Issues," Participants of this conference included the Chairman and Executive Director of the National Commission on Materials Policy, the Director of the National Bureau of Standards, and members of the Interagency Council for Materials. The findings and concerns of this conference were put to use by the 93rd Congress. They were read into the Congressional Record and later cited on the Senate floor during the debate of S. **3279,** a bill to establish a National Commission on Supplies and Shortages, as justification for such a commission. This bill would establish a temporary commission to keep tabs on materials, serve as an early warning system in case of threatened dislocations, propose solutions, and design a permanent institution for congressional and executive consideration.

The concept of such a commission was first introduced in **1952** by the Paley Commission, the U.S. President's Materials Policy Commission, and was again advocated by the National Commission on Materials Policy in 1973, a year after the second Henniker Conference. This bill was passed by Congress and became Public Law **93-426** on September 30, 1974. Since that time, the National Commission on Supplies and Shortages has been active in research looking to the development of public policy.

The third Henniker Conference, in August 1974, examined various options for implementing a national materials policy. It emphasized the need for reliable and accessible information on all aspects of materials management; called attention to the interdependence of nations with regard to the production and exchange of materials; and explored opportunities for materials conservation, recycling, and the improved use of institutions for materials management, Many of the topics for discussion and analysis–for example, "Stockpiling for the Future: A Commentary on Ways that a National Stockpile Could Be Socially

Beneficial," and "Materials Information, An Examination of The Adequacy of Existing Systems"- received congressional attention, As a result of this concern, Congress asked the Office of Technology Assessment to assess the impacts of stockpiling for economic purposes and to analyze the adequacy of present materials information systems for the technology of materials supply, processing, and uses, Thus, both the stockpiling assessment and the assessment of materials information systems, which have recently been completed by OTA, had their genesis in the third Henniker Conference.

**National Materials Policy Legislation**

But technology assessments are just one way that Congress is responding to materials-related issues. The many bills dealing with materials subjects introduced in the 94th Congress illustrate the type and scope of problems facing Congress in the materials arena, and reveal how Congress has chosen to respond to these problems.

On June 17, 1976, Congressman James Symington, Chairman of the House Subcommittee on Science, Research, and Development, together with Congressman Charles Mosher, ranking minority member of the subcommittee, introduced H.R. 14439, the "National Materials Policy, Research, and Organizational Act of 1976. " This bill, if passed, would 1) establish a national materials policy for the United States, 2) create a materials research and development capability, 3) improve the flow of new scientific and technological information arising from materials research, and 4) provide an organizational structure for the effective application of such research capability, These four components of the bill are awesome and require careful planning and analysis if they are to be implemented and coordinated into the present working materials cycle.

H.R. 14439 proposes to establish in the Executive Office of the President a "National Materials Policy Board" chaired by a Special Assistant to the President for Materials Policy. Members of the Board would include the Director of the Office of Science and Technology Policy, the Chairman of the Council of Economic Advisers, the Executive Director of the Domestic Council, the Chairman of the Undersecretaries' Committee of the National Security Council, and not more than eight public members appointed by the President. This Board would advise the President with respect to alternative methods of implementing materials policy; recommend programs to implement policy; and review and recommend to the President appropriate actions re -

garding programs in the Federal budget affecting national materials policy.

To implement the findings of the "National Materials Policy Board" would be the function of the "Commission on Materials Research and Operations," composed of a number of cabinet officers, the Director of the National Science Foundation, administrators of the National Aeronautics and Space Administration and the Energy Research and Development Administration, and two public members appointed by the President to serve as Chairman and Vice Chairman. The Commission would review programs recommended by the Board to implement national materials policy and establish such programs which seem appropriate. Such programs would include, for example, the development of information systems relating to the materials cycle or the encouragement of proper and efficient use and reuse of materials, including assistance to industry in carrying out such programs.

H.R, 14439 would also create a "Select Congressional Committee on National Materials Policy" in each House of Congress, composed of Members from standing committees having jurisdiction over material problems, Each Select Committee would be composed of 14 Members, 7 Republican, 7 Democratic, These "Select Committees" would assess changes recommended by the President in national materials policy, review recommendations of the "Commission on Materials Research and Operations, " and study and review broad questions of national materials policy.

This bill is currently pending before the House Committee on the Judiciary, the Committee on Rules, and the Committee on Science and Technology, Executive comment is now being received from a number of Federal agencies, An identical Senate bill, S. 3637, was introduced on June 29, 1976, by Senator Frank Moss, who explained at the time that "The bill offers an excellent starting point for what I would like to see become a national discussion, I hardly need remind my colleagues of the considerable energy which has been needlessly expended, the sidestepping and false starts which might have been avoided, or the cohesion and comprehensiveness which have been so seriously lacking in so many of our national debates because of this very failure to promote and administer a full-scale materials/resource policy. The bill provides a vehicle which can go far in alleviating a host of problems which have beset this country ever since we realized that the world's goods and services are scarce indeed and finite to be sure,"

The need for a national materials policy has been emphasized from the beginning with the work of the Paley Commission in

1952, by the Boyd Commission in 1973, in the proceedings of the three past Henniker Conferences, and in numerous publications of the National Academy of Science/Academy of Engineering, like the study by the Committee on Mineral Resources and the Environment (COMRATE),

Thus, for the past 25 years, materials experts in both the public and private sector have been pointing out to Congress the need for an overall national materials policy. While Congress has generally responded to specific materials needs by enacting or at least proposing limited action programs–the labeling of products, transport of dangerous substances, recycling of municipal wastes, research in novel energy materials, and so on — it has only been in recent years that Congress has begun to respond to the overall materials picture. The establishment of the National Commission on Materials Policy, the National Commission on Supplies and Shortages, and the Office of Technology Assessment has provided Congress with three mechanisms for anticipating future materials problems.

As I see it, the role of the National Commission on Supplies and Shortages is to address the more specific question of what institutions and provisions of Government are needed to assure American industry a smooth and reliable flow of essential materials under an orderly pricing structure. The role of the OTA, on the other hand, is longer-ranged. OTA is charged with addressing such questions as: 1) How could the Congress proceed, in the foreseeable future, to meet the policy needs of the United States in the field of materials management and materials technology? and 2) How do we relate our management of materials to full employment, economic soundness, the preservation of our environment, the frugal but adequate use of energy, and our relations with other countries?

Such questions need to be addressed, and here at Henniker both the institutional and supply/demand questions of the Commission and the broad legislative policy questions of OTA are of concern, Your role in this continuing improvement of communication is essential to this ongoing process, and your past record of involvement gives you sound credentials to affect our materials policy.

Before turning the podium over to Dr. Paladino, who will discuss materials assessments for Congress and the role the Office of Technology Assessment Materials Program plays in those assessments, I should like to close by expressing my appreciation for your participation, It is the “spirit of Henniker,” the working together of materials experts from all fields and backgrounds, that has provided a support base of vital information for our work.