The Evolving National Policy for Materials

Our future materials policy needs a much broader interpretation of the national security.

Franklin P. Huddle

This article traces U.S. materials policy since World War I, characterizes the abrupt change in the status of materials in the mid-1970's, and discusses contemporary approaches and concepts that respond to this change. The article concludes that national materials policy-making in the United States has been a succession of fragmented, incoherent spasms. There has been no awareness of the sweep of events over a long period in the past, and little concerted attention to future prospects.

Materials policy is complex because it is affected by different groups with different problems and different options to achieve the range of objectives. There is no way that national policy can fully meet all national needs. Only the U.S. Congress, an institution designed to provide political solutions through compromise, is equipped to mediate the conflicting claims on national policy in this essential field. But the Congress requires authoritatively and objectively analyzed technical information and data on supply and demand and on the economy, to chart a policy for the future.

Herein, I define materials as "stuff that things are made with." Materials have a "life cycle" from extraction to refinement to processing to fabrication to use in finished products and thereafter to discard or recycling. This sequence is called the "materials cycle." National materials policy is "the identification of those aspects of the total materials cycle for which concerted national actions will probably serve the public interest, and the prescription of what these actions should be" (*1*).

The industrial development of the United States can be divided into three epochs; the extractive extended from the earliest colonial period to about 1900, that of manufacturing ended about 1960, and that of services began about 1960.

The author is senior specialist in science and technology of the Congressional Research Service, Library of Congress, Washington, D.C. 20540.

The Extractive Period

Despite the program initiated by Alexander Hamilton as first Secretary of the Treasury to promote manufacturing, factory labor did not outnumber farm, mine, and forest workers until almost the close of the 19th century. The early emphasis on the extractive industries assured that, with the rise of the factory economy in the 1800's or so, the abundance of food, fiber, ore, and fuel conveyed the durable impression of limitless natural resources to sustain industry. The United States, therefore, easily met its expanding industrial requirements while also exporting large quantities of coal, petroleum, and metals.

A first indication of waning abundance came after entry of the United States into World War I. The sharp increases in demands for raw materials in 1917 and 1918 brought shortages in parts of the country later specified in the "Harbord List." Reorganization of the War Department in 1919 included the establishment of an industrial mobilization planning unit in the Office of the Undersecretary. In this office, a list was prepared in 1921 by Colonel Harbord of 28 materials that had presented supply difficulties during the war (*2*). However, much of the difficulty with shortages during that war came from the confusions and inexperience with planning for military requirements. (Huge demands were forecast and production well underway to support a fresh two-million-man army for a planned 1919 offensive at the time the war ended.)

The Manufacturing Period

World War I accelerated a shift in emphasis from extractive to manufacturing industries. In the 1920's, manufacturing became clearly dominant in the United States. While the production of food, fiber, fuel, and minerals continued to rise, the number of workers in these industries declined steadily; meanwhile, manufacturing became the primary occupation of U.S. workers. Despite management emphasis in the 1920's on labor productivity, the growth of manufacturing industry required a continuing increase in the work force, as well as increasing quantities of an ever-widening list of industrial materials.

The two decades that followed World War I were a period of boom in the 1920's and bust in the 1930's. New discoveries of petroleum and further exploration of western coal and copper deposits conveyed the impression of limitless natural wealth. The United States was the leading exporter of copper in the world. But in the 1930's, the Great Depression brought a sharp dip in demand for products and materials. Factories, steel mills, copper refineries, and coal mines went idle. At the depth of the depression, copper hit an all-time low price of 4.7 cents a pound and the state of Arizona began to use it to make automobile license plates. Much New Deal legislation was aimed at making raw material surpluses manageable.

However, a little-noticed trend was occurring during these two decades. Technologists in England, Germany, France, and the United States were engaged in a search for ways to enhance the properties of the basic materials (steel, copper, and aluminum) with alloying additives (nickel, chromium, manganese, vanadium, molybdenum, zirconium, and tungsten). New or increased uses were found for organic materials (rubber, copra, palm oil, kapok, tung oil, pyrethrum, and many others). Uses of other nonferrous metals (tin, lead, zinc, and magnesium) expanded. Exotic metals like beryllium, uranium, and columbium (niobium) found specialized industrial uses, as did nonmetallic minerals like mica, quartz crystal, graphite, talc, and asbestos. When World War II began, in September 1939, all these materials and many others went to war. That war, fought over a wider geographic spread with a greater mobilization of troops and resources than World War I, called for a vast range of new kinds of hardware and sophisticated technology. A list of materials that presented supply problems in the war, prepared by the staff of the Army-Navy Munitions Board (*3*), numbered 298 items and was probably incomplete.

The United States entered the war at the end of 1941, proposing once more to serve as the "arsenal of democracy." Excess industrial capacity was put to work on war production. Mines, mills, and smelters worked overtime. New petroleum pipelines were built to bring fuel to war industries. A $750-million synthetic rubber industry was

built from scratch. Many new materials came into importance as radio, radar, and sonar became more sophisticated. Primitive gas turbine engines created a small but growing demand for high-temperature alloys. The $2-billion Manhattan District project called for substantial quantities of beryllium, high-purity graphite, and stainless steel. Tungsten carbide was used in enormous quantities in antitank ordnance. The capacity to refine aluminum and magnesium was greatly increased to build President Roosevelt's promised 50,000 planes a year.

Immediately after the war, a new "Strategic and Critical Materials Stock Piling Act of 1946" became effective. Its purpose was to reduce or eliminate a "dangerous and costly dependence" of the United States on "certain strategic and critical materials" essential in a war emergency. The program would accept transfers of war surpluses, purchase in the market, and secure on long-term contracts the materials needed to complete these objectives. The act also instructed the Departments of Interior and Agriculture to conduct research in ways to develop and extend supplies and to find substitutes for strategic and critical materials.

As the inflationary pressure of pent-up consumer demand after World War II was beginning to lose its force, the Korean War broke out. The impact of this conflict on U.S. industry was notable. While the theater was not large, heavy use of helicopters, combat aircraft, and artillery consumed substantial quantities of strategic and critical materials.

In addition, the fact that the conflict was initiated by a communist regime was interpreted to signify that aggressive action by force of arms to extend the sway of "international communism" in Korea was the product of deliberate policy by "World Communism" and that further aggressions were to be expected elsewhere. To anticipate and deter this perceived threat became the main line of U.S. policy; it entailed restoration and mobilization of U.S. forces, reequipment of the Navy and Air Force, reopening of defense plants, construction of new industrial facilities, arming and equipping of U.S. allies in Europe and elsewhere, and an ambitious program of materials stockpiling. These activities coincided with the peak of Marshall Plan assistance to war-devastated European nations and other foreign aid programs, and the outflow of U.S. goods abroad stimulated a new wave of consumer demand in the United States. By 1952 U.S. production of manufactures was about half the world's, and industrial consumption of materials reached similar proportions.

It was during the Korean War years, 1950 to 1952, that the Paley Commission prepared its historic report, *Resources for Freedom* (*4*). The commission was impressed with the rate at which U.S. materials resources were being chewed up. Arkansas bauxite was nearly exhausted. The rich Mesabi iron range was about gone. Imports of materials necessary for U.S. industry were rising generally. This country had become one of the world's largest importers of copper. And the demands of new technology were enlarging the list of essential imports to include such items as palladium, tantalum, cobalt, hafnium, and especially uranium.

Extrapolation of statistics for future U.S. materials requirements based on trends over the years 1947 through 1951 gave a frightening picture of exhaustion and foreign dependence. On the other hand, extending the figures of per capita consumption in the United States to the rest of the world suggested that total world exhaustion of many materials would not be long delayed.

Accordingly, the Paley Commission urged four national measures: (i) statistics on the relation of the supply of materials to the demand should be carefully maintained and closely watched; (ii) resource conservation and development should be pressed, with emphasis on new materials technology in substitute materials; (iii) a nongovernmental institution should be established to monitor the state of materials supply and demand; and (iv) a new governmental institution close to the President should be established to formulate and direct national materials policy.

The Paley report was released in June 1952, during the closing months of the Truman Administration. National attention was focused on the presidential campaign during the rest of that year, and little effort was devoted to implementing the recommendations of the report. Studies were made by the National Security Resources Board (NSRB) (*5*) and the U.S. Munitions Board (*6*) on implementing actions, and the NSRB report was duly transmitted to Congress. However, as the Korean War subsided, mobilization programs tapered off, stockpile goals began to be achieved, and demands for materials eased. The mining industry, tuned to expanded wartime demands, found itself once more producing surpluses. The plight of this industry confronted the new Administration in 1953.

Materials policy between 1946 and 1953 had centered on mobilization readiness through stockpiling and conservation. The rationale of this two-part policy was to hold essential requirements to the bare minimum by conservation measures and to build reserve stocks to meet the needs of an expanded war situation. Appearance of postwar surpluses called for a change in policy.

On 26 October 1953, President Eisenhower appointed a Cabinet committee to inquire into national policies affecting the production and utilization of metals and minerals. He also stressed the need for balance between domestic mineral development and assured access to overseas supplies for peace or war, implicitly calling attention to the plight of the domestic mines. At a meeting of the Cabinet in March 1954 it was decided that the national stockpile should be enlarged to provide a market for the depressed domestic mining industry, with particular reference to lead and zinc. (The price of lead rose 20 percent and that of zinc 24 percent during the next 9 months.)

On 30 November 1954, in a more formal set of recommendations, the Cabinet committee called for a substantially enlarged stockpile "to meet the tremendous surges of demand that come with war." It noted that existing stockpile objectives were minimum objectives, based on substantial wartime imports and stringent conservation measures. Accordingly, it recommended supplemental long-term objectives to reduce or eliminate foreseeable wartime shortages, reduce dependence on imports, and eliminate the need for extreme wartime conservation measures.

The committee went further. Minerals were of two classes, those produced in the United States and those imported. Determinations of supply and demand should be made on a case-by-case basis, and comprehensive programs should be mounted to expand domestic capacity to maintain production, plus an "intensive search for new deposits and development of new properties. . . ." It called for easing taxes and giving financial assistance for mining activities, improving discovery technology, more vigorously exploring for minerals, revising mining laws that restrict exploration, improving collection and dissemination of data on minerals, studying ways to improve utilization of minerals, and coordinating the government with the mining industry. Planning would be based on a 5-year war, as urged by the Department of the Interior, instead of on a 3-year war which the Joint Chiefs of Staff preferred as a basis for stockpile objectives. In addition, the principle was adopted that the stockpile should contain enough of each material to meet one full year of normal use (*7*). In brief, the new policy combined the earlier concept of a war reserve with a new concept of underwriting the market for surplus minerals produced domestically and subsidizing new domestic

sources of minerals, all on a case-by-case basis.

As the economy sagged in the closing years of the decade, this policy had a mixed effect on the economic health of a number of domestic mines. The expanded stockpile benefited some mines. However, the policy also led to the accumulation of worthless and inaccessible low-grade chromite at the Stillwater, Montana, deposit, procurement of domestic tungsten at four times the world price, and a large accumulation of copper.

Perhaps most important, the purchases of several metals at elevated prices by the stockpile drew U.S. metal off the market while foreign producers filled the gap at the attractive supported prices. Thus, when the national stockpile objectives were reached and buying stopped, prices fell. The intent of the program had been to stimulate a healthy and productive domestic mining industry but few of the new mines thus "stimulated" remained open after the bonanza ended. Reliance on imports of metal continued to expand thereafter.

When John F. Kennedy became president, national materials policy underwent another review, this time by the Congress. To conduct this review, the President turned to Senator Stuart Symington (D–Mo.), who earlier had been chairman of the National Security Resources Board (NSRB). A week later, the President created the Executive Stockpile Committee "to review the principles and policies which guide our national stockpile . . ."; the chairman of the committee was the Acting Director of the Office of Emergency Planning (successor to the NSRB).

The Senate investigation was retrospective; that of the Executive branch dealt with future policy. Both groups agreed that stockpile secrecy had been excessive, that objectives should be simplified, that stockpile accumulations were unbalanced and for some materials far beyond reasonable levels, that military opinion as to the duration of a future war should govern the setting of objectives (that is, a 3-year war rather than a 5-year war, but also the possibility of a number of small wars), that provision should be made for reserves under conditions of a nuclear war, and that stockpile purchases to support domestic mining should be abandoned. One addition to policy, suggested by the Executive Stockpile Committee (*8*), was that in setting stockpile objectives, consideration should be given to "the possibility that in a mobilization situation short of war, sources of raw materials may be denied to us."

In its final report in 1963 the Symington Subcommittee was sharply critical of the domestic purchase programs of the stockpile (*9*). These had been justified, the report said, as "in the national interest to develop and maintain a mobilization base for certain highly strategic materials." But "the hearings showed that, without exception, the domestic purchase programs failed in the attainment of this objective."

A separate policy study had been commissioned in 1962 by E. A. McDermott of the Office of Emergency Planning, to be performed by a group of consultants under the leadership of W. Y. Elliott of Harvard University. This group prepared a draft report titled "Materials availability for the Free World," which was widely circulated within the government but never made public. At a colloquium at the American University, 24 November 1964, Elliott and his associates summarized some of the findings of the study (*10*). He called attention to the neglected roles of science and technology in generating new requirements for exotic materials and in devising techniques of conserving and extending materials supplies. He warned that indiscriminate dumping of stockpiled materials would injure world markets. He urged retention of stocks as a cushion against manipulation of the supply of materials as a consequence of "guided revolutions" and "blackmail," especially in developing nations. And he observed that "our government has no initiating program center, either for planning or for experimentation." In the draft report itself (*11*) he had written:

> A repercussion on the stability of the new countries and on the ability of the Free World to continue assisting them to a healthy development is a natural byproduct of any such large scale disruption of access to the world's basic raw material resources.

The first line of defense against these threats, Elliott continued, was the totality of U.S. defense and foreign policy programs, including foreign aid, support for U.S. allies, and regional alliances. The second line of defense was a vigorous program of technological development of substitute materials and conservation measures, supplemented by an adequate national stockpile. What was needed was a "balanced materials policy," designed and orchestrated at a high level of government.

Between 1963 and 1970, despite a growing commitment of U.S. forces in Vietnam, national materials policy received little official attention. Successive sales of "excess" materials were made from the national stockpile with formal legislative approval. The role of the Office of Emergency Planning diminished. Military attention was divided between maintenance of the strategic (nuclear) deterrent and an attempt to master with technology the adversary in Vietnam. Materials research and development concentrated on serving the "high technology" of aerospace, nuclear hardware, antiballistic systems, and military electronics.

However, in 1967, the Congress began to consider the subject of environmental quality. This trend involved a new approach to national materials policy. One concern was for the injury done to the land and the pollution of streams by strip mining. Another was for air pollution from fossil fuels, atomic reactors, metal refineries, aluminum reduction plants, and iron foundries. A third was the pollution of the land and air resulting from disposal of huge quantities of solid wastes. It became evident to more and more analysts that all forms of environmental pollution (except for such transients as thermal and noise pollution) were the consequence of the mismanagement of materials. Accordingly, environmental policy might have been perceived at the outset as one subset of national materials policy. As one study (*12*) pointed out,

> As a general principle, environmental degradation is the result of misplacing materials. Materials useful in one situation become harmful in another. Degradation of the environment can be halted by maintaining control over the location of materials. Application of this principle; however, becomes a complex problem, because materials vary in so many important respects: as to abundance, price, salvage value, useful applications and properties, ease of reprocessing, and injurious effects on the environment.

This study, prepared at the request of Senator J. C. Boggs (R–Del.), was followed in April 1969 by a report by an ad hoc committee, also organized at Boggs' request. The report called attention to the need for an adequate supply of industrial materials for peace or war, the need to practice frugality in the light of growing world demands for these materials, the need to satisfy ever-more-demanding requirements for improved properties of materials, and the need to manage materials so as to preserve a benign and unpolluted environment. To these purposes the committee proposed formation of a national commission to draft for congressional consideration a set of recommended policies governing the handling of materials from extraction to disposal (*13*).

Senator Boggs promptly introduced a bill to implement these recommendations. It was attached as an amendment (Title II—National Materials Policy) to the Resource Recovery Act of 1970, Public Law 91–512, approved 26 October 1970. The White House sent for Senate approval in June 1971 the nominations of the seven-member National Commission on Materials Policy (NCMP), they were accepted,

and the commission convened for its first meeting 15 September. The commission report recommended that we (i) provide adequate energy and materials supplies to satisfy not only the basic needs of nutrition, shelter, and health, but a dynamic economy, without indulgence in waste; (ii) rely on market forces as a prime determinant of the mix of imports and domestic production in the field of materials but at the same time decrease and prevent wherever necessary a dangerous or costly dependence on imports; (iii) accomplish the foregoing objectives while protecting or enhancing the environment in which we live; (iv) conserve our natural resources and environment by treating waste materials as resources and returning them either to use or, in a harmless condition, to the ecosystems; and (v) institute coordinated resource policy planning which recognizes the interrelationships among materials, energy, and the environment (*14*). The fifth point introduced for the first time in formal policy literature the concept of the interconnectedness of materials, energy, and environment, a relationship that was to become more salient as the energy crisis deepened.

Perhaps the most remarkable distinction between the Paley report of 1952 and the NCMP report of 1973 was that the former dealt extensively with the needs of national security but in the latter, military requirements were not touched on, and only passing reference was made to "security."

The Services Economy

The NCMP report was issued at a time when the United States was well into the third great epoch of economic change, the postindustrial or services economy. A graph depicts what was happening: Engineering materials and energy fuel consumption were roughly keeping pace with the population increase, but the gross national product (GNP), between 1940 and 1950, had begun a steep upward climb, with a second even steeper slope after about 1960. This GNP rise (in constant dollars) was attributed to the rapid expansion of employment and institutions producing services rather than goods. There were a number of implications for national materials policy to be derived from this development. For example, (i) the extractive and manufacturing sectors (producers and processors of materials) were a declining fraction of the total economy but no less essential to its total functioning; (ii) the tax base would be increasingly skewed because much of the services sector was tax-supported; (iii) hardware used by services industries (medical equipment, computers, aircraft, electronics, photocopiers, cable television, and others) tended to be "high technology" items characterized by high cost, frequent design change, and small volume, and requiring small quantities but a greatly expanded variety of essential materials with special properties; and (iv) the requirements of materials for the rapidly expanding services industries were superimposed on a continuing requirement for basic consumer goods that was keeping pace with the population growth. Taken together, these two sets of requirements presented a picture of tremendous complexity. It was increasingly difficult to know what was happening in materials markets.

Materials policy during the extractive epoch had been to discover, recover, process, and sell materials while improving the technology of their fabrication. During the manufacturing epoch, the policy had been to maintain sources of domestic and foreign supply, while further improving technology of use, materials performance, and conservation. Today, in the services epoch, the role of materials is vastly more complex, and the policy for their national management is correspondingly intricate.

For one example, the basic materials industries in the United States (such as steel, glass, and wood) increasingly tend to resist technological innovation. It is not for want of new inventions or technological ideas; high-risk innovations are seldom embraced in an established, highly competitive, narrow-profit-margin industry built large to exploit economies of scale. Many companies are faced with unmanageable capital replacement problems plus the costs of compliance with health, safety, and environmental regulations. Energy and natural gas shortages loom. Transportation presents uncertainties. Foreign competitors have newer capital equipment and often more compliant governments watching over them. American companies need a flexible stance, an ability to respond to challenges, exploit opportunities, and adapt to the new epoch. But they have grown rigid, even bureaucratic.

Another policy issue involves the relationship of materials to the dwindling U.S. resources of natural gas and petroleum and the prospective shortage of electric power. If the forces of the "free market" cannot compel energy conservation, the government may have to intervene. It is estimated that the U.S. steel industry wastes a third of the energy it buys. Steel technology in this country evolved at a time when energy was cheap; to convert to technology less wasteful of energy would exceed the industry's ability to raise the necessary capital. Similarly, the glass industry was built on the use of natural gas; it may not be able to afford today the costs of converting to electric furnaces.

A third policy issue relates to the heavy reliance of U.S. industry on imported materials. Virtually all U.S. supplies of chromium, manganese, cobalt, tin, columbium, aluminum, titanium, platinum, and palladium are imported. More than half of our fluorine, mercury, bismuth, nickel, selenium, zinc, tungsten, and cadmium comes from other countries. Other industrial countries are competing vigorously for supplies of these materials, and producing countries are exploring ways to exploit their monopoly position. Only the enormous agricultural strength of the United States prevents this country from suffering a persistent deficit in balance of payments. Among the options open are (i) a program of conservation to reduce the total amounts of materials needed, (ii) the building of commercial stockpiles, (iii) negotiation of a network of international agreements for the equitable sharing of world resources, (iv) vigorous research and development of substitutes either for use or as standby protection for the future. Some economists hold that market forces will operate effectively to correct shortages when they occur, but when industrial companies are already operating so close to the margin, the "correction" is likely to be achieved by their closing down.

Today national materials policy in a postindustrial epoch seems to require increased efficiency of use, reduced volume of throughput of materials in industry, increased recycling and reduced quantities of disposable wastes, reduced effluents, closer control over toxic and dangerous materials, more durable materials in engineering designs, and the development of systems of international cooperation in the sharing of materials and technology.

Developments Toward a National Materials Policy

There have been a number of important developments in the mid-1970's. For example, the U.S. Department of the Interior (notably from the Bureau of Mines and Geological Survey) has written a series of factual reports and policy studies in the field of minerals. There have also been stirrings in the Department of Defense and the Central Intelligence Agency. The General Services Administration currently has under way activities in materials planning, stockpile policy, long-range economic planning for industrial preparedness, and policy on priorities and allocations for De-

fense and the Energy Research and Development Agency.

A number of congressional committees are working on materials policy with support from the Office of Technology Assessment, the Congressional Research Service, and the General Accounting Office.

The report of the National Commission on Materials Policy to Congress inspired some 300 legislative proposals (*15*). Eleven committees have been exploring various aspects of materials policy in a post-industrial economy. Examples of the subjects under congressional scrutiny during 1975 include: solid waste management for energy conservation, resource recovery and recycling, stockpiling and stockpiled materials, import tariffs on raw materials, tax credits for material recycling, a permanent national commission, a materials forecasting agency, a materials and resources information system, economic stockpiling, utilization of existing stockpile for nondefense purposes, and materials science and technology and industrial health.

The Office of Technology Assessment (OTA) has under way a major program of assessments in national materials problems initiated under the direction of J. B. Wachtman, Jr., and continued by A. E. Paladino (*16*). The effort centers on three major programs, the adequacy of materials information systems for public policy-making, the accessibility of minerals on public lands, and the future uses of a national materials stockpile. These studies, all nearing completion, are being conducted under contract. Two other assessments address problems of recycling and materials aspects of product durability. Assessments in international trade and seabed mineral development will also have important implications for a national materials policy.

OTA's tentative plans for materials assessments center on such topics as the technologies of determining minerals in the ground and of offshore mining, materials limitations in energy systems, materials implications for new automobiles, R & D for recovery of metals from low-grade ores, and in substitutes for scarce materials.

The General Accounting Office has under way seven approved programs of studies concerning "industrial materials"; (i) federal collection analysis and dissemination of raw materials' data, including forecasts of supply and demand; (ii) federal role as a proprietor of raw materials resources on public lands; (iii) international polices and practices and their impact on the availability of raw materials, including policies for controlling imports and exports of materials and agreements to develop seabed resources; (iv) federal research and development efforts to conserve raw materials, to increase supplies of materials, and to provide substitutes for the more rare and costly raw materials; (v) in-house policies and practices and contracting practices to conserve the use of scarce raw materials; (vi) federal organizational structure to cope with the interdependence of raw materials problem; and (vii) federal policies to stimulate the private sector to increase the production, recycling, and conservation of materials, through judicious land use, building codes, tax incentives, and so forth.

One congressional initiative is the Temporary National Commission on Supplies and Shortages (TNCSS). This initiative opened with a nationally televised address by Senator Mike Mansfield (D–Mont.), majority leader of the Senate, 1 February 1974, calling attention to the deteriorating condition of the United States in materials supply. A bill establishing the commission was introduced 22 May and passed and signed into law in September 1974. The commission was instructed to report its findings as to future prospects of shortages of materials and on the need for a permanent watchdog institution to foresee and to act in advance to meet future prospects of crisis relating to materials. The TNCSS, which held its first meeting 16 September 1975, 8 days after the appointment of the public members was announced, proposes to complete its report by 31 December 1976. D. B. Rice, president of the Rand Corporation, was designated chairman and George Eads, executive director (*17*).

On 19 November Rice and Eads met with Senator Mansfield who presented a letter cosigned by himself and Senator Hugh Scott (R–Pa.) urging the commission to implement the major recommendations of past studies rather than repeating them. What was needed, emphasized the letter, was "... *designing* the appropriate instrumentality that can provide strategic information assessments together with specific *policy options* that might be employed today to help mitigate or prevent the crisis, if any, perceived on down the road." The letter also referred to the need for a "coordinated strategic economic information system." The issue was not a free market economy versus a planned economy, but to provide a clearer perception of what lay ahead "so that the nation might better prepare itself." In other words, the commission should concentrate on designing an institution to collect and analyze information and define possible solutions for the problems it foresaw.

It is not yet clear whether the Mansfield-Scott letter will have its apparently intended effect of freeing the commission from the straitjacket of classical economic theory. The preference of conventional economists for a free market (or even the gold standard) neglects the painful consequences of market perturbations. It ignores the obvious departures from a free market occasioned by state trading, politically motivated boycotts, and competition with government-subsidized foreign purchasers for scarce supplies.

The Organization of Petroleum Exporting Countries has taught other developing countries several invaluable lessons. Freedom to drive two-and-one-half-ton automobiles at high speeds has been challenged. An envious world has looked on while we luxuriated in a high-consumption economy, but today the developing countries are realizing that the resources they possess are more potent as an economic weapon than is our threat not to buy them. National security requires a stable economy with assured supplies of materials for industry. In this sense, frugality and conservation of materials are essential to our national security. Security means more than safety from hostile attack; it includes the preservation of a system of civilization. We need to achieve the security of designing a way of life that is acceptable to us and compatible with the rest of the world.

The necessity for progress must be reconciled with the constraints imposed by the finiteness of materials, capital, and places to put our trash and pollutants. Good management includes getting maximum use out of each elemental atom, closing the materials cycle, maintaining the value of materials throughout the cycle, using the more abundant materials in preference to the less abundant, keeping the energy level of materials as high as possible, and using the smallest feasible quantity of materials to accomplish any given purpose.

Materials decisions are among the most widely diffused of all human activities. The consumer exerts his choice in the marketplace. The industrial design engineer, materials engineer, and process engineer make decisions about what goes into the product. The extraction and processing of materials into useful forms call for decisions from scores of industries. Prices of materials tend to fluctuate widely, according to the supply. The ideal is to have just enough all the time, with stable prices and orderly flows. Only in this way can rational decisions be made as to which material is most efficient in which application. On the other hand, when systems become this orderly, there is a tendency toward institutional hardening of the arteries. When this

happens, the system is ill equipped to respond to the changes that do occur.

I suggest three future policies in materials. First, we should identify those economic, technological, and political elements that encourage or discourage good materials management and respond to these findings. Second, we should maintain surveillance of all aspects of national materials management to detect emerging obstacles to good performance and lags in execution. Third, we should develop an institutional capability for (i) quickly correcting sudden deficiencies in national materials management and (ii) detecting and gradually correcting undesirable trends in the management of the materials cycle.

In more specific terms, these three policies translate into programs of action. Under the first we should make ground rules for the control of pollution the same everywhere, avoid springing sudden and severe restrictions on industry, encourage research to overcome observed defects in our use of materials or to expand opportunities for improved uses, establish standards to reduce needless variety of alloys or plastic compositions, and make the flows and price fluctuations of materials more regular. Most of the sensible measures in the management of materials are mutually supportive. For example, if we learn how to make our materials perform better with less, we can afford to pay more for them per unit, which means that we can afford to mine and process leaner ores; it also means that recycling is likely to be more profitable. Yet the price to the consumer of finished goods can remain the same.

With respect to the second policy, the main requirement is for better information about materials. Since the decisions on materials management are made in so many places, it is necessary that information appropriate to each kind of decision be made available where the decision is made. Adam Smith's theory was that all market transactions take place in the presence of complete information. We are far from this perfection in our management of materials; for the marketplace to function, we need to know more than we do now.

The Paley report of 1952 (*4*) best describes the program of action called for by the third policy: "There must be, somewhere, a mechanism for looking at the problem as a whole, for keeping track of changing situations and the interrelation of policies and programs. This task must be performed by a Federal Agency near the top of the administrative structure." The National Commission on Materials Policy also proposed that a "comprehensive Cabinet-level agency be established for materials, energy, and the environment" with a parallel organization in the Congress, and that as an interim measure a "Natural Resources Coordinating Committee" be established to "begin the task of integrating materials, energy, and environment policy." The Temporary National Commission on Supplies and Shortages now has the opportunity of closing this story that began more than a half-century ago.

References and Notes

1. Definitions are extracts from U.S. House of Representatives, Committee on Science and Astronautics, *Science Policy, A Working Glossary* (Government Printing Office, Washington, D.C., ed. 2, 1973).
2. F. P. Huddle, *Conserv. Bull.* **4**, 7 (May 1955).
3. The Munitions Board, *Military Procurement: A Guide for Joint Industry–Military Procurement Planning* (Government Printing Office, Washington, D.C., 1948), pp. 25–29.
4. The President's Materials Policy Commission, *Resources for Freedom* (Government Printing Office, Washington, D.C., 1952), vols. 1 to 5.
5. National Security Resources Board, *The Objectives of United States Materials Resources Policy and Suggested Initial Steps in Their Accomplishment* (Government Printing Office, Washington, D.C., 1952).
6. U.S. Department of Defense, "Comments and position on the recommendations of the President's Materials Policy Commission," prepared by the Munitions Board, October 1952.
7. "Report of the U.S. President's Cabinet Committee on Minerals Policy," November 1954.
8. U.S. Senate, Committee on Armed Services, *Inquiry into the Strategic and Critical Materials Stockpiles of the United States* (Government Printing Office, Washington, D.C., 1962–63), p. 3089.
9. U.S. Senate, Committee on Armed Services, *Inquiry into the Strategic and Critical Materials Stockpiles of the United States: Draft Report of the National Stockpile and Naval Petroleum Reserves Subcommittee* (Committee Print, Government Printing Office, Washington, D.C., 1963), p. 66.
10. W. Y. Elliot, in *Washington Colloquium on Science and Society*, S. F. Seymour, Ed. (Mono Book, Baltimore, 1967), pp. 54–65.
11. W. Y. Elliott *et al.*, "Materials availability for the Free World," unpublished draft report, 1963.
12. U.S. Senate, Committee on Public Works, *Availability, Utilization, and Salvage of Industrial Materials* (Committee print, Government Printing Office, Washington, D.C., 1968), p. 2.
13. U.S. Senate, Committee on Public Works, *Toward a National Materials Policy* (Committee print, Government Printing Office, Washington, D.C., 1969).
14. National Commission on Materials Policy, *Materials Needs and the Environment Today and Tomorrow: Final Report* (Government Printing Office, Washington, D.C., 1973), letter of transmittal.
15. H. Bullis, C. McBee, W. Boesman, "Summary of Materials-Related Legislation Introduced into the 94th Congress," prepared by the Congressional Research Service, 1975.
16. Dr. Wachtman was on loan from the National Bureau of Standards; Dr. Paladino is from the Raytheon Corporation.
17. Other members of the commission are Senators John V. Tunney (D–Calif.) and Bill Brock (R–Tenn.), Representatives Thomas M. Rees (D–Calif.) and J. William Stanton (R–Ohio), William E. Simon (Secretary of the Treasury), L. William Seidman (Assistant to the President for Economic Affairs), James T. Lynn (Director of the Office of Management and Budget), Alan Greenspan (Chairman of the Council of Economic Advisers), and public members Hendrik S. Houthakker (Professor of Economics at Harvard), George Kozmetsky (Dean of the College of Business Administration and Graduate School of Business, University of Texas), Philip H. Trezise (Senior Fellow, Brookings Institution), and Nat Weinberg (Economist).