Resume of U.S. Technology Policies

Review reveals lack of broadly-based, systematic, continuous planning toward coordinated technology policy

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DEFINITIONS AND IMPORTANCE OF TECHNOLOGY AND TECHNOLOGICAL INNOVATION TO WELFARE OF U.S.

For the purposes of this paper "technology" is defined as the aggregation of methods, materials, and devices used to provide goods and services. "Technological innovation" means new aggregations for providing novel goods and services, or for providing already available goods and services at lower cost and/or with fewer resources.

Dr. Ancker-Johnson

Our "quality of life" if improved by technological innovation:

- The economic aspects because technological innovation results in expanded employment opportunities and enhanced productivity that brings growth in real income.
- The political aspects because such innovation provides a strong defense capability, a favorable competitive position in international trade, and the ability to aid lesser-developed countries raise their standards of living.
- The humanistic aspects because new technology furnishes better means to protect the earth's ecological system; more humane working conditions; and a more adequate food supply, housing, transportation, communications, and health care.

The bulk of technological innovation has occurred in small, ingenuous steps as a result of economic pressures. Ultimately it relies on how advanced basic knowledge is. Since 1940 innovations have resulted increasingly from the planned, organized search for new knowledge. It is this shift which caused Drucker to call the U.S. the first "knowledge society."[1]

The relationship among the several stages in "planned" technological innovation are illustrated by the development and application of the laser (Light Absorption and Stimulated Emission of Radiation):

- Enlargement of fundamental scientific knowledge (the mathematical language required to formalize quantum mechanics was at hand when physicists first discovered quantum phenomena).
- Successful applied research (laser action was demonstrated only after appreciable understanding of quantum energy states was available).
- Product/process development (a grasp of the lasing principle eventually spawned gas lasers and solid-state lasers, as well as lasers large enough to walk through and also so small as to be barely visible).
- Manufacture (more than 35 U.S. companies produce at least one kind of laser).
- Distribution and application (lasers are found in metal cutting tools and surgical equipment, and are used to trigger chemical reactions).
- Coupling of technologies (solid-state lasers coupled with optical glass fibers comprise potentially a communications system of much larger capacity than any previous system and one whose production is much less demanding on material and energy supplies).

From the LES U.S.A. Annual Meeting

This innovative chain is very rarely so recognizable as a series of connected links, nor are the individual links usually so distinguishable, as in the laser example. *Most generally, technological innovation is brought to fruition by economic pressures** — hence the old saying, "Necessity is the mother of invention." The "father of invention" is science and technology, the supply of knowledge obtained through research and development.

Some examples of U.S. inventions which led to widespread technological innovation stimulated by economic realities are given late in this paper. In addition, foreign inventions have led to major technological innovations, such as the dieselization of U.S. railways after World War II and later the rise of dominance of U.S. jet-powered planes. These innovations reduced labor and fuel costs per unit output and improved performance as well. The rapid application of computers in U.S. business operations and direct telephone dialing cut labor costs per unit output; the introduction of oxygen into steel manufacture reduced the required capital investment. The know-how underlying these innovations ranged from very

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*Even in the laser example ecomonic realities stimulated the advance which made the first demonstration of the potentially so useful new communication system feasible: after the system that coupled solid-state laser with glass fibers was conceived great reduction in the attenuation of light as it traveled along through the fibers was required, and achieved, before the first practical system was built.

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old to relatively new, but the engineering design and testing which led to the commercial application was driven by economic pressures.

Technological innovation requires people possessing special skills. Scientists and engineers must gain new understanding of the natural laws and discover novel applications. Creative people must invent, alone or in organized groups, such as those frequently found in industrial laboratories. Other ingenuous people must recognize and apply technology "not invented at home," an activity that might involve purchasing rights to use patents owned by foreigners. Every brand of technician and craftsman is necessary. Technological innovation cannot happen without people who can design, construct, and manage complicated production systems; control quality; help others use innovations; and recognize needs that can be met with an emerging innovation.

Technological innovation also requires an adequate supply of materials and capital. And the development and supply of materials for a new product or process is, in itself, determined by technological innovation, e.g., the substitution of aluminum for the higher-priced copper electrical cables, and the likely substitution of the still cheaper glass fiber cables.

CONTRIBUTIONS OF TECHNOLOGY TO DEVELOPMENT OF U.S.

In 1875, the U.S. per capita GNP, valued in 1975 prices, was about $1,000. One hundred years later it had increased sevenfold. In 1875, 45% of the U.S. population was involved in farming. Today less that 5% of the population is so occupied. During these hundred years, the farming population declined by 53%, whereas the non-farming population multiplied 8.2 times.[2]

	1875	1975
Per Capita GNP ($)	1038	7136
Total U.S. population (million)	45.0	212.7
Farm population (million)	20.3	9.5

By 1950, the U.S. was perceived by all countries as possessing the most fortunate citizens: economically highest advantaged, best protected militarily, enjoying the most opportunities for avocations, etc.

During these 100 years significant U.S. technological innovations (and U.S. adoption of innovations from abroad) contributed singularly to the U.S. quality of life. Some examples follow:

PIVOTAL U.S. INVENTIONS

1876	Telephone
1884	Automatic Typesetting Machine ("Linotype")
1891	Motion Picture Projector
1903	Airplane
1907	Electronic Vacuum Tube
1908	Conveyor Belt for Assembly
1911	Harvesting Combine
1923	Iconoscope Electron Scanner (Television)
1928	Mechanical Cotton Picker
1935-50	Synthetic Textile Fibers
1937	Xerography
1942	Nuclear Reactor
1946	Electronic Computer
1947	Continuous Coal Miner
1947	Electronic Transistor, followed by integrated circuits
1954	Stimulated Emission of Radiation (MASER)
1958	Satellite Communications
1967	Optical Waveguides

The most comprehensive statistical analysis of U.S. economic growth, that made by the Brookings Institution's Edward F. Denison, treats the period 1929-1969.[3] "Advances in knowledge", "education per worker", and "economics of scale" — three major factors in technological innovation — were responsible for 85% of the productivity increase[a] in that 40-year period. This increase, Denison estimates, accounts for 45% of the U.S. economic growth during those 40 years. MIT's Robert M. Solow, on the basis of a slightly different analysis, comes to essentially the same conclusions.[4]

Michael Boretsky, U.S. Department of Commerce, has analyzed the U.S. manufacturing industry, the sector that shows the impact of technological innovation much more directly than does the economy as a whole.[5] He compares, during the 1957-1973 period, technology-intensive industries with other industries. The technology-intensive industries perform approximately 80% of U.S. industrial R&D and employ scientists, engineers, and technicians in other than R&D functions to a much greater extent than do the other industries. His comparisons of performance show clearly the importance of technological innovation to U.S. economic security:

Average Yearly (1957-1973)	Technology-Intensive	Other
Real output growth rate (%)	5.5	3.8
Employment growth rate (%)	1.5	0.8
Productivity increase (%)	4.0	2.9
Inflation growth (%)	0.9	1.6
Foreign trade balance ($B)	+8.1	-4.0

Technology-intensive industries grew 45% faster, their employment 88% faster, and their productivity 38% faster than other industry; their contribution to inflation, however, was 44% lower.

Although the contributions of science and technology have been indispensible to the development of the U.S. throughout its history, technological innovation is currently exhibiting undesirable trends.

CHALLENGE POSED BY RECENT TRENDS

In spite of the demonstrated importance of science and technology to the nation's welfare, there are several indications that the United States' performance in science and technology has deteriorated in the last few years. This is documented in the National Science Board report, "Science Indicators — 1974," which was transmitted to Congress by President Ford on February 23, 1976. Fewer

[a]Productivity increase is defined as growth in real national income per person employed and so is interpreted as increased output per worker.

money and manpower resources are being invested in research and development, and also this research and development is resulting in fewer inventions and is contributing less effectively to productivity and competitiveness in international trade. Furthermore, the general societal environment is today less conducive to technological innovation, and appears to be becoming even less so.

1. *Investment: Resources*

Over the last decade, the total expenditure for R&D in the United States has shown a steady decline. This is in sharp contrast to the steady (and in one case dramatic) increases found in many industrialized foreign nations.

	Percent Change During 1969-73 in Total R&D Expenditures in 1969 Dollars
United States	- 3
USSR	+43
West Germany	+40
Japan	+74
France	+11

Moreover, since World War II, most of the R&D effort in European countries and Japan has been oriented toward civilian economic development whereas in the U.S. the major emphasis has been on defense and space objectives.[6]

	Percent of GNP for Civilian R&D in the 1960's
United States	1.2
West Germany	1.7
France	1.6
Japan	1.5

Support of science and technology in the United States has either leveled off or decreased in most scientific disciplines.

	Percent Change in the U.S. Expenditures 1969-1974 (in 1972 dollars)
Total R&D	-6
Federally funded total R&D	-15
Federally funded basic research	-13
Federally funded applied R&D	-16
Privately funded total R&D	+7
Privately funded basic research	-3
Privately funded applied R&D	+8

The number of scientists and engineers engaged in R&D per capita has declined in the U.S. since 1969, but has continued to grow in other industrialized countries. Japan had three times as many people engaged in science and technology per dollar of GNP as the United States during the decade of the Sixties.[6]

In the United States, there has been a shift in manpower trained in science and technology to work in other areas. Between 1968 and 1974, the employment of scientists and engineers increased by only about 90,000, from 1,543,000 to 1,632,000. In this time span, however, the country's educational system produced some 750,000 scientists and engineers. Assuming a normal attrition rate of the employed, 2% per year, and 2% unemployment rate of total S&T manpower, as reported by the Bureau of Labor statistics, these figures imply that the 1974 employment of people classified as scientists and engineers was short of the available manpower trained in those disciplines by about 400,000. Hence, between 1969 and 1974, these 400,000 trained in S&T had to look for jobs in fields other than the professions for which they were trained.

2. *Results: Inventiveness, Productivity, International Trade*

The declining investment of resources in R&D is accompanied by some disquieting results of U.S. R&D efforts.

Inventiveness. Patent activity is an indicator of the technological progress of a country, although it should be kept in mind that some inventions are not patented, not all patented inventions ultimately are incorporated in marketed items, and inventions vary greatly in their technological and economic significance.[7]

The U.S. share of patents filed worldwide has decreased in the last decade:

	1963	1973
Patents of U.S. Nationals*	66,715	66,935
Patents of foreign Nationals*	274,947	360,353

(*Multiple filings counted only once)

This table shows that foreign inventors obtained 31% more patents in 1973 than in 1963, whereas U.S. inventors, even though the U.S. population increased by 11% in this period, were granted only 0.3% more patents in 1973 than in 1963.

The foreign inventors' share of patents issued by the U.S. Patent and Trademark Office has increased:

	1963	1975
Patents of U.S. Nationals	53,619	50,155
Patents of Foreign Nationals	12,782	26,271
Foreign/U.S.	1:4.2	1:1.9

In several areas of technology, foreign inventors have become indisputable leaders. For example, in the following subject areas the foreign inventor share of U.S. patents during 1973-1975 has been:

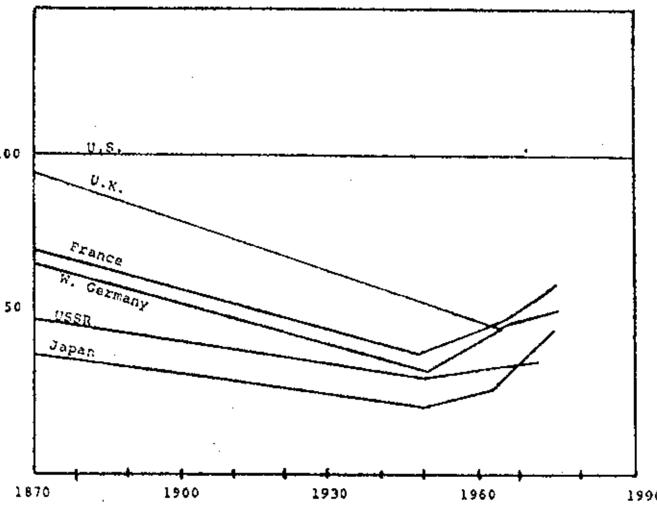
Still cameras with electric film advance	86 percent
Electromagnetic fluid pumps	83 percent
Metalcasting using electrodes	81 percent
Electromechanical oscillators	74 percent

A study by Gellman Research Associates, Inc. of 500 major new products and processes worldwide, over the past two decades, shows a marked decline in U.S. innovation. Of these 500, the U.S. was responsible for 82% of the major innovations in the 1950s, but it accounted for only 55% by the mid-1960s. Moreover, the fraction of American innovations rated as "radical breakthroughs" declined nearly 50% in the period 1967-73 compared to the period 1953-59.[6]

In the 1953-59 period, the greatest number of major innovations was produced by firms employing fewer than 1,000 employees, whereas in the 1967-73 period manufacturing companies with more than 10,000 employees were responsible for most of the innovations. In 1973, there was a tremendous concentration of industrial R&D effort with just 31 large companies accounting for more than 60% of R&D expenditures by industry. The withdrawal of small companies from the innovation race may be a large factor in the decline of U.S. technological dominance in world trade.[6]

Productivity. The nation's productivity also provides a measure of the effectiveness of our science and technology effort. Although the contributions of R&D and technological innovation to the economy are presently understood in broad and general terms only, the contributions of R&D and innovation to economic growth and productivity are believed to be "positive, significant, and high."[6] U.S. productivity growth in all sectors dropped from an annual average rate of 2.4% from 1870-1966 to 1.5% from 1966-1973.[8] Part of the drop is associated with the economic slowdown, the influx of youth (inexperienced) into the labor force, inflation, and regulatory requirements; but part of the drop is probably associated with a decline in the ratio of R&D to GNP.[9]

An international comparison shows that the U.S. productivity gain between 1960 and 1974 is smaller than that of Japan, France, West Germany, the United Kingdom, and the USSR — a fact which some feel attests to the success of our foreign policy of aid for reconstruction following World War II. Although the United States still has the lead in productivity in terms of GNP per civilian employee, this lead has been reduced dramatically. The productivity gap has narrowed by 50% since the 1950's, with most of the decrease occurring in the late 1960's.



PRODUCTIVITY GNP PER CIVILIAN EMPLOYED COMPARED TO U.S.

Fig. 1

Since the middle sixties, moreover, the U.S. has experienced not only a relative decline in labor productivity growth, but also a relative decline in capital productivity growth (output per dollar's worth of investment in plant and equipment). From 1947 until 1966, the value of fixed capital (plant and equipment) invested by the private sector in 1947 dollars grew about 15% less rapidly than the value of its output (private sector part of GNP), but since 1966, the value of this capital grew some 21% faster than the value of output.

	1947-1965	1965-1973
1. Average annual growth of private GNP in constant dollars, % per year	3.9	3.8
2. Average annual growth in value of private nonresidential capital stock (gross value of plant and equipment) in constant dollars, % per year	3.3	4.2
3. Ratio of growth of capital to growth of GNP (2 : 1)	0.85	1.21

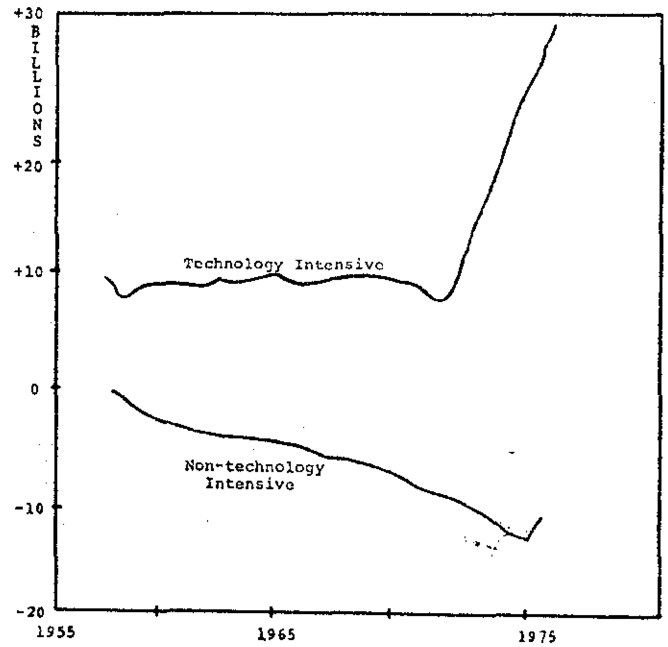
The service sector of the economy is far from realizing the potential of science and technology for increasing its productivity. The importance of this sector is evident from the fact that it now employs one-half to two-thirds, depending on definitions, of the U.S. work force.[10] Currently, the service sector contributes little to the U.S. balance of trade. Furthermore, productivity improvement in the service sector has been significantly lower than in the manufactured goods sector.[10] The cost of producing a business letter is 40% higher than it was 10 years ago.[11] Health care costs have increased from 4.6 to 7.6% of the GNP between 1950-74.[11] The expenses of state and local governments, which employ one out of six workers in the United States, have increased six-fold in the past 20 years.[12] Salary increases for state and local government employees amounted to 188% between 1953 and 1973, compared to 141% for manufacturing employees.[13] Modern information-handling techniques and automation have great potential for reversing these unfavorable productivity trends in the service sector and for improving the quality of these services.

Most economists argue that the decline in U.S. productivity growth is cyclical, or at most is temporary. Some argue that it is not caused by the slowdown in technological progress, but that this growth will return to its previous long-term rate once conditions in the economy return to "normal." As proof of this, reference is made to the countinued technological progress evident in the increased use of computers, information processing devices, photocopying machines, etc.

Boretsky[14] has tried to assess the merit of such reasoning by investigating the trends in the use of particularly significant technological innovations, namely those that are known to have produced great advances in U.S. productivity over a considerable time span. Examples are the substitution of oil and gas for coal, substitution of motor vehicles and aircraft for railroads and water barges, automation of industrial processes, mechanization and automation of material handling operations, industrialization of farming and food processing, substitution of synthetic raw materials for natural materials, and computerization of data processing. This investigation indicates that the pre-1965 diffusion rates of these especially significant innovations has slowed, since the mid-sixties, except for the spread of computerization and mechanization of data and paper processing. In some cases a surprising return to more labor-intensive processes has started.

Although the decline in the U.S. productivity growth since the mid-sixties may be attributed to many factors, the major factor, in our opinion, is the decline in technological advance — a decline that is consonant with the decreased investment in R&D. Hence, it is not wise to assume that an "automatic" reversal of this decline will occur.

Balance of Trade. The United States continues to enjoy a large, favorable balance of trade in commodities produced by R&D intensive industries.



U.S. BALANCE OF TRADE
Fig. 2

However, the favorable balance of trade in these technology-intensive commodities has come to depend primarily upon exports to developing nations and to Canada. Our trade in manufactured products with Europe has not improved much since 1971, the year of the first devaluation of the dollar. Moreover, a deficit balance developed with Japan in the mid-1960's and continued through 1973, largely because the U.S. imported electrical machinery, professional and scientific instruments, and non-electrical machinery.[6] To some economists these trade trends represent a decline in America's economic position because of the "catching up" of industrial competitors. In Kindleberger's (and our) view, the discouraging element is that we are no longer replacing dying exports with a new wave of innovative exports.[15 *]

3. *Altered Climate for Technological Innovation*

The climate for technological innovation in the U.S. has been altered in the last few years. Many interrelated factors are involved in this alteration:

—Inflation.

* * *

*The balance of trade graph shows a deficit in the overall U.S. trade balance in 1971, the first such deficit in almost 100 years. The trade deficit of 1971 produced a string of devaluations of the dollar. The graph shows that in 1975 our trade situation greatly improved (the U.S. achieved an overall surplus of $11.5 billion, compared to a deficit of $1.5 billion in 1971, $5.8 billion deficit in 1972, and $2.5 billion deficit in 1974). This improvement has often been attributed to the devaluation: However, the bulk of this improvement is accounted for by the large increase in the value of exports of food products where devaluation could hardly have played much of a role (foreign demand for these products is fairly inelastic), and by countries against which the dollar was either not devalued (Canada) or was actually appreciated (LDCs). Our trade in manufactured products with Europe and Japan, against whose currency the dollar was drastically devalued, either did not improve very much (Western Europe) or even deteriorated (Japan). Devaluation of the dollar is not a viable alternative to fostering technological advance as a means of reversing the weakening of the technological competitiveness of domestic industry in world markets.

—Capital shortage

—Growing emphasis on short-term returns on investments

—Indirect foreign intervention

—Increased regulation

—Lesser patent incentives

—Need for new sources of energy and materials

—Need for more efficient use of the available supplies

Results of Inflation

Among the bad results of inflation and inadequate capital formation are rising production costs, declining productivity, loss of jobs, and, inevitably, less R&D investment. Whether or not the situation is temporary or fundamental to our advanced industrialized economy, and thus calls for a shift from a consumption ethic to one of frugality, it is irrefutable that new, cost-effective technological innovation will both be affected by, and have an effect on, the adequacy of the capital supply.

Both inflation (average annual rate of inflation from 1970 through 1975 was 6.6%) and the low average rate of return (profit on sales by all U.S. manufacturing firms averaged 4.6% in the same period) are making capital formation very difficult. All sorts of enterprises are suffering the ill effects. For instance, the aerospace industry reports that its plant and equipment lifespan has been increasing over the 1965 to 1974 time span from a 10-year maximum life in 1965 to 15 years in the 1970s. Its inability to replace obsolete equipment is asserted to cause operating inefficiencies and a retarded productivity growth because it cannot utilize the most advanced technology.[16]

Another negative effect caused by capital shortage is the difficulty new companies have "getting started." The number of innovative technology-based companies that have started recently is much less than a few years ago. In 1972, there were over 400 small-company public issues of which approximately a quarter were for small technical companies. New small-technical-company issues (for companies with net worth of less than $5 million) amounted to $349 million in 1969, $6 million in 1974, $10 million in 1975, and — with the improvement in the stock market — $15 million in the first two months of 1976.[17,18]

Some of the decrease may be due to the two recessions since 1969, and the reduced procurement by DoD and NASA for products embodying advanced technology; however, these possible explanations cannot be separated from the fundamental problems of inflation and capital shortages.

The decrease in "startups" of advanced technology-based companies is cause for great concern, because experience shows clearly that such enterprises have been principal sources of the structural and competitive vigor of the economy in domestic and international commerce. One cannot help but wonder from whence the 3M, IBM, Xerox, Texas Instruments, Digital Equipment, National Semiconductor, etc. companies of the future will come — young technology-based companies that between 1969 and 1974 provided 133,000 new jobs while well-established companies like Bethlehem Steel, DuPont, GE, General Goods, International Paper, to pick at random, during the same period provided only 18,000 new jobs.[17]

Industrial management is persistently making decisions

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on the basis of cash-flow and annual profit performance rather than long-term productivity and sales growth. This preference by top management tends to slow the pace of innovation since innovation pays only in the long run.[19]

Environmental Regulations

The climate for innovation is also affected by the increased number of environmental regulations introduced in the 1970s because of increasing degradation of the environment by the waste products of industrialized society; the high rate of introduction of new synthetic chemicals (around 1,000 per year); the depletion of some natural resources; and the ecological, health, and aesthetic impacts of large energy projects. At present, it is not clear whether these regulations have had a net positive or negative effect on innovation,[20] but complying with these regulations does lead to higher costs and all their attendant problems. Even as the advances of technology have contributed to these causes for regulations and as these regulations put constraints on the types of technology that can be used, it is apparent that new technology must contribute to finding reasonable solutions that properly balance benefits with costs and risks.

Increased environmental controls place a demand on energy. For instance, a recent study [21] of the iron and steel industry has shown that 10% of the energy budget is required for environmental protection. Despite a more than 50% increase in energy prices relative to all other prices since 1973, and despite the significant potential which exists for energy conservation,[22] energy usage per dollar for economic output in the United States has decreased only slightly since the oil embargo:

	1973	1974	1975
Energy (quads of BTU)	74.7	72.9	71.1
Gross domestic product (in billions of 1972 dollars)	1225.7	1203.7	1181.3
Energy/GDP (economy-wide) (relative to 1973 level)	1	0.994	0.988
Energy/GDP (industry) (relative to 1973 level)	1	0.963	1.030

How much of a constraint or stimulus limited and/or expensive energy will be to innovation is far from clear. For example, until Middle East oil was discovered in huge quantities in the late 1940's, the prediction of scarce Western Hemisphere oil stimulated large R&D programs on synthetic fuels and shale oil in major petroleum company laboratories, as well as in the Department of Interior's Bureau of Mines. These programs were abandoned until the OPEC oil embargo again stimulated national interest.

The disquieting trends in the nation's recent science and technology performance and the new inhibiting elements in the climate for innovation present a challenge for technology policy. Should these trends continue, they could lead, on the international front to:

—A further decline of the nation's economic and political position, vis-a-vis "friends" as well as "adversaries."

—Pressure on the external value of the dollar.

—The gradual worsening of its terms of trade, causing a lowering of the U.S. standard of living.

On the domestic front, these trends could result in:

—A continued lag in growth of productivity and real income.

—Lasting inflationary pressures.

—Enduring high interest rates.

—Greater pressures for the redistribution of income.

—Lagging improvements or even a decline in the present level of the quality of life.

These challenging trends are the result of many factors, but undoubtedly, a critical factor is the inadequacy of the U.S. Government's policies with regard to the nation's industrial technology.

CURRENT FEDERAL TECHNOLOGY POLICY

Technology is so much a part of all activities, both private and government, that there are many different "technology policies" sponsored by, endorsed by, or acquiesced to by the Federal Government. Absent a deliberate effort, it is no surprise that the overall set of policies lacks unity and coherence given the rapid pace of technological change, the increasing U.S. (and world) dependence on technology, and the variety of interests involved.

The fragmentation and incoherence of Federal technology policies today, however, is harmful to the U.S. as it interacts with a world no longer dominated by U.S. technology as it was for two decades after World War II. The harmful or potentially harmful effects have been discussed in the preceding section.

This section gives a general overview of the more important existing Federal policies which together constitute "current Federal technology policy." Thus, Federal technology policy is the sum of actions taken by the U.S. Government affecting:

1. The production of technological innovation significant to the national economy.
2. The diffusion and/or exploitation of technology throughout the domestic economy.
3. The diffusion and exploitation of technology for international advantage.

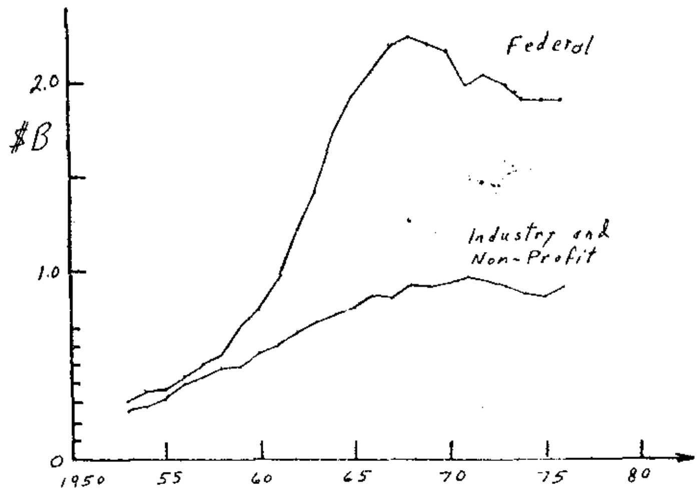
Some of these actions have been deliberate and others only in retrospect are seen to be in fact part of the sum equaling "technology policy." This lack of coordination and coherence need not be.

Technological innovation (as defined above) is novel aggregated methods for providing previously unavailable goods or services or already available goods and services at lower cost in money or natural resources. Federal actions affect not only the U.S. Government's ability to innovate, but also the ability of all the other sectors of the economy: profit-seeking enterprises; universities and other not-for-profit institutions; and state and local governments.

1. *Production of Technological Innovation*

The fundamental knowledge of nature which undergirds the technology exploited to provide human needs and wants is derived from *basic research.* Such work is mostly done in universities and similar institutions, frequently funded, as a direct result of Presidential and Congressional actions, by the National Science Foundation and the National Institutes of Health. Other Federal agencies which fund or perform themselves some basic research are DoD, ERDA, USDA, EPA, and DoC's NOAA and NBS. That small part of these agencies' overall budgets devoted to basic research is by Congressional action directly related to their statutory missions. A recent provision ("Mansfield Amendment" PL 91-441, 1970) made this requirement very explicit for the large DoD Research and Engineering appropriations.

Expenditures on basic research in constant dollars has been decreasing:



EXPENDITURES FOR BASIC RESEARCH
(1967 Constant Dollars)
Fig. 3

There is essential agreement among all parties that the support of basic research is a proper Federal Government function, extending even to the education and training of its practitioners. Disagreements are focused on amount of support, areas of science to be supported, and training of scientists and engineers. The success of Federal support is evidenced by the U.S. dominance of Nobel prize awards since World War II.

If this policy is to be fully successful, however, so that basic knowledge fuels technological innovation at an adequate pace, the contracts between the recipients of Federal Funds for basic research, primarily universities at approximately $3B/Y, and industrial firms must be solid. The gradual assumption by the Federal Government of the dominant role with support of basic research in the universities has potentially the harmful result of lessening the incentive and opportunity for industry to perform this type of research. It thus becomes imperative that the contact between universities and industry be fostered.

New materials, new devices, new products, new techniques, and new processes are created, with ever increasing dependence on basic research, in all three economic sectors, i.e., for-profit enterprises, not-for-profit institutions, and all levels of government. The creation of these manifestations of technology by *applied research* and *engineering* is heavily influenced by Federal policies and practices. It is here, not in basic research, that the ambiguities and incoherence among Federal technology policies becomes apparent.

Expenditures by Federal Government in applied R&D have been decreasing sharply since 1966 until 1973:

EXPENDITURES FOR APPLIED R&D
(1967 Constant Dollars)
Fig. 4

The U.S. Government has, ever since the Constitution was enacted, encouraged privately-funded development of new technology by providing U.S. *patents* to inventors. The inventor is granted a short-term (17 years) monopoly in return for publication of the invention.

In recent years, however, the U.S. Government has also extended the antitrust concept, namely, that free price competition must prevail among standard, non-patented products, to products of different technological category. As a result, of the increasing difficulty encountered in obtaining the legal protection of the patent monopoly as intended by the patent system, privately funded development of new technology is inhibited.

The U.S. Government has "stepped in" to fund *specific applied research and engineering* rather haphazardly but connected with these general criteria:

—Providing society or assuring its provision with public goods, most notably national defense, public safety, education, health care, transportation, and communication.

—Ensuring that the quality of the physical environment is preserved and improved.

—Conducting its own operations, especially those which collect, process, communicate, and preserve large masses of information.

—Aiding industry that is fragmented into units too small to carry out effective technology development, such as in farming and food processing, minerals utilization, and fishery technology.

—Exploiting technological opportunities of clearly national impact or avoiding national loss of prestige when risks and costs are too high to be undertaken solely by private interests; examples are the exploration of space, and the development of nuclear and solar energy technologies.

The *development of Federally-funded technology has been mainly carried out by private organizations* although the U.S. Government has nearly 100 major in-house laboratories and development centers, and completely supports 39 large privately operated development centers.

The bulk of Federally-funded but private-sector-executed applied research and engineering originates from DoD, NASA, and ERDA, whose policies have consistently stressed the importance of contractor R&D. Both DoD and NASA buy large amounts of high technology hardware and software in support of their mission, so it is reasonable to expect their support of contractor R&D. DoD grants back to the contractor about 2% of the purchase price of advanced-technology equipment as an "independent R&D" fund. No other agency is authorized to support R&D this well.

Federal agencies vary widely, also, in their treatment of the *property rights to inventions resulting from Federally-funded contractor research and development.* Primarily for administrative ease, and as a further contractor incentive, DoD assigns invention rights to the contractor. The legislation establishing NASA and ERDA require that the Government acquire the property rights, with the possibility of reassigning them to the contractor. Other agencies routinely acquire and retain the full property rights. Applied research and engineering executed within Federal laboratories in support of agency missions generates more U.S. Government-owned patents.

The number of patented inventions resulting from Federal funding is very small compared with the number generated by industry and not-for-profit institutions with their own funds:

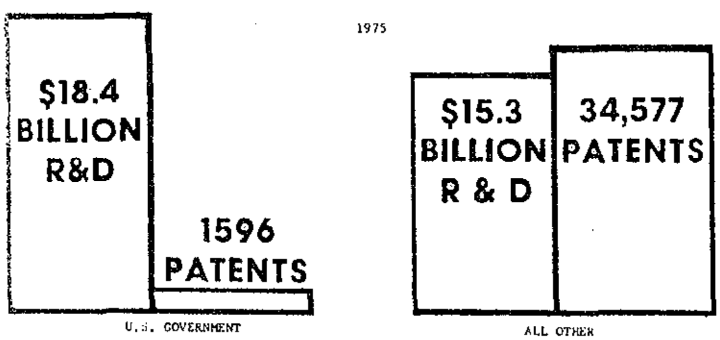
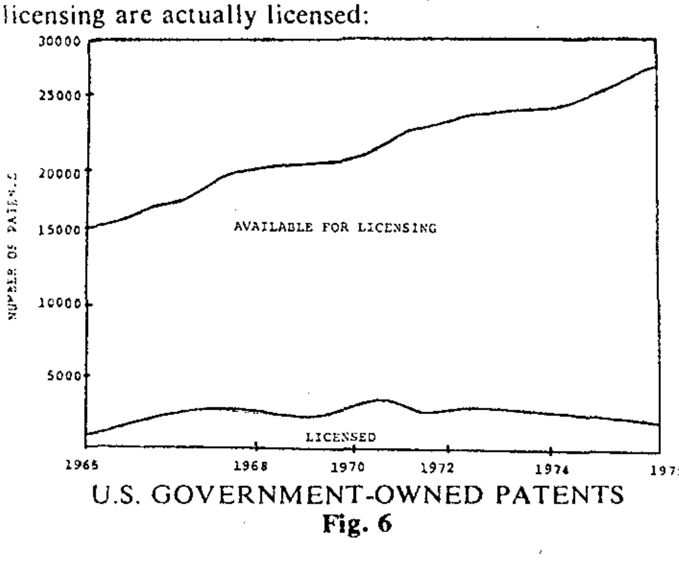


Fig. 5

In order for a U.S. Government-owned patent to be used by a company, a license must be issued. A tiny fraction of U.S. Government-owned patents available for licensing are actually licensed:



U.S. GOVERNMENT-OWNED PATENTS
Fig. 6

The policy for obtaining protection abroad for Federally-funded inventions is sketchy. Although a 1947 Executive Order designated the Secretary of Commerce as the primary official to protect U.S. technology abroad by obtaining foreign patent protection on Federally-owned inventions, until a year or two ago agencies generally ignored the order, and granted foreign patent rights to their employees. The usual result has been the abandonment of foreign patent protection; NASA and ERDA have been exceptions.

A proposed bill to rationalize and harmonize these policies pertaining to Federally-funded inventions is being cleared for submission to the Congress.

A Government policy — "Buy American" — has affected U.S. technological innovation, perhaps as a general disincentive. U.S. goods are preferentially bought under this policy, unless foreign goods can be bought at 94% or less of the U.S. price (in the case of civilian agencies, such as TVA) or 66% or less (in the case of DoD). Foreign manufacturers are thus given a powerful incentive to devise new, lower-cost technology.

The Morrill Act of 1863, an expression of U.S. Government support for general technological innovation in the private sector, enabled the establishment, by direct grant of Federal land and money, of state-operated colleges to promote the *agricultural and mechanical arts* and to train their practitioners. Much of the development of U.S. agriculture as well as the pre-World War II U.S. manufacturing industry relied heavily on the applied research and engineering performed in the "Aggie" colleges and on their graduates.

Today there is no similar, broadly-based Federal program for promoting general technology development in the private sector. Rather, as outlined above, each Federal agency promotes the creation and development of new technology related to its subject mission.

2. *Diffusion Exploitation of Technology Throughout the Domestic Economy*

In general, but with some notable exceptions, the guiding beliefs behind Federal activities affecting the diffusion and exploitation of technology in manufacturing have been that commercially applicable *manufacturing technology* is only developed by the private sector and that the self-interest of each firm acting in the marketplace will ensure optimum diffusion of the technology to other firms and its exploitation by them. The Department of Justice, however, questions these beliefs, and aggressively pushes demands that some privately-owned technology be made available to all.

Several agencies that themselves produce technology have mounted technology diffusion and exploitation programs. There is, however, no broadly based, coordinated Federal strategy for actively promoting the diffusion of commercially important manufacturing technology.

Conflicts Absent

The conflicts in Federal policies in this field are absent in two other technology intensive fields: agriculture and health care. In both these fields there are planned, coordinated, and well-funded Federal programs to provide the stimulus needed for rapid technology diffusion and exploitation. Two years ago a new technology for combatting corn blight was rapidly developed and diffused by the USDA. The most recent example is President Ford's request for $135M to innoculate all U.S. citizens in just a few months with the swine flue vaccine.

Some Federal programs for diffusing and exploiting *specific* manufacturing technology and innovation have been carefully conceived and executed with consideration of potential national impact. Others have apparently developed without such planning, and certainly without coordination with other agencies. A partial list of current programs follows:

—NBS promotes, nationwide, through voluntary non-Federal organizations, through service to regulatory agencies, and through its own programs the adoption of a compatible set of meaningful technologies:

1. A modern system of weights and measures for commerce.
2. Standards of physical measures for process control and engineering.
3. Prescription and performance standards for industrial and consumer products.
4. Laboratory and field test methods and in such calibrations for research, engineering, production, health care, and safety.
5. Evaluated data on materials and matter for R.D.E manufacturing, and commerce.

These basic programs are absolutely essential to the functioning and development of the U.S. industrial sector, and reflect long-standing publicly-endorsed policies.

—NTIS collects, organizes, and promotes nationwide awareness and use of new technical information, especially that generated by government agencies. The information is contained in technical reports, technical notes, data files, and Federally-owned patent applications.

—NTIS also collects, organizes, and promotes nationwide awareness and use of computer programs and models (software) generated by all Federal agencies.

—NTIS promotes nationwide the use of new Federally-owned inventions plus access to the technology expertise and facilities available from Federal laboratories.

—The Department of Defense has a well-funded program for diffusing and exploiting manufacturing technology important to lowering the cost of DoD-procured items.

—NASA partially funds the operation of nine "technical application centers" from Connecticut to California which provide literature searches for industry, and has "technology coordinators" in NASA field centers to bridge the gap between NASA experts and industry questioners.

—NASA also funds a computer software clearinghouse at the University of Georgia for public sale of NASA computer programs and models.

—NASA and NSF, jointly or separately, fund three nationwide programs to promote the application of technology to state, county, and regional government units. The technology being promoted is usually NASA-generated. The programs involve stationing a technically-trained individual in approximately 40 city or county offices, and also the fielding of several teams of NASA-trained experts who look for potential applications of NASA technology. Although the focus is on nonindustrial applications, manufactured items are frequently needed to solve the problems.

—EDA funds the establishment of (primarily) state university-based industrial extension services, and has helped establish 15 units.

—USDA continues to fund, jointly with the states, an agricultural technology development and application service in each state and county in the nation.

There are *other Federal policies and their implementations* that bear on the diffusion and exploitation of technology. In at least some cases, their particular contributions to the aggregate Federal technology policy was even less carefully planned and coordinated than those listed above. They include:

—Tax credit for investment in plant and equipment. first instituted in 1964 with the rate of 7%, suspended in 1972 and reinstituted in 1974 with the rate of 10%. The rationale of this policy is the assumption that new technological know-how is being continuously incorporated in newly designed plants and equipment and that the utilization of the new technology will be faster with tax credits. There is little, if any, quantitative evidence regarding the degree to which new technology is exploited faster with this mechanism than without it or with another.

—Compulsory licensing of privately held patents to other domestic *and* foreign potential users is increasingly demanded by the Department of Justice in the name of antitrust, as mentioned earlier. Between 1941 and 1959 as many as 107 judgments were issued (13 in litigated cases and 94 by consent) and these affected such giant sources of technology as:

American Telephone and Telegraph Co.
Western Electric Corp.
IBM Corp.
General Electric Co.
Westinghouse Electric and
  Manufacturing Corp.
Radio Corp. of America
Hughes Tool Co.
Bendix Corp.
Combustion Engineering Corp.
Minnesota Mining and Manufacturing Co.

Surveys of the literature on the direct impact of antitrust activity on innovation have found that the antitrust remedy of compulsory licensing has not been especially successful in generating widespread licensing and utilization of the technology in question. Furthermore, companies subject to compulsory licensing in antitrust decrees have reduced their patenting activity.[23]

—Federal procurement policy as a means for speeding the innovation process, including diffusion and exploitation of new technology, is being addressed by the NBS Experimental Technology Incentives Program. Since ETIP's start three years ago, it has successfully helped several agencies to incorporate routinely in ongoing procurement much more cost-effective practices. Whether ETIP's experiments will show that Federal procurement can be used as a lever to accelerate technology diffusion in producing nonmilitary items remains to be seen.

—The U.S. copyright law has conflicting impacts on the diffusion of technological information. Publications from private organizations are copyrighted and can support costly advertising and promotional campaigns, leading to widespread diffusion. Similar Federal publications cannot be copyrighted, and thus the U.S. Government relies mainly on massive free distribution of documents for information diffusion and exploitation.

3. *Diffusion and Exploitation of Technology to Achieve Foreign Policy Objectives*

As the preceding sections show, the U.S. Government supports, on a massive scale, the development of technology needed to achieve national domestic goals. These include the capability

—To defend the U.S. against foreign attack.

—To produce the food necessary for the people.

—To produce the necessary nonpetroleum-based energy.

—To educate the people.

—To provide health care to the people.

—To provide public transportation.

—To conduct Federal operations efficiently and effectively.

There are other national goals related to U.S. foreign policy which also have strong technology components. The diffusion and exploitation of technology to serve foreign policy objectives sometimes is in conflict with domestic policy objectives, but this is not peculiar to technology. Rather it is the inevitable result of the need to adjust domestic policies to accommodate a rapidly-changing and uncontrollable international environment.

Among U.S. foreign policy goals are:

—To maintain the freest possible flow of technology across national boundaries, while recognizing that most U.S. technology is proprietary and therefore subject to private rights.

—To assist the governments of the less-developed countries (LDCs) to improve the well-being of their citizens by increased use of technology.

—To exchange technology with developed countries friendly to the U.S. for strengthening of their and our domestic economies.

—To promote international trade among nearly all nations and especially U.S. exports of technology-intensive products (including agricultural products).

—To enhance the effectiveness of the United Nations and its affiliated organizations, such as WIPO and UNIDO.

—To protect supplies of materials essential to U.S. manufacturing and the domestic economy.

U.S. technology exploitation by friendly, but trade-competitive nations is subject to the conflicting pressures of the domestic need to increase job opportunities and the traditional free-flow of technological information and know-how from the U.S.

In the last year or two, U.S. technological assistance to developing countries has been a major element in U.S. initiatives and responses to the needs and demands of these countries for a "New Economic Order." NASA, USDA, ERDA, NBS, HEW, and EPA have assisted these nations for many years in obtaining access to the worldwide pool of space, agriculture, nuclear energy, product standards, health care, and environmental technologies. More recently, NTIS has helped these countries create effective general technology extension services. Although there is some uneasiness that U.S. technology assistance to LDCs will result eventually in loss of U.S. export markets, the Federal policy remains supportive of U.S. technology exploitation by LDCs.

U.S. technology exploitation by self-proclaimed adversaries is, however, subject to different Federal policies that stress the need to maintain a strong U.S. military capability. This often results in a conflict between export promotion policies and national security policies.

Specific Federal policies and mechanisms related to exploitation by others of U.S. technology are sketched below:

—Technology-related data commonly used in general education and all other publicly available technical data that do not relate significantly to design, production, or utilization of specific products or industrial processes, including data usually contained in patent applications in U.S. and other countries. U.S. Government considers the international exchange of such data to be equivalent to the traditional "free flow of ideas" and authorizes such transfers to all destinations.

—Unclassified technological data developed at U.S. Government's expense independent of whether related to design, production, or utilization of specific products or industrial processes. Government promotes export of such data to all non-communist countries, usually, at least until recently, free of any charge to the recipient; in the future, such transfers might be subject to some "R&D recoupment fee." This policy was promulgated by President Kennedy's memorandum on U.S. Government patent policy of October 10, 1963 which stated:

> "The public interest is . . . served by sharing of benefits of Government-financed research and development with foreign countries to a degree consistent with foreign policy."

The export of such data to communist countries and Southern Rhodesia is subject to U.S. Governmental approval.

—Export of new technology embodied in products not on CoCom (International Export Control Coordinating Committee) list. U.S. Government generally authorizes such exports, on terms set or negotiated by private exporters, to all countries except Southern Rhodesia, Cuba, North Korea, Vietnam, and Cambodia. Exports to Sino-Soviet Bloc are subject to case-by-case approval by Department of Commerce.

—Export of new technology embodied in products on CoCom list (products which, by the agreement of CoCom, could contribute significantly to the military capability of potential adversaries of the United States and of its allies). U.S. Government generally authorizes such exports, on terms set or negotiated by private exporters, to all countries except communist countries, excluding Yugoslavia, and Rhodesia, provided, however, that the recipient assures the exporter it will not reexport these products to communist countries, etc., without the consent of the U.S. Government.

—Classified technical data developed at U.S. Government expense related to design, production, or utilization of strategic (CoCom) products, including their civilian derivatives. No transfer of such technology, including financial and other terms, may be effected unless specific approval is granted by the Department of State's Office of Munitions Control, the Nuclear Regulatory Commission, or the National Security Agency.

—Privately-owned technological data relating to industrial processes usable in production of strategic products. The export of such technology to non-communist countries, except Southern Rhodesia, is the prerogative of private exporters if the foreign importer provides satisfactory assurance it will not reexport the technology or products based thereon to any other country without the approval of U.S. Government; the direct export to communist countries and Southern Rhodesia is subject to prior approval by the Department of Commerce.

—U.S. Government strongly favors importation of new technology in all forms especially as know-how in contrast to technology intensive products.

4. *Summary*

This brief resume of many of the more important Federal technology policies reveals the lack of broadly-based, systematic, and continuous planning toward a coordinated national technology policy. Since the U.S. must determine the national interest out of a mix of often conflicting and contradictory goals of narrow-interest groups, the lack of adequate national policy planning in the rapidly-changing field of technology is especially damaging.

President Ford in 1975 took an important step toward remedying the situation. He asked Congress to establish statutorily, the Office of Science and Technology Policy (OSTP) in the Executive Office of the President (EPO). The President's desire is to have OSTP provide "pros and cons" on the science and technology aspect of all policy decisions, but not act as an advocate of science and technology *per se* — the role the old Office of Science and Technology in the EOP was perceived by others in the EOP to have assumed. On May 11, 1976, the President signed the OSTP law and on August 9th Dr. H. Guyford Stever became the director and also the President's Science Advisor.

In anticipation of the establishment of OSTP, the President in November, 1975, formed two science and technology advisory groups. One group focused on contributions of technology to economic strength ("Ramo Group") and the other was concerned with anticipated advances in science and technology ("Baker Group"). In meetings of the Ramo group, the need to stimulate innovation has been identified as a priority issue, and concern has been expressed that there is no Executive Branch Agency that has taken a leadership role in stimulating civilian technological innovation.[24] The Ramo Group formally suggested to the Vice-President and the Secretary of Commerce on May 18 that the DoC assume this role.

Actually, the President's 1972 Science and Technology Message to Congress called on the Department of Commerce to serve as the focal point within the Executive Branch for policies concerning industrial research and development. The Department was directed to appraise, on a continuing basis, the technological strengths and weaknesses of U.S. industry; to work with other agencies in identifying barriers to industrial progress; to propose measures to assure a vigorous state of industrial progress; and to promote the transfer of Federally-owned technology into the civilian economy. Some work has been undertaken in the Department along these lines, but we agree with the President's Science and Technology Group that more can and should be done.

Federal technology policy is defined above as the sum of actions taken by the U.S. Government affecting:

—Production of Technology

—Diffusion and Exploitation of Technology Domestically

—Diffusion and Exploitation of Technology for International Advantage.

Table I groups various possible Federal Government actions to stimulate technological innovation under these three headings plus another: Analysis and Planning

The first group of activities in Table I, A. Analysis and Planning, impacts on the remaining three groups. The analysis and planning function would result in information on needs and opportunities for innovation and on barriers which hinder it. Such analysis and planning would provide a rational basis on which to choose and implement specific actions from the other three groups whose sum, together with those actions already in effect, would at any one point in time, constitute U.S. Technology Policy. The degree of analysis and planning which would be desirable in the U.S. is open to debate. Certainly what is envisioned is not to be confused with planning in centrally controlled economies like the Soviet Union, but rather what is required is some degree of indicative planning, such as is employed in certain Western European countries and Japan. At the minimum, the analysis and planning function should develop appropriate technico-economic indicators to characterize the needs and opportunities in various industries. With a larger degree of planning, technology assessments which would weigh various technological options, cost/benefits, and adverse consequences, could furnish inputs for the formulation of investment guidance policies.

The Federal actions in the other three categories are either new or are expansions and modifications of those that are current Federal technology policies (Section IID). Under *B. Production of Technology* are actions designed to assure basic resources, appropriate proprietary rights, and direct support of industrial R&D. Collected here are also tax measures affecting the industrial research and development phase of the innovation process.

Under *C. Diffusion and Exploitation of Technology Domestically* are grouped measures for diffusing information, developing manpower, supporting commercialization of innovation, stimulating the creation of new technical enterprises, and aiding independent inventors. Under the last heading, *D. Diffusion and Exploitation of Technology for International Advantage,* are methods for improving U.S. competitiveness in international trade and for providing technological support to lesser developed countries.

TABLE I

POSSIBLE FEDERAL TECHNOLOGY OPTIONS

A. ANALYSIS AND PLANNING

B. PRODUCTION OF TECHNOLOGY

Resource assurance

1. Skilled S&T manpower development
2. Stable and adequate basic R&D support

Provision of proprietary rights

3. Patent law revision

Federal support of industrial R&D: direct

4. Interest-free or low-interest government loans for industrial R&D
5. Grants for generic industrial R&D

Federal support of industrial R&D: tax measures

6. Increase in investment credit for R&D plant

7. Increase in depreciation allowances for R&D plant
8. New tax credits or equivalent cash payments for industrial R&D
9. Tax credits or cash payments for industrial R&D expenditures, not plant
10. Tax credits or cash payments for incremental industrial R&D
11. Tax credits or cash payments for incremental industrial R&D in chemical and capital goods industries

C. DIFFUSION AND EXPLOITATION OF TECHNOLOGY DOMESTICALLY

Information diffusion

1. Gathering, organizing, and disseminating scientific and engineering information
2. Educational publications on consequences of major technology changes
3. Science court to establish credibility of scientific information
4. Provision of information to state and local governments
5. Consumer technology information services
6. Enhanced NBS voluntary performance standard effort

Federal support of commercialization

7. Funding for commercialization of selected government inventions
8. Funding for commercialization of socially desirable private inventions
9. Stimulation of innovation during Federal procurement policy

Reduction of barriers to innovation

10. Patent law revision
11. Federal patent policy
12. Modification of antitrust laws to allow cooperative R&D
13. Determination and modification of regulations inhibiting innovation
14. Social cost/benefit analysis of proposed regulations
15. Manpower retraining, relocation and pension program
16. SEC study of the effect of corporate remuneration policies on innovation

Creation of new technical enterprises and aid to independent inventors:

(a) Direct financial aid

17. National Research and Development Corporation to finance innovation activity of individual inventors
18. Preferential treatment to new technology enterprises in government contracts
19. University small technical enterprise associates
20. Free patent protection

Creation of new technical enterprises and aid to independent inventors:

(b) Indirect financial aid

21. Assurance of venture capital availability for new technical enterprises
22. Government guarantee on SBIC loans to new technical enterprises
23. More generous capital gains tax treatment
24. SBIC's incorporation under Subchapter S or as partnerships
25. Increased liquidity through SEC and IRS modifications
26. More favorable founder stock option incentives
27. Tax deductibility of investments in new technical enterprises
28. Graduated corporate income tax rate structure
29. Use of government infrastructure services

D. DIFFUSION AND EXPLOITATION OF TECHNOLOGY FOR INTERNATIONAL ADVANTAGE

Improvement of U.S. competitiveness in international trade

1. Policy statement on free flow of publicly available data
2. Limit of decrees on compulsory licensing to domestic availability
3. Increase of U.S. effectiveness in international standards-setting
4. Improved control of design and manufacturing technology
5. National benefit equalization tax
6. Disallowance period of seven years for export of technology, per se, developed with Federal funds
7. Transfer of technology, per se, to eastern bloc only through "Techport"
8. Expansion of export promotion programs

Technological support of lesser developed countries

9. Business code of behavior
10. Establishment of bilateral commissions
11. Organization of multilateral commissions
12. Expansion of World Bank activities
13. Expansion of foreign aid programs

International Cooperation

14. Promotion of cooperative industrial R&D

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Case Against Compulsory Licenses

(Continued from Page 194)

torney General in charge of legal incentives to invent[18b] while there is one in charge of fighting restraint of trade irrespective of any debilitating effect on the incentive to invent. This is partly because the only advocates for the constitutional patent system appear to be servants of some big self-interest when they appear before Congress, even when they are in fact servants of the public interest in a viable system of inducement of needed new technologies.

This is partly because there are likely not 1,000 people in this nation, a pathetically small and ineffective lobby, who really understand R&D economics. And almost none is in a position of political or economic influence while antitrust advocates ranging from Ralph Nader to Senator Hart have made for themselves positions of important influence.

It is not enough for us to say that patents are constitutionally endowed and antitrust is a Johnny-come-lately, and stomp off into the corner to pout about, or onto the golf course to forget about, the growing hurricane of antitrust philosophy. For this storm is washing away the goose house, the house of the geese who throughout our history have been laying golden eggs of new important inventions.

Not only the R&D community — which in significant part has its head in the sand as of now — but the trade regulation community, must be brought to a set of value-judgment priorities that assures a larger incentive for R&D.

A critically necessary party of that incentive must be a licensing law that licensors can trust; a licensing law that is something other than an invitation to the courthouse; a licensing law that encourages the businessman on the business firing line, to make his commitment to invent.

* * *

To explain with a concrete example the social mischief in the form of R&D discouragement of antitrust policy, we could use field-of-use licenses or discriminatory royalties or any one among a dozen license practices. But having stated my general conclusions, I will proceed here to treat in depth only one small part of one of the many license-practice topics. The topic is compulsory licensing. The part is royalties.

Contrary to popular belief, we in the United States are up to our ears in compulsory license law.

The constitutional phrase "exclusive right" notwithstanding, in the last six years we have in this country seen the enactment of the Plant Variety Protection Act[19] which provides for *royalty free* compulsory licenses on new varieties of tomatoes and other soup vegetables, and for *royalty bearing* compulsory licenses on other sexually reproduced plants.[20]

We have also seen the enactment of the so-called Clean Air Act[21] with compulsory patent licensing provisions.

There are, I believe, five *de facto* compulsory patent license statutes now on our books.

The pending copyright law revision bill which has been passed by the Senate and will be reported out by the House subcommittee in July (1976), seems almost assured to bring into our law in 1977 new copyright compulsory licenses in no less than five distinct areas, perhaps more.

We saw in 1974 Congressional action wherein a tie vote saved us for a couple of years from compulsory licensing of much energy technology.

We have seen the experience rating — the law in action — of the new section 41 of the Canadian patent law[22] providing for compulsory licensing of pharmaceuticals and foods.

In the courts, compulsory licensing is a popular remedy for both fictional and real antitrust violations. Further:

We have seen in 1974 the establishment in the Second Circuit of the concept of compulsory license by reason of failure to work the invention.[23] The court there took a step which Congress has considered many times but has never enacted.