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GPO 944-502

a return in the form of a levy on commercial sales and a share in the royalties of any licensing agreements.

The government programs promoting the use of computers through advisory services have been funded at $4 million per year. Typically, these services are provided by the National Computer Center, the Computer Aided Design Center, and the Aldermaston Project for the Application of Computers to Engineering.

Further support of the computer industry includes the government purchasing policy to "Buy British" unless there are strong reasons for purchasing foreign equipment, and government attempts to pursuade British firms to adopt the same policy for their computer purchases.

2. Electronics

Recent government support for the electronics industry has included a $13 million investment in three leading companies for the development of micro-electronic devices and integrated circuits. The investment was prompted by a guarantee made by the Minister of Trade and Industry to the NRDC.

Future government support of the electronics industry is expected in the form of loans and joint ventures, with strict arrangements for repayment. Future support for integrated circuits is not expected except with regard to applications to hardware systems (e.g., to control automobile fuel injection systems).

3. Telecommunications

Most of the $24 million in government support for telecommunications has been concentrated on the development of Stored Program Control to operate automatic telephone switching centers. This support has been provided through the NRDC with the Plessey Co. Ltd. in a joint venture, with some cooperation of the Post Office (which operates the nationalized telecommunications system). Laser research in telecommunication has received a small amount of support, but support for satellite earth stations has been curtailed.

There has been some criticism however, that the industrial research establishments do not serve industry properly and that their research programs are too "ivory-towerish." Some industrial and government spokesmen have advocated the closing of the establishments but the present government has recently stated that they will continue. An effort is being made to direct the research programs toward becoming more relevant to industrial needs, but a method for implementing this policy has not yet been selected. One suggestion is to adopt some form of the Rothschild customer-contractor proposal. As applied to the industrial research establishments, it envisions that sponsoring industry divisions within DTI would be allocated funds in their appropriations which are now appropriated to the Research Division within DTI which is responsible for the industrial research establishments. The sponsoring division would act as "proxy" customers determining what R&D is needed and contracting for it through the Research Division to the appropriate industrial research establishments. Included in the cost would be the 10 percent surcharge to finance the basic R&D program of the industrial research establishments. That basic program would be suggested by Requirements Boards.

H. Programs of Assistance to the Computer, Electronics and Telecommunications Industries

A variety of programs exist in the United Kingdom for R&D support of the computer, electronics and telecommunications industries. Broadly, the objectives of these programs are to establish and maintain viable industries in these three areas. Some of these programs have limited and rather specific objectives; the majority are short-to-medium term, for the government policy is to avoid continued support for these industries.

1. Computers

Government programs in support of the computer industry are directed not only toward technological advance but toward increased computer usage as well. The three major technology incentives programs are:

a. The Computer Merger Scheme

The most substantive assistance to the computer industry has been through an R&D grant to International Computers Ltd. (ICL). In creating ICL by a merger of

No mechanism has yet been selected for use in the future, but it is generally accepted that some form of support must be given since the risk and high financing needed are beyond the means of most British firms. It may be necessary to use a flexible system of support, rather than the strict formula used under the present Launching Aid program, deciding each project on its own merits in relation to the national interests.

G. Industrial Research Establishments

Within DTI there are six industrial research establishments: the National Physical Laboratory (NPL); the National Engineering Laboratory (NEL); Warren Spring Laboratory (WSL); Office of the Government Chemist; the Torry Research Station; and the Safety in Mines Research Establishment. The first three provide a variety of research services to industry; the latter three have more specific functions and are not of further interest here.

The research services provided by these industrial research establishments are both short-term (research for specific problems) and long-term (continuing research programs). Government support started in 1918 when DSIR assumed general administrative and financial responsibility for NPL, the first industrial research establishment.

The industrial research establishments operate under existing legislation and their funds have been included in the budget of DTI (and its predecessors, DSIR and MinTech). Direct government funding for all of these is approximately $35 million. The NPL, NEL and WSL receive direct annual funding from DTI, amounting to about $16 million, $6.7 million and $3.5 million respectively. In addition, each performs contract work for industry and other government departments which is repaid at cost. Income from contract work amounts to about $935,000 at NPL, $479,000 at NEL and $350,000 at WSL.

The industrial research establishments undertake work for industrial firms and consultants on a reimbursable basis. Contractors having similar interests are encouraged to sponsor research contracts jointly. An estimated fee is quoted in advance, and this estimate may not be exceeded without approval of the contractor. Reports describing the work can usually be freely published by the contractor provided that such publication policy for this support. The research associations have contributed significantly to technological advancement in many industrial sectors, and the evidence suggests that grant support will remain available.

F. Launching Aid

Launching Aid is the equivalent of an interest-free loan for development of civilian aircraft and engines. The amount is proportional to the initial estimated costs of design, development, start-up and "learner" costs (i.e., the higher labor costs incurred in early production stages), repaid to the government by levies on sales. The program was started in its current form in 1960 as part of the arrangement where the aircraft industry was persuaded to merge and regroup, leading to the formation of British Aircraft Corporation and Hawker-Siddeley Aviation. Support was also given to other specific aircraft developments primarily intended to ensure that British European Airlines would continue to fly British aircraft, thus avoiding the long-term unfavorable balance of payments which would have resulted from purchase of foreign aircraft. In addition, developmental efforts for two other aircraft and for two engines were supported for their worthwhile export potential; their manufacturers did not have sufficient resources for production without governmental assistance. The underlying objective is earning foreign currency and reducing imports in cases where the level of risk involved and the high financing required exceed the capacity of the company concerned. Launching Aid policy is incorporated in the Civil Aviation Act of 1949. Although no new projects have been assisted by means of Launching Aid since 1967, the program is still in operation. A variety of proposals for Launching Aid have been made, but all have been rejected recently except a request for $82 million to $162 million from Rolls Royce (1971) Ltd. for aid in developing the "stretched RB-211 "engine." In the period from 1960 to 1967 almost $175 million has been expended for Launching Aid projects other than that for the Rolls-Royce RB-211 engine. The latter project was initially supported at the level of $125 million; an additional grant of $112 million has not been spent as a result of Rolls Royce going into receivership.

The amount of Launching Aid for a project is an agreed proportion of the launching costs, based on an initial estimate; it is usually not more than 50 percent. For the RB-211 engine, Since the research associations are independent, the government is careful not to endanger their independence. The money received by revenue grant is included in the total income and is not distinguished from the finances derived from the members. The resultant total income is used to support the general program as determined by the Council of the Research Association. In addition to the financial incentives provided by grants, the income of the associations derived from investments or royalties is exempt from taxation.

As noted above, one class of work performed by the research associations is that of a contract nature. In 1970, about 24 percent of the total income (about $44 million) was derived from "repayment" work of one kind or another. Most of this work was carried out for industry, but contract work for government departments and for other national agencies accounted for over one-third of it.

Generally, the research associations have provided their memberships with broad technical and information services. Information services often include extensive library, reference, and transportation facilities. At the present time, an additional fee is charged if complex technical questions are asked and some research is required to provide the answers. Unsolicited information resulting from the general program is also disseminated to the member firms.

The research associations have provided R&D support for their industry under the general program, the contract work and group projects. Many of them have well-equipped laboratories and technical staff to carry on high-quality research. The research or development is generally aimed at solving specific problems or improving productivity by means of new processes or modifications to older processes or equipment.

Owing to the wide range of activities and sizes of the research associations, direct benefits are difficult to assess. However, two divergent views may be noted, depending on the size of the member companies.

- Although the ojbectives specified above have to some degree been accomplished, the extent of success in small firms is considered to be limited. Only a small fraction of the small firms in any industry hold membership in research associations. Since the widespread application of skills among industry at large was an original objective, it is implied that the associations

- investigate problems of common interest to the industry as a whole which cannot be carried out economically or conveniently by any single member

- improve the utilization of scientific manpower with the attendant economies of central operations

- transfer new research ideas and technological know-how from many sources into the industry

- stimulate and assist the smaller firms without research facilities of their own so that they can apply R&D to their operations.

Company membership in a research association is voluntary. At present, there are about 40 associations in operation which receive a portion of their funds from government grants.

Each of the grant-aided research associations is legally the responsibility of its member firms and is controlled by a council elected by the membership. A fund of over $2.6 million was set aside by government legislation in 1917 for general grant support in order to encourage the formation of the research associations. That fund was depleted in 1932; from then until 1945 the grant support was included in the annual Parliamentary budget. Since 1945, grant-supporting funds have been included in the appropriation for the sponsoring government department (i.e., DSIR, MinTech, or DTI).

Grants usually cover five-year periods and are normally reviewed prior to renewal. The amount of government grant for the period is usually a fixed percentage of the income provided to the association by its industrial members, subject to a specified minimum income to be raised. The rate of the grant, based on the income supplied by the membership.

In addition to this type of revenue grant, special non-recurring grants may be made available for capital improvements, such as new buildings and expensive plants. Such grants cover a portion of the total cost, provided that the members subscribe the remaining funds. R&D programs undertaken in areas of national interest can be assisted by grants up to 100 percent under the program of Financial Support for R&D in Industry. Other special assistance grants have been offered to improve liaison services. At one time, "earmarked" grants were made available to assist the research associations in undertaking desirable projects and to research associations and universities, for which the cost of R&D might be too great to sustain. The basic concept behind the program is that an industrial firm (or other recipient of financial support) shares the risk of the R&D project. Thus, there should be more incentive to do the best job possible and to keep development costs down.

This program emanated from the Science and Technology Act of 1958 sponsored by the Conservative Government. The Science and Technology Act of 1965 gave the program some additional powers. The level of spending has been increasing yearly and is now about $9.3 million per annum. There is no set limit on the total amount which can be spent under this program; however, any individual project requiring over 50,000 pounds (approximately $133,000) must be approved by the Treasury.

The method and terms of support have varied with the circumstances of each project. On research projects where the results are to be disseminated freely (e.g., work done by research associations or universities), DTI has contributed up to 100 percent of the cost. On the other hand, for development projects aimed at a marketable product, the government has typically contributed about 50 percent of the cost.

In those cases where the contractor profits as a direct result of government support, DTI seeks a return to the taxpayer by a levy on commercial sales and a share in royalties from licensing. The amount of levy has generally been about 4.5 percent, but has ranged from about 2.5 percent for the shipbuilding industry to about 10 percent in electronics. The amount is usually set on the basis of the profit margin of the industry.

A firm wishing to receive this form of support submits a proposal to the Development Contracts Section of DTI followed by informal discussions and preparation of a final application. To be accepted by government for support, the firm's proposal must meet the following requirements:

- documentation of an advance in technology
- good prospects for commercial success
- service in the national interest
- an offer to share in the cost.

The program is now being phased out as a result of the change in government in 1970. It is being replaced by a new program of tax allowances and reductions which are also designed to promote conditions likely to stimulate higher investment. However, it has been in operation for too short a time to permit evaluation.

The standard long-term rate of a grant was 20 percent of the approved capital expenditure; in the regional development areas, the long-term rate of grant was 40 percent. For expenditures incurred in 1967 and 1968, the rates were increased to 25 percent and 45 percent respectively.

Investment grants were made on approved capital expenditure or scientific research for processes related to the manufacturing, shipbuilding, mineral extraction and construction industries, and for investments in computers, ships and hovercraft. In general, the approved expenditure was the purchase price and could include the cost of installation. It could also include lease-purchase payments and installment payments, excluding interest and service charges, and the cost of an asset manufactured by the claimant for his own use.

Scientific research was defined, for purposes of the Act, as "any activity in the fields of natural or applied science for the extension of knowledge." Grants were available for new machinery and plant if they were to be used in carrying on such research related to a qualifying industrial process.

Grants were also available, in some circumstances, towards the approved costs of producing a prototype which was to be used in carrying on qualifying scientific research related to manufacturing. However, the production of simply an improved model of an existing device did not qualify for grant. In order to qualify, the product design to be tested by prototype had to embody significant new features or applications of existing scientific principles not already incorporated in an existing device of the same type.

The grants towards approved capital expenditures on new computers, including peripheral equipment, did not require a qualifying industrial process. Thus, computers used by business, banks, commercial offices and computer bureaus were eligible, as well as those applied to industrial processes. The nationalized industries and the Post Office were also eligible for grants, but not government departments.

been a lag of approximately 7 to 10 years, largely because "no one wants to be first" in trying out a new technique. It may be observed that the majority of the 1.25 million machine tools in use in the United Kingdom are more than 10 years old; and less than 10 percent are less than 5 years old.

The Preproduction Order Support Program was set up under the Science and Technology Act of 1964. Government support for the program has, until very recently, been declining, from about $3.5 million in FY 1969 to less than $1.4 million in FY 1971. However, an increase in support has recently been observed. In total, over $21 million has been spent by the government for the purchase of 300 machine tools.

Under basic concepts of this scheme, DTI is prepared to buy advanced machine tools and lend them without fee to potential purchasers or users. The equipment manufacturer is thus assured of a market for advanced designs of machines which the user is encouraged to try without taking undue risk.

The government buys a number of preproduction models of a machine developed by a British manufacturer at cost, with an additional allowance for development expenses. The number purchased has been approximately 3-4 percent of the predicted production orders of the model over the next three years. The machines are loaned free to selected users who evaluate them in a service environment and report on their performance to the manufacturer and to the Department of Trade and Industry.

The user assumes the cost of installation and, at the end of an agreed evaluation period (usually less than two years), has the option of "purchasing" the machines at substantial reductions (because of depreciation and tax allowances) or returning them to DTI. (Typically, the cost to the user is about 50-60 percent of the full initial cost.) The Department may also rent the machines to the user.

This program has been used mainly for machine tools and, on a much smaller scale, for machinery for textiles, plastics, printing, and fish processing; mechanical handling and construction equipment; and scientific equipment and instruments.

The program has been reported to be successful according to several sources. The government, the machine tool industry and the user industries have all reacted favorably to the scheme.

operation are:

- Public Sector Inventions. NRDC licenses industrial firms to exploit inventions paying the full cost of further development if it considers the prospects of recovering the investment to be good. License terms are a matter of normal commercial negotiation. A royalty payment is usually required, most often as a percentage of sales. Sometimes shares in the firm and dividends are required by NRDC.

- Joint Ventures with Industry. NRDC may provide financial assistance to firms for developing new products, processes or techniques. NRDC has generally contributed 50 percent of the development cost, expecting to recover the investment with a profit. Should the supported project be successful, NRDC receives a levy on sales and a share of the firm's profits related to the project.

In all cases, a Development Support Agreement is negotiated which takes into account several variables, such as probable risk, prevailing interest rates, and the strength of the firm or industry.

The NRDC program has almost universally been considered to be a success. For the fourth successive year, the revenue account shows a surplus, of which a major part has been used for reinvestment in projects and a lesser portion to reduce the accumulated deficit. A substantial part of its income (over $20 million for the fiscal year ending March 1972), however, is derived from a comparatively small group of inventions, the primary one being in the pharmaceutical industry. This phenomenon is not unexpected, for NRDC usually gets involved with projects entailing a high degree of risk, and has been referred to as the "lender of last resort."

Over 25,000 inventions have been submitted since 1949. Of these, about 6,000 have been accepted for development and/or licensing. In the recent past, NRDC has been assessing about 2,500 proposals annually, and has become involved in about 500 per year. Of these, about 120 qualify for financial development support.

The perceived success of the NRDC program is reflected by the fact that many other countries have adopted the NRDC plan for impelmentation in their own industrial environments. These

Prior to 1970, the government supported capital investment in industry through a system of grants. These applied not only to machinery and plant in general, but also to research and prototype development related to qualifying industrial processes and, in certain cases, to computers. Investment grants are now being phased out, the program having been terminated. A new investment incentives program of tax allowances and reductions is scheduled to replace these grants, but operational details have not as yet been fully formulated.

The Industrial and Regional Development Program, which started in April 1972 with the creation of the Industrial Development Executive within DTI, provides tax allowances for expenditures for plant, machinery, new industrial buildings and structures. Although not primarily directed towards R&D facilities, such facilities would qualify for tax allowances, and have in fact been widely used by advanced technology industry, notably electronics.

Several programs now in operation use grants as incentives. The Industrial and Regional Development program mentioned above also provides for grants in designated development areas toward capital expenditure on new buildings and modernization of existing buildings. For many years, grants have been given in support of the industrial Research Associations, and this support is continuing.

Under the program for financial support of R&D in industry, the government may contribute up to 100 percent of the cost on research projects if the results are to be freely disseminated. For projects which are aimed at developing a marketable product, the government has contributed a share of the cost. When a profit is made by the contractor on government-supported projects, the government seeks a return on its investment by means of a levy on commercial sales and a share in royalties from licensing.

Patents developed in government research establishments are usually turned over to the National Research Development Corporation for exploitation. This is also done,in some instances, where patents result from discoveries related to work contracted for by private firms but performed in government establishments, retained by the government and handled as above. In other instances, the patent rights go to the private firm funding the research.

The United Kingdom is also involved in cooperative technology enhancement programs with other countries. The joint program with France for the development of the Concorde SST is probably the best example of technologically successful inter-governmental cooperation in R&D enhancement. The British government has expended substantial sums on this program, but does not expect to recoup its investment because of the Concorde's limited sales potential, estimated at 50 to 60 units.

The United Kingdom also planned to participate in the projected tripartite United Kingdom-French-German agreement to produce a wide-bodied passenger aircraft (Airbus A-300B) but withdrew when it became clear that adequate sales could not be guaranteed. However, Hawker-Siddeley Aviation, in a non-government supported project, was awarded the contract to develop and produce part of the wings for the A-300B aircraft.

In the area of technology transfer through licensing of foreign technology, the United Kingdom is the only heavily industrialized nation, other than the United States, which exports more technology than it imports.

B. Organization for S&T Policy Development and Implementation

Government policy for Science and Technology (S&T) is established by Parliament and implemented by Parliamentary Acts. In order to assist in forming policy there have been various advisory councils, such as the Central Advisory Council for Science and Technology, chaired by the Chief Scientific Advisor to the Government; the Council for Scientific Policy, which advises on basic research; and the Advisory Council on Technology, advising on the application of advanced technology in British industry. Under the present government, the position of Chief Scientific Advisor has been retained. However, the Central Advisory Council for Science and Technology has been abolished, as has the Advisory Council on Technology. A new position, Chief Scientist of DTI, has been established and is held by the former Controller of Industrial Technology in MinTech. Thus, the focal point within government for applied R&D is the Department of Trade and Industry. Basic research and post-graduate training are the responsibility of the Department of Education and Science.

Government services to industry, often including applied R&D, have been implemented by means of both general and special purpose programs. General purpose programs include assistance for industrial and regional development, assistance to private industry

In addition to abolishing the IRC, the Conservative Government has effected a general reorganization of agencies implementing S&T support. The old Ministry of Technology was restructured and merged with the Board of Trade to form the Department of Trade and Industry (DTI), the agency with major S&T responsibilities currently. There has also been a review of the R&D funding apparatus, undertaken at the Parliamentary level, and probing such fundamental policy issues as the development of criteria for government support of basic and applied R&D. The government apparently realizes that industry must be kept viable and that some form of sponsorship is necessary. However, the mechanism for meeting these needs has not yet been established at the time of this report.

Differing points of view have been put forward by Lord Rothschild and Sir Dainton in the form of government "Green Papers," which provide a basis for public debate; a "White Paper" defining the official government position is expected shortly.[1] The Dainton report contains moderate recommendations for restructuring the present Research Councils, and appears to represent the majority view of the U.K. scientific establishment. On the other hand, the Rothschild report proposes far-reaching and seemingly controversial changes, including general adoption of a contractor customer relationship between those who perform R&D and the government departments to which that R&D pertains. Debate on the Rothschild report centers on the assumption that a customer agency is sufficiently knowledgeable to specify what it wants. In addition, general research programs (i.e., those not specifically directed towards a customer's needs) would be paid for by a surcharge (of no more than 10 percent) on those departments with specifiable research needs.

There are trends evident whereby many older programs which provided investment grants on capital expenditures for machinery, plant, computers and prototype development, were being replaced by programs of tax allowances. Such expenditures indicate the new direction for policy under the new government.

The major thrust of the programs supported by the current government has been to improve the technology base of the full industrial spectrum. At the same time, there have also been individual programs designed to assist a particular industry, for example, shipbuilding, computer, aluminum, machine tools, and cotton and allied textiles. The more important of these programs are described in greater detail in Part II of this appendix.

1/The "White Paper" was released while this report was being prepared for publication.

Tradition has always been a strong factor, and a conservative attitude prevails throughout most of British industry. For example, the owner of a small machine shop is often reluctant to invest in a new tool to replace an old one which has always done the job, and can still do it, albeit at a slower rate than is now possible with the replacement. Furthermore, although the United Kingdom has been a trading nation for many years, its relatively small domestic market still strongly influences decisions affecting industry, particularly with regard to investment in the private sector. Investors often appear reluctant to commit funds for purposes other than those concerning the projected domestic market of the new venture. These factors all affect the decisions which government must make relating to industrial progress and supportive funding.

Government involvement in science and technology dates back to 1916, when a Department of Scientific and Industrial Research (DSIR) was first established as the focal point within government for matters relating to applied R&D. Research Associations, intended to foster the diffusion of R&D throughout potential industries, began to function in number during the early 1920's. Much later, when the Labor Government was in office between 1964 and 1970, it tended toward government intervention in the private sector, when necessary, accompanied by such action as might be required to ensure a strong industrial complex. Numerous programs were directed to assist industry at all levels.

Under Labor Government reorganization, responsibility for the industrial sector was consolidated in the Ministry of Technology (MinTech), whose purpose was to "guide and stimulate a major national effort to bring advanced technology and new processes into British industry." MinTech took over, by stages, the sponsorship of a wide range of industries. As seen by MinTech, the relationship entailed a positive attitude while examining problems of particular industries in an attempt to identify constructive measures which the government could take in collaboration with industry.

The Ministry of Aviation was merged with MinTech in 1967, extending sponsorship responsibilities to include electronic equipment required for civil aircraft and air traffic control, and for meeting Ministry of Defense requirements for aircraft and airborne weapons and equipment, guided missiles, nuclear weapons, and electronic equipment. By 1970, MinTech had responsibility and sponsorship for virtually the whole of the electrical, electronic and mechanical engineering industries, including electrical and mechanical engineering products generally, motor vehicles, electrical

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ATTACHMENT 2

Keidanren Standing and Ad Hoc Committees

Committee on General Policy
Committee on Economic Research
Committee on Statistics
Committee on Industrial Policy
Committee on Land Development
Committee on Energy
Committee on Industrial Technology
Committee on Transportation
Committee on Marine Transportation
Committee on Forestry
Committee on Small and Medium Business
Committee on Public Nuisances Prevention
Committee on Agricultural Problems
Ad Hoc Committee on Liberalization of Capital Movements
Ad Hoc Committee on Improvement of the Government's Organization
Committee on Information Processing
Committee on Overseas Metal Resources
Committee on Fiscal and Monetary Policies
Committee on Taxation
Committee on Capital Market
Committee on Economic Laws
Committee on Capital Movements
Ad Hoc Committee on Industrial Finance
Committee on Accounting
Committee on Foreign Relations
Committee on International Finance
Committee on Foreign Trade
Committee on Economic Cooperation
Ad Hoc Committee on Tariffs
Committee on Preferential Tariffs
Committee on Cooperation with Indonesia
Committee on Japan-Thailand Cooperation
Committee on Oceanic Resources
Atlantic Institute Committee

case. (For example, on a loan application to build synthetic paper plants, JDB is not clear on how or what to consider regarding the disposal of waste materials, and may hesitate to approve the loan.) To alleviate this problem the technical staff of the Bank consults with appropriate staff members of other government agencies. In addition, since April 1972, JDB has established a Technology Assessment Commission, consisting of experts outside the government establishment (i.e., university professors and others) to advise it on such matters. The second problem for JDB is how to meet the country's social needs, such as the development of a new road system (e.g., monorail) or a new traffic system in the light of the new technology assessment criterion.

independent domestic oil companies and enhancing their financial position; and to the marine transportation industry for the construction of new types of vessels incorporating the latest technological developments in marine transportation and for building up the transport capacity of the industry to meet the rapid growth in imports and exports;38/

- assisting structural reorganization and modernization of equipment facilities through loans to industries (such as machinery and electronics) especially designated by law, and to several other essential industries (such as automobile, special steel, petrochemicals, textiles, ammonia, and non-ferrous metals) for improving their international competitive position through mergers, mass production, joint investment, and specialization in production;39/

- fostering domestic technology through loans for the utilization of domestic technology by private enterprises, particularly the use of domestically-made electronic computers, including financial assistance to JECC for the purchase and leasing of computers. 40/

JDB is clearly involved in a wide range of lending activities. It should also be noted that the term "development" is broadly interpreted to cover projects from the structural reorganization of industries and the modernization of equipment and facilities to the construction of pilot plants, terminals, and heating and air-conditioning systems to the commercialization of new technologies.

38/ In 1963, under "Interim Law for Consolidation of the Marine Transportation Industry," 88 marine transportation companies were merged into six groups, to which JDB extended some financial benefits. In March 1971, the outstanding loans to this industry exceeded $1,940 million.

39/ The amount of JDB loans extended for this purpose was was $94.2 million in FY 1970.

40/ See p. 249

raising productivity, efficiency, and volume of sales of those fimrs although the improvement has been very gradual. There are two particularly significant indicators: first, a downward trend of the share of smaller enterprises to the total value of manufactured goods has since 1955 been slightly reversed; and second, increased productivity in smaller enterprises has somewhat narrowed the gap between them and larger companies.

3. Government Development and Equipment Loans

The Japan Development Bank (JDB), a Government Financial Institution, was established in 1951 "to supplement and encourage the credit operation of ordinary financial institutions by supplying long-term funds in order to promote economic reconstruction and industrial development."35/ Its operations keely reflect Japan's postwar policies with respect to science and technology, economic reconstruction, industrial and regional development, and technological advancement.

Since its inception, the Bank has extended loans totaling nearly $8.5 billion, and its capital has grown from around $32.5 million to about $758.5 million. Its annual net profits have varied from $32.5 million to more than $76.5 million, and it has paid a total of $727.3 million into the National Treasury, close to the Government's investment (758.5 million) in JDB. By March 1971 the Bank's annual lending program amounted to nearly $1-1/4 billion, and its outstanding loans and foreign credit guarantees to more than $6.7 billion, thus ranking the Bank as one of the largest development finance institutions in the world.36/

Initially, JDB obtained its funds by issuing bonds, which it floated in the domestic market. These bonds were not readily accepted, greatly constraining the Bank's operations. The Bank of Japan later brought up the outstanding bonds and JDB itself was reorganized. It was given greater independence (more than any other government financial institution in Japan) and its authority to issue bonds

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35/ The Japan Development Bank, The Japan Development Bank Law and articles of Incorporation of the Japan Development Bank p.1.

36/ Japan Development Bank, Functions and Activities, Japan Development Bank, 20th Anniversary, 1971, Daito Art Printing Company, Ltd., June 1971, pp. 1-3.

e. Tax Exemption of Quasi-Governmental Corporations

All quasi-governmental corporations operating under special charter and created for the purpose of developing new technologies in specific areas are completely exempt from taxation.

2. Special Tax and Other Incentives for Small and Medium-Sized Enterprises

The special economic and technological problems encountered by small and medium-sized enterprises and government efforts to cope with them were described earlier. 34/ The government provides further assistance to these enterprises through special tax and other incentives, as well as loans at favorable terms through government-financed lending agencies, as described below.

a. Tax and Other Incentives

The following incentives are open to all small and medium-sized enterprises in addition to those available to large enterprises:

- A 50 percent tax credit for R&D expenses, including the cost of facilities except land.

- A 20 percent first-year accelerated depreciation on the value of any kind of newly-acquired equipment; for larger enterprises, this depreciation allowance applies only to certain types of designated machinery and equipment.

- Lower corporate tax rates which, for small enterprises, average 28 percent (compared with 36 percent for large enterprises).

- Non-taxable reserve funds, the magnitude depending on the purpose of the reserve fund and the company's total income.

- Exemption from anti-trust regulations under special conditions; e.g., small, financially weak enterprises are allowed to form a cartel in order to avoid going bankrupt. Normally, companies submit an application for approval by the Fair Trade Commission (FTC), but first request of MITI that it intercede with FTC in their behalf.

34/ See pp. 222-223.

and development to tax credits for the acquisition of fixed assets and depreciation allowances to accelerate commercialization and diffusion of newly-developed technologies. These are discussed in the section which follows. Special tax and other incentives applicable only to small and medium-sized businesses and long-term loans at favorable terms available through the Japan Development Bank will be discussed in the following two subsections.

1. General Tax and Other Incentives

Government tax incentives for the enhancement of technology are general in nature, and not restricted to designated industries, program areas, or applications. Their objectives are to encourage investment in research and development and to foster commercialization of newly-developed technologies, promoting not only the development of new technologies, but also accelerating applications and diffusion throughout the economy.

a. Special Tax Credit for R&D Expenses

This incentive, designed to induce investment in research and development, was introduced in 1967 to remain in force for three years, but was subsequently extended and has been retained through FY 1973. It applies to R&D expenditures incurred by any company in any industrial or other area, and is of particular assistance to small companies which otherwise would be unable to engage in R&D activities. A company is allowed a 25 percent tax deduction on R&D expenses which represent an increase of no more than 12 percent over the highest R&D expenses incurred by the company in any one year since 1967. A total of 50 percent is allowed on any portion of R&D expenses in excess of that 12 percent increase. If R&D expenses fall below the 1967 level in one year but increase by, say, 30 percent above that level in the following year, the company is allowed the regular 25 percent tax deduction on the first 24 percent (rather than 12 percent) and the 50 percent deduction on the remaining 6 percent of R&D expenses. The tax deduction is credited against the company's corporate tax, limited to a maximum of 10 percent of that tax. It whould be noted that the government is rather liberal in its interpretation of what constitutes an R&D expense.

b. Special First Year Depreciation

This incentive is designed to accelerate industrialization and modernization in industry. A company wishing

Corporation takes over all reports, patents, and any other material generated during the course of development. If the project is considered to be a success, the firm is given a period not to exceed five years to commercialize the newly-developed product or technology and to repay the full amount of money advanced by JRDC, but interest-free. The firm is also required to pay the agreed royalties, half of which is retained by JRDC and the other half turned over to the original researcher and his institution. In most instances, the developing firm elects to proceed with exploitation, and is then granted an exclusive license for a specified period of time, usually five years. Following this period of monopoly, the new product or technology is opened for licensing to other firms, subject to a specified fee. Royalties resulting from such an arrangement are shared by the first successful firm, JRDC, and the originating researcher and his institution.

JRDC also acts as a middleman for those firms (usually small companies) which have the capability to commercialize given research findings and the scientists and engineers (and their laboratories) which possess the pertinent knowledge. For such "mediation projects" the Corporation receives a service fee from both parties if the mediation is successful. The Corporation successfully concluded 28 mediation projects during the first ten years of operation.

JRDC officials and the Japanese Government believe that the Corporation has made exceptional contributions in the matters of invention, innovation, and commercialization of new technologies. The ratio of success in development exceeds 90 percent, and two-thirds of the current operating budget derives from returns on earlier investments, ascribed to judicious selection of promising R&D projects and suitable firms. A government publication released in the spring of 1972, describing JRDC's accomplishments during the first 10 years of its operations (1961-1970), indicates that the Corporation's capitalization has grown from $1.95 million to $15.29 million while its staff has increased from 18 to 66 persons. The Corporation evaluated a total of 622 R&D projects selecting only 83 as commissioned projects, an adoption rate of 16.1 percent. The remaining projects were rejected for various reasons, primarily lack of economic merit, novelty or sufficient research. Three of the commissioned projects were withdrawn from implementation, 26 were still under development; 54 had been completed, 40 of which were judged successful. It should be observed that the high rate of successful development translates into only five successful projects per year.

JRDC is a non-profit "Corporation under Special Charter" operating under the administrative authority of STA, whose concurrence for all important actions (including the awarding of contracts) is mandatory. As a public corporation, JRDC can be flexible in its dealings with government agencies, private business, universities, and research institutions and does not have to report to the Diet. Although modeled after the U.K.'s National Research Development Corporation (NRDC), JRDC receives an annual appropriation, rather than borrowing funds from the government.

JRDC's organizational structure consists of a President, an Executive Director, four full-time Directors, two part-time Directors, and Technical Advisory Council of 10 members from government, industry, and the universities. The Council reviews the activities, programs, and recommendations of the staff, which currently consits of about 70 persons. There are 50 scientists and engineers, 35 of whom develop contracts while 15 are in project evaluation.

JRDC obtains about one-third of its funds from STA by appropriation, and the remaining two-thirds from returns on previous investments (i.e., through repayment of interest-free loans and royalties resulting from the commercialization of successful projects). Its operating budget for FY 1971 was about $6.5 million. In the fall of 1971 the corporation was capitalized at $12.6 million, and the capitalization has been increasing at a rate of $1.5 million a year, chiefly as a result of successful investments.

JRDC follows a prescribed procedure with the following five steps:

1. Selection of "Commissioned" Projects

Researchers in more than 100 national, university, other public research laboratories and private research institutes are encouraged to submit research results which have good potential for industrial exploitation. The corporation receives as many as 150 applications for assistance per year. Each is reviewed by JRDC's technical staff to determine whether there is any financial or other impediment to proceeding with the development stage; whether the project is a good candidate for industrial exploitation; and whether and in what way it will contribute to the national economy. Approximately 10 to 15 projects are selected each year for development and, after approval by the Council, become "commissioned projects". Little, if any, additional research is required, and selected comprehensive national plan for ocean research and development. Factors accounting for this interest include: the rapid consumption of natural resources; the need to discover new resources; the possibility of using ocean space for urban requirements (such as offshore airports, power plant sites, and recreational facilities); the desire to keep abreast of highly-industrialized nations in the West in all areas of technological development; the need to develop new "sunrise" industries to take the place of maturing industries and maintain high economic growth; and the conviction that ocean research and development will lead to the manufacture of many high-technology products with foreign trade potential and profits.

The plan specified five priority areas:

- A comprehensive survey of the continental shelf around Japan, including basic strata research for possible location of natural resources and the development of improved underwater topography and geology surveying techniques.

- Investigation of and research into the marine environment and the establishment of a marine Information Control Center for the collection and processing of oceanographic information.

- Research to develop improved aquacultural techniques, cultivated fishing grounds in shallow waters, and large-scale pilot farming of edible fish.

- Development of remote-controlled underwater oil-drilling rig and related facilities and relevant technology.

- Research and development of pioneering and common engineering techniques for marine exploration, including establishment of experimental facilities, development of diving techniques, and engineering techniques for marine structures.

The national plan also recommended development of seawater desalting technology and by-product recovery, research on underwater metallic and other mineral resources, development of improved utilization technology of albumen resources, and research for development of undeveloped and unutilized living resources.

The government has been gradually implementing the Council's recommendations, although the main R&D thrust

g. Nuclear Ship Development Agency (NSDA)

Construction of Japan's first nuclear ship, the "Mutsu", was started by NSDA in November 1967. The ship will have a gross tonnage of 8300 tons, will be 380 feet long, will have a reactor power of 35 MWT, and is scheduled for operation in 1973.

The construction cost of the "Mutsu", around $50 million, includes shore facilities at Mutsu City in northern Honshu. The ship, to be used for oceanographic research and for the training of crewmen, will have limited capacity for handling special cargo. Since its purpose is developmental, it is not expected to run economically. Budget appropriations for FY 1970, FY 1971, and FY 1972 were $6.4, $4.2, and $2.2 million respectively.

Considering the economic potential of nuclear-powered merchant ships, particularly container ships, Japan joined with West Germany in establishing a Nuclear Ship Study Committee. The committee reported in March 1972 that a nuclear-powered container ship of the Kamakura Maru class [33/] could compete with similar conventionally powered ships. Although a nuclear-powered vessel would cost around $13 million more to build ($35.7 million as against $22.7 million for a ship with conventional power), lower operating costs, based on relative stability of nuclear fuel costs versus increasing oil costs and reductions in nuclear indemnity rates, could make the ship competitive. However, many technical, economic, and legal problems would remain to be resolved.

2. Space Program

STA's National Space Development Agency (NASDA) was created in October 1969 to direct and manage the development, launching, and tracking of satellites and the development of rockets for launching satellites. Its initial budget was a governmental allocation of $1.4 million supplemented by contributions from the private sector. NASDA cooperates closely with the Space Activities Commission (SAC), established in 1968 as an advisory body in the Prime Minister's Office.

Japan's early space research activities were spearheaded by Tokyo University's Institute for Space and Aeronautical Sciences (ISAS), leading to the development of the first

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33/ The container ship would have a gross tonnage of 51,000 tons, carry 1840 containers, and have a service speed of 26 knots, reportedly the fastest in the world for this kind of vessel.

d. Development of Nuclear Fuel

PNC is also engaged in the development of nuclear fuel, operating a Uranium Enrichment Technology Development Laboratory at Tokai at which R&D on uranium enrichment technology is underway. Industry is encouraging the government to develop R&D goals so that a plant with sufficient uranium enrichment capacity could be built by 1985 to meet one-half of domestic requirements.

All uranium now used in Japan has been enriched in the United States. The supply of enriched uranium from the U.S. will be adequate for the next few years, but additional capacity will be needed from some source by the end of this decade.[32/] Annual Japanese requirements for separative work is expected to be between 8,000 and 10,000 MT by 1985 or about one-half of the present U.S. capacity.

PNC's budget for R&D on uranium enrichment technology amounted to $2.3 million in FY 1971 and was used for the development of a separation mechanism and rotor materials, and the trial manufacture of two high efficiency centrifuges. In FY 1972, $6.16 million was set aside for uranium enrichment research: $4.54 million of that amount was allocated to PNC for R&D on the centrifuge method and $1.62 to JAERI for R&D on the gaseous diffusion method.

In April 1972, PNC announced completion of the centrifuge test facility with ten centrifuge machines. It is now conducting dependability tests on the system. Longer range plans call for completion of a design in late 1973 for standard manufacture of centrifuges, to be followed by a test of a centrifuge cascade in 1975. Successful testing of the cascade would lead to the construction of a pilot plant in the late 1970's.

e. Development of Uranium Resources

Japan's increasing demand for uranium ore to operate its nuclear reactors requires a stable supply of uranium raw materials, inducing PNC to undertake prospecting both at home and abroad. Since 1956, new techniques

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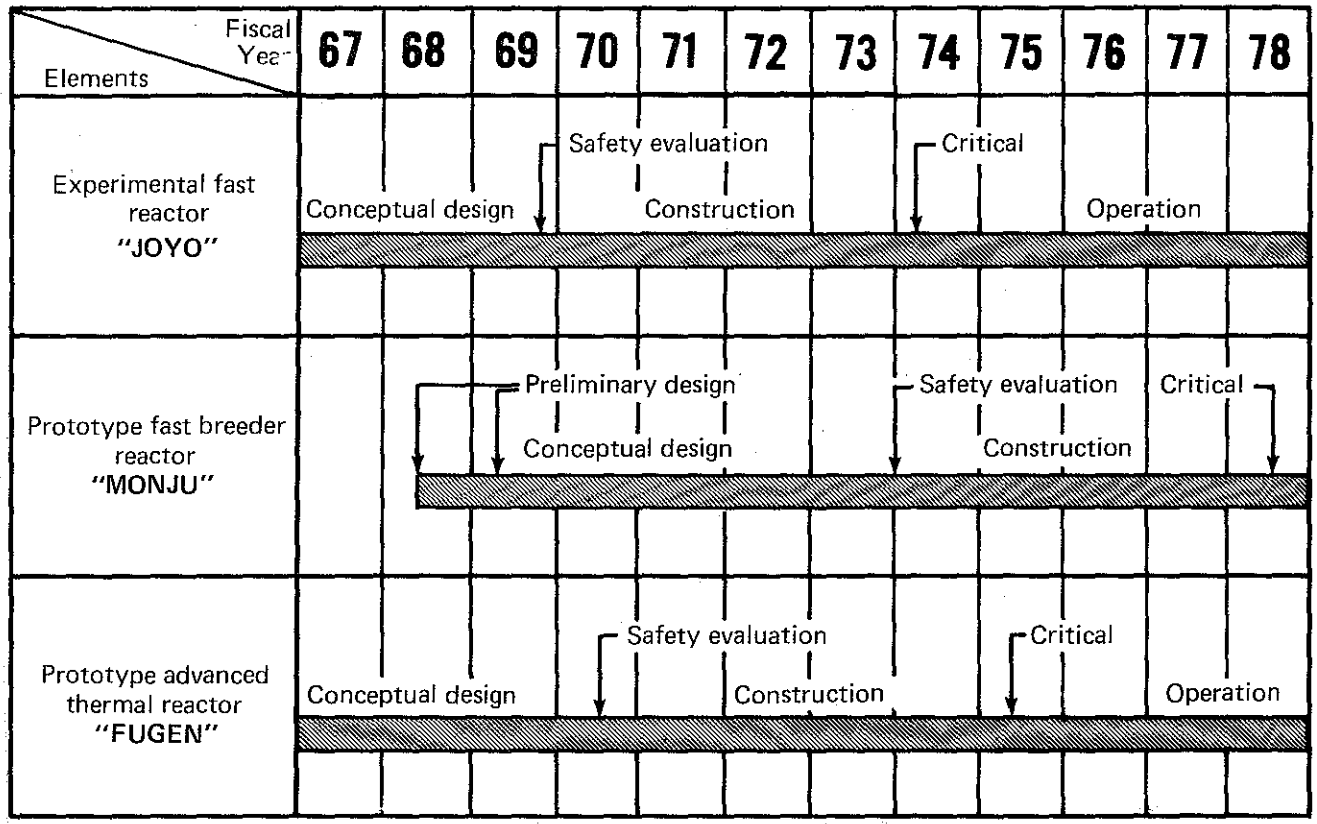
32/ The present U.S./Japan Bilateral Agreement for Cooperation in the field of nuclear energy contains a provision for enriched uranium which is limited to a net adjusted U-235 ceiling of 335,000 kg.

FIGURE 11

PNC Power Reactor Development Program



A measure of the importance of the atomic energy program is given by government funding: in FY 1972, $182 million was set aside for atomic energy R&D programs, an increase of 18.3 percent over FY 1971. This was the largest single item in the FY 1972 R&D budget (nearly 15 percent of all R&D) other than funds allocated to national universities primarily for basic research.

a. Japan Atomic Energy Research Institute (JAERI)

JAERI's operations resemble those of a multi-purpose U.S. AEC National Laboratory, doing R&D in reactor technology and safety, radiation chemistry, radioisotopes development, and tasks in systems development for gaseous diffusion enrichment, including development of barriers, a UF_6 loop, and a 13-stage cascade. Four companies are designing a 200 KW axial flow compressor for JAERI's UF_6 circulating loop. Its principal facilities are located at Tokai, where it maintains three research reactors (Japan Research Reactor No. 2-JRR-2, 10 MWT, D_2O graphite, first Japanese-made reactor; and JRR-4, 2.5 MWT, pool type); also the Japan Power Demonstration Reactor (6E-BWR 12.4 MWE) which has doubled its output through the use of a new core, a fast critical assembly, and several thermal critical assemblies.

JAERI is also responsible for the operation of the Japan Materials Testing Reactor (50 MWT) located at O-Arai and a fuel reprocessing pilot plant facility. Its major radiation chemistry and food irradiation facility is located at Takasaki, where research in practical uses of radiation is conducted.

b. Power Reactor and Nuclear Fuel Development Corporation (PNC)

The Japanese Government has turned to the exploitation of nuclear power for the generation of electricity. Based on present rates of expansion of demand, the country will require about 8.7 million kw. of nuclear generating capacity by 1975 and 60 million kw. by 1985. PNC was created to achieve these targets and to "make Japan independent in the technology related to energy generation."[31]

31/ Power Reactor and Nuclear Fuel Development Corporation, PNC, Tokyo, Japan, 1971, p.2.

9. Turbofan Engine for Aircraft

This project for which MITI has allocated $19 million was started in 1971 and is scheduled to be completed in 1975. The development of the turbofan engine, designated FJR 10, is being conducted in two stages. Phase One calls for the development of a 10,000-pound thrust engine, with a by-pass ratio of 6.5 and a turbine inlet temperature of 2100^{o}F. Phase Two will produce a 20,000-pound thrust engine four years later. Ishikawagima-Harima, Mitsubishi, and Kawasaki Heavy Industries are conducting the initial research work under contract for the National Aerospace Laboratory.

D. Joint Government-Private Sector Technology Projects

The number of joint government-private sector technology projects is so extensive and the variety so broad as to preclude examination here of even the largest projects in all program areas. In general, the Japanese government allocates relatively small to modest funds for various technology programs, apparently guided by the philosophy of investing R&D resources over a broad spectrum of new technologies rather than concentrating efforts in only a few advanced technologies. Nevertheless, as mentioned earlier, atomic energy, space, and ocean development have received large amount of funds and high priority for implementation. The major projects in those program areas have therefore been selected for discussion below, but this does not imply that other program areas, judged by other criteria, are not equally important or that their long-range impact is likely to be less significant.

Joint-venture projects carried on by the government and private industry are subject to the same general principles and conditions for financing and implementation as projects under the National R&D Program. Two distinguishing features are that implementation is less urgent (except, perhaps, for the projects in the atomic energy, space, and ocean development program areas) and, more importantly, that the private sector underwrites part of the overall cost of each project. Financial participation by the private sector ranges from a token 3-5 percent to as much as 50 percent of the total cost, depending on the overall cost of the project, the risk involved, and other comparable factors. Moreover, the more a company contributes, the greater the participation it is likely to be granted when the prototype piece of equipment or pilot plant is subsequently turned over to the private sector for commercial exploitation.

FIGURE 10

Performance Characteristics of Electric Car Prototypes

Type of Car	Cargo		Passenger cars (and Vans)		Buses
	lightweight	compact	light-weight	compact	large-size
Passenger + loading capacity (kg)	2 persons + 200kg	2 persons + 1,000kg	4 persons (or 2 persons + 100)	5 persons (or 3 persons + 300)	60 - 80
Gross vehicular weight (kg)	approx. 1,100kg	approx. 3,500kg	approx. 1,000kg	approx. 2,000kg	approx. 15,000kg
Maximum speed (km/h)	more than 70	more than 70	more than 80	more than 80	more than 60
Mileage per one recharge (km)	130 - 150	180 - 200	130 - 150	180 - 200	230 - 250
Acceleration (0-30 Km/h) in sec.	less than 5	less than 5	less than 4	less than 3	less than 8
Climbing ability (speed of climbing an inclination of 6^{o}) (km/h)	more than 40	more than 40	more than 40	more than 40	more than 25

Specifications:

(1) The weight of a battery shall be less than 30% of the gross vehicular weight.

(2) The energy density of a lead storage battery shall be 60 wh/kg. However, this is based on constant output for five hours.

(3) The mileage per one recharge is based on value in continuous running at a constant speed of 40 km/h.

drilling fields both overseas (see below) and on Japan's continental shelf. To assist in this effort, the government has initiated an extensive geological and mineralogical seabottom survey program of the entire continental shelf. 24/ The government-private sector investment for major petroleum development is expected to reach nearly $3 billion over the next ten years.

Published plans indicate that the undersea oil drilling rig program will consist of two basic subprojects, 25/ one being the full system design, from the pipe-handling system and the drilling equipment and production to the tests for a trial model. The second subproject is more extensive, involving development of equipment and offshore drilling engineering techniques, including research on drilling plant performance and adjustable drilling platform, research on automatic operation of the drilling equipment, design and production of trial model of pipe-positioning device, research on centralized control systems of oil wells, development and production of trial models of safety heaters and of Cyclone separators, and research on the security provisions for offshore mining. The R&D work is underway at AIST's Mechanical Engineering Laboratory, the only national research institute for mechanical industry in Japan.

Since Japan depends heavily on foreign sources for oil, arrangements have been made with other countries for overseas development of oil resources. In October 1967, the government established the Japan Petroleum Development Corporation to provide risk capital to private firms willing to undertake overseas oil exploration. "By 1969, twelve companies were operating in 15 areas of the world either in joint operations with foreign capital, through production sharing agreements, or under concessions from the country concerned."26/

7. Electric Car

Although much progress has been made in recent years in improving the fuel and remodeling the internal combustion

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24/ A coastal development planning map prepared by the Geographic Institute shows that at present technology levels, only about 80,000 square kilometers of offshore area is fit for development, including reclamation, fish and shellfish culture and underwater transportation.

25/ Marine Technology Research and Development Plans, SR-1002, p.2.

26/ Ministry of Foreign Affairs, The Japan of Today; op.cit. p.50.

The hardware which has been developed possesses a logical operation speed on a level with the best standard type large machines of the world, the mean order execution time being between 0.2 μs and 0.3μs (a micro-second is one millionth of a second). As on-line technology and TSS technology were developed simultaneously, the results of this Project are expected to have a major influence on large scale computer production technology in this country.

In practice and contrary to expectations, the completion of the super-high-performance electronic computer proved to be a disappointing failure. Knowledgeable people claim that the computer is almost useless and that, as a result, it is virtually unsaleable.

3. Desulfurization Process

This project involves the development of a process to remove sulfur from stack gas and from fuel oil. It was started in 1966 and scheduled to be completed in 1971, with a total $7 million allocated by AIST for implementation. As for desulfurization of stack gas, two processes - activated magnectic oxide and activated carbon - have now been developed into commercial applications, while the results of research and development on the technology for removing sulfur from heavy oil, completed this year, are now being assessed.

4. New Process for Olefin Products

Anticipated shortages in naphtha supplies induced AIST to institute this project in 1967. It was designed to develop a new process to produce olefin products from crude oil, instead of from naphtha. A total of $11 million was allocated and completion was scheduled for 1973. However, AIST announced cancellation in April 1972, after spending well over $3 million, since the desired results had not been produced. In addition, a decrease in the demand for naphtha reduced the urgency to develop a new process. Work on basic design of a 120 ton-per-day pilot plant for olefin production is now underway, on the basis of research results obtained thus far.

5. Sea Water Desalting and By-Products Recovery

Rapid industrial development and urbanization throughout Japan has caused an increase in demand for water at a rate

In 1954 the leading Japanese manufacturers of sophisticated electrical equipment, afraid to face foreign competition, urged the Japanese Government (MITI) to help develop a computer industry. 19/ Policy guidelines were developed in 1955 on importation of foreign technology through patent licensing, and protection from foreign capital and imporation of computers. An electronics Industry Act was passed in 1957, providing government financial assistance to computer manufacturers, among other, in the form of subsidies for R&D, loans for commercialization of products, and loans and accelerated depreciation for investment in plant and equipment. Computer production (components) got underway in 1957, and by 1961 Japanese computer output was valued at $13 million, shared by seven major manufacturers. Domestic production of computers (and coordinating units) expanded at an annual rate of 42.5 percent between 1959 and 1970, reaching nearly $876 million in 1970. The government's assistance to computer manufacturers was largely catalytic, the total amount of subsidies, loans, and accelerated depreciation allowances being less than $25 million for the entire period.

Although IBM and Sperry Rand sought authorization to establish computer manufacturing facilities in Japan in 1960, MITI sought to exclude them. After long and bitter negotiations, Sperry Rand entered into a joint venture with Oki Electric Industry Company in 1967, the latter owning a 51 percent interest in the new company, thereby classified as a domestic producer. IBM was granted permission to establish production facilities in return for the licensing of IBM's basic patents to all interested Japanese manufacturers, aiding the technological advancement of the domestic computer industry. IBM has since been restricted to a production quota not to exceed 35 percent of the domestic output of computers, and to date remains the only "foreign" producer of electronic computers in Japan.

MITI has also protected the domestic industry by regulating computer imports through relatively high tariff rates (highest where Japan is least competitive), and by annually established foreign exchange allocations for computers, which have increased steadily.

19/ Kaplan, op.cit. p. 79. Two earlier attempts by the Ministry of Education and the Japan Telegraph and Telephone Corporation, respectively, ended in failure.

publicizing, makes every effort to achieve their commercial exploitation. The Association is authorized by the government to license patents on a non-exclusive basis, for which service it is entitled to receive 10 percent of the royalties paid by the private company; the remaining 90 percent goes to the government. The time frame for payments and the rate of royalty vary from case to case, depending on the contract negotiated between the Association and the private company. However, the Association must abide by certain government standards. This mechanism has been moderately successful in effecting the transfer of government-owned patents for commercial exploitation by the public sector.

Potential private investors are encouraged to make use of the R&D facilities of private laboratories and associations which are often partially subsidized by the government, usually for the purchase of equipment. Assistance may also be provided by the Research Development Corporation of Japan (JRDC), specifically created for this purpose and discussed in detail later. If a private inventor develops and patents a product or process, he is entitled to retain exclusive rights even if he received generous assistance from the government for most of the research work involved.

C. Fully-Subsidized National Priority Projects

The National R&D Program, which currently comprises nine projects, was started by MITI's AIST in FY 1966 for the purpose of developing new advanced technologies needed to keep abreast of developments in other industrialized countries and to maintain the growth momentum of the domestic economy. Each project under this program is known as a National R&D Project and is given a top national priority. In essence, such projects are laying the foundation for the development of whole new industries (the "sunrise" industries of the future) which will create new competitive opportunities abroad and raise the standard of living at home. Projects are therefore carefully selected after long consultations and planning in collaboration with the private sector and the scientific community and are fully subsidized by the government.

Six National R&D Projects were initiated by AIST between 1966 and 1970, and three more in 1971 to meet mounting social needs, such as pollution control and abatement. High risk, large expenses, and long duration are given as the principal reasons for the government's willingness to underwrite the full cost of these projects. Yet in spite of the national importance attached to these projects, less than $21 million was allocated for the National R&D program in the government's FY 1972 budget, about 18 percent more than for FY 1971.

sector. Industry officials who serve on one or more advisory bodies to government agencies keep abreast of spcific needs as they are identified and encourage their companies to submit proposals. The company which originates an eventually funded proposal may become the sole (and usually at least the prime) contractor, depending on the extent to which other companies get involved in implementation.

Proposals which originate in government institutes and laboratories, as well as those from private inventors, normally go through several screening processes, competing with other project proposals as they move up the ladder from lower to higher government agency. Thus, many proposals submitted at the prefectural or local research institute level never reach the STA, MITI, or other ministerial level because they are eliminated earlier.

3. Project Financing

If a large-scale technology project is not fully subsidized by the government, the latter normally finances between 50 percent and 90 percent of the total cost, including cost of new plant facilities and equipment. The percentage depends on the project's priority, the cost and risk involved, duration, extent of commercial applicability of the final product, and the degree to which the government wishes to encourage effective participation by industry. On most other projects the government participates on a 50-50 basis. As further inducements to industry, there is a variety of tax and other incentives (except on fully subsidized projects), discussed later.

Project funding generally covers cost through development of a final prototype, (i.e., up to the pre-production stage), including the construction of prototype plants. Throughout the project the government works closely with the private companies involved to insure that they acquire all available knowledge on the advanced technology being developed. As a rule, many engineers, scientists, managers, and other officials are detailed to work in government establishments on loan from the private sector, which also provides a "topping off" to compensate for the lower salaries paid by the government.

One of the participating companies is chosen to receive the newly-developed product (e.g., a prototype reator) for commercial production, or the prototype (pilot) plant for private operation. To facilitate commercialization of the new technology, the government may recommend the extension of a concessional loan (i.e., a loan at favorable terms) of the national government. One hundred and two of the fields recommended by the CST stemmed from economic and social needs such as atomic energy development and cancer research.[17] Although the Council did not indicate a level of priority for each R&D field, atomic energy, space, and ocean development subsequently emerged as large-scale national program areas and were placed under STA's administrative authority.

Since 1961, the Japanese Government has initiated a large variety of projects and mechanisms for the development and application of new advanced technologies, too many to be discussed within this appendix. Thus, in the sections which follow, only the JRDC, the nine national R&D projects, and the most important projects under the atomic energy, space, and ocean development program areas will be discussed separately.

Similarly, since the mechanisms used for technology enhancement are as significant as the projects themselves, the next section will summarize how major technology programs are planned, developed, and implemented; how government and industry interface in this endeavor; and how a variety of inducements are used to attract private sector participation and to accelerate the commercialization of new technologies.

I. S&T Policy and Program Planning

In 1960 CST published a report outlining measures for the government to undertake during the next 10 years in order to attain specified S&T goals. A 1966 supplement to this CST report identified 121 R&D fields important enough to warrant government sponsorship and assistance. Preparation of the CST reports had involved close and protracted consultations among representatives from the government, the private sector, and the scientific community; an approach to the development of S&T policy which has remained virtually unchanged. However, the proliferation since 1960 of programs, agencies, government research institutes, and quasi-government research corporations, all of which must interact with many, often divergent, interests in the private sector, renders the formulation of S&T policy today far more difficult and complex.

17/ Thirteen additional fields were based on academic needs, such as nuclear physics and biological science, and six fields (such as Antractic research) required international cooperative research. Planning Bureau, Science and Technology Agency; Governmental and Administrative Organization in the Field of Scientific Research, March 1971, p. 7.

FIGURE 9

Exports/Imports Ratio in Technology Trade, 1963-1970

Receipt/Payment Ratio in Technology Trade (%)

	Japan	U.S.	U.K.	France	W. Germany
1963	0.07	8.35	-	0.73	0.37
1964	0.09	8.34	1.07	0.76	0.40
1965	0.10	9.29	1.04	0.79	0.45
1966	0.10	9.86	1.21	0.74	0.42
1967	0.11	9.16	1.07	0.85	0.47
1968	0.11	9.30	1.08	0.60	0.45
1969	0.13	9.68	0.98	0.63	0.38
1970	0.14	9.51	—	—	0.39

Government involvement in environmental protection activities is therefore bound to grow fast during the 1970's, consistent with similar international efforts in which Japan is cooperating and also with the country's penchant for seizing promising opportunities to develop new technologies and products which it can later export worldwide.

4. Foreign Technology Imports

Foreign technology imports, which played an important role in Japan's postwar industrial development, were carefully scrutinized by MITI and selected in order to minimize the cost of the country and to ensure that control of the domestic industries involved did not pass to foreign hands.

Close examination of the Japanese Government's recent R&D budgets reveals no basic change in policy with regard to foreign technology imports. Japan will continue to be heavily dependent on advanced technologies from abroad, for insufficient resources are being allocated to permit large-scale development of new technologies and innovations in Japan. There are two factors, however, which will have a significant impact on Japanese industry and which may force the government to modify its imports policy. In the first place, as the country advances technologically, the supply of new technologies from abroad will begin to diminish. In the second place, foreign licensors of technology are increasing their demands on Japanese licensees for both higher financial returns and greater share in the management of joint ventures.

Japanese foreign technology imports steadily increased from 958 cases in 1965 to 1768 cases in 1970. More than one-half of the technology imports during the 6-year period 1965-1970 were supplied by the United States; these declined gradually between 1967 and 1970; but were slightly higher in 1971. According to an STA report released in February 1972, Japan paid $433 million for foreign technology imports in FY 1970, 17.7 percent more than in FY 1969. The United States accounted for 56 percent of the contracts awarded, compared with 14.2 percent for West Germany, 8.1 percent for the United Kingdom, and 5.5 percent each for France and Switzerland. General machinery, chemicals, and electrical equipment accounted for around 27, 20, and 12 percent, respectively, of all technology imports. Technology imports related to pollution control increased about 200 percent over FY 1969; including techniques for desulfurization, waste water treatment, dust collecting and garbage treatment, and automatic exhaust gas treatment.

5. Liberalization of Technology Imports

Controls over imports of foreign technology, first imposed by MITI during the period of reconstruction, have not been popular

FIGURE 8

Distribution of FY 1972 R&D Budget by Category
and
Average Annual Increase Since FY 1968
(millions of dollars)

Category	R&D Budget FY 1972	% of Total	% Increase Over FY 1971	Average Annual Increase Since FY 1968
National universities	487	39.5	20.8	12.8
Atomic energy	182	14.7	18.3	28.8
Government laboratories	136	11.0	9.6	9.2
Grants and subsidies	129	10.5	101.3 [1]	35.8
Space research	78	6.3	58.7	37.8
Defense research	45	3.6	37.1	13.7
Ocean research	29	2.4	31.6	49.1
Major projects	21	1.7	18.5	13.3
Pollution control	16	1.3	97.6	88.8 [2]
Administration	10	1.8	11.1	7.9 [3]
Others	100	8.1	0.1	11.2 [2]
Total	1,234	100	25.4	19.0

1/ Increase reflects sharply increased aid to science and engineering departments of private universities

2/ Since FY 1970

3/ Since FY 1969

FIGURE 7

Government R&D Budgets FY 1968 - FY 1972
(millions of dollars)

Category	FY 1968	FY 1969	FY 1970	FY 1971	FY 1972
National universities	302	341	365	403	487
Private universities	25	26	-	-	-
Atomic energy	67	97	126	154	182
Government laboratories	96	97	109	124	136
Grants and subsidies	44	52	51	64	129
Space research	23	30	48	49	78
Defense research	28	30	29	33	45
Ocean research	6	10	15	22	29
Major projects	13	15	16	18	21
Pollution control	-	-	5	8	16
Administration	16	8 1/	8	9	10
Others	-	-	81	99	100
Total	622	710	854	984	1,234
National Budget	19,212	21,881	25,811	30,565	37,241
S&T budget as % of national budget	3.23	3.24	3.30	3.21	3.31

1/ Decrease is the result of new definition, not changes in administration

Notwithstanding the above, consensus is not always achieved, and even recommendations made by Keidanren, have at times been ignored by the government. For example, the Federation's original recommendation that AIST be made part of STA rather than MITI, went unheeded. Keidanren has also been unsuccessful so far in its efforts to alter the top structure of the Science and Technology Council and change its authority from advisory to executive, and is currently trying to soften the government's proposed new laws and standards on environmental issues because of their potential adverse effects on industry. (It candidly admits, however, that there is a large gap between the two sides.) The Federation also has been trying to persuade the government to spend a larger proportion of the GNP on research and development, but the government has not as yet positively moved in that direction. Nevertheless, Keidanren seems to be generally satisfied with the government-private sector relationship and interaction.

Generally speaking, the private sector both expects and accepts interference by the government, knowing that decisions involving national policy will be made only after close and extended consultations with the private sector.

The government has a paternalistic attitude toward the private sector, and undertakes programs only after reaching a "consensus" with the other side. This often requires extended time in consultations during which differences are slowly ironed out and a mutually agreeable course of action is charted. The initiation of new technology programs, business consolidations, technology imports, etc., have all been effected in this manner, with the government guiding matters, rather than imposing its authority, in the interest of the national well-being. The government has often not gotten its way, the failure being due as often to disagreements within the government (between MITI and MOF, for example) as between the government and the private sector (usually the large conglomerates).[13/]

The "consensus" process between government and the private sector is greatly facilitated by several factors:

- Industry officials serve on hundreds of government advisory councils and committees, thereby not only participating in and steering policy planning from the very beginning, but helping to avoid major confrontations between the two sides. "Participation in the planning process," says Kaplan, "in effect gives business leaders a vested interest in seeing the plans carried out."[14/] Moreover, the result has been the same whether the initiative originated with the government or the private sector and "many economic developments that have benefitted the country have come out of industry initiatives and business inputs into the planning process."[15/]

- Most high business officials have broad contacts in many government agencies, having previously worked for the government until the mandatory age of retirement at 55. During their tour of service for the Japanese government, civil servants, particularly those in the higher positions, are

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[13/] For a more detailed description of why the "consensus" process works and why sometimes it fails, see Eugene J. Kaplan, op. cit., pp. 60-67.

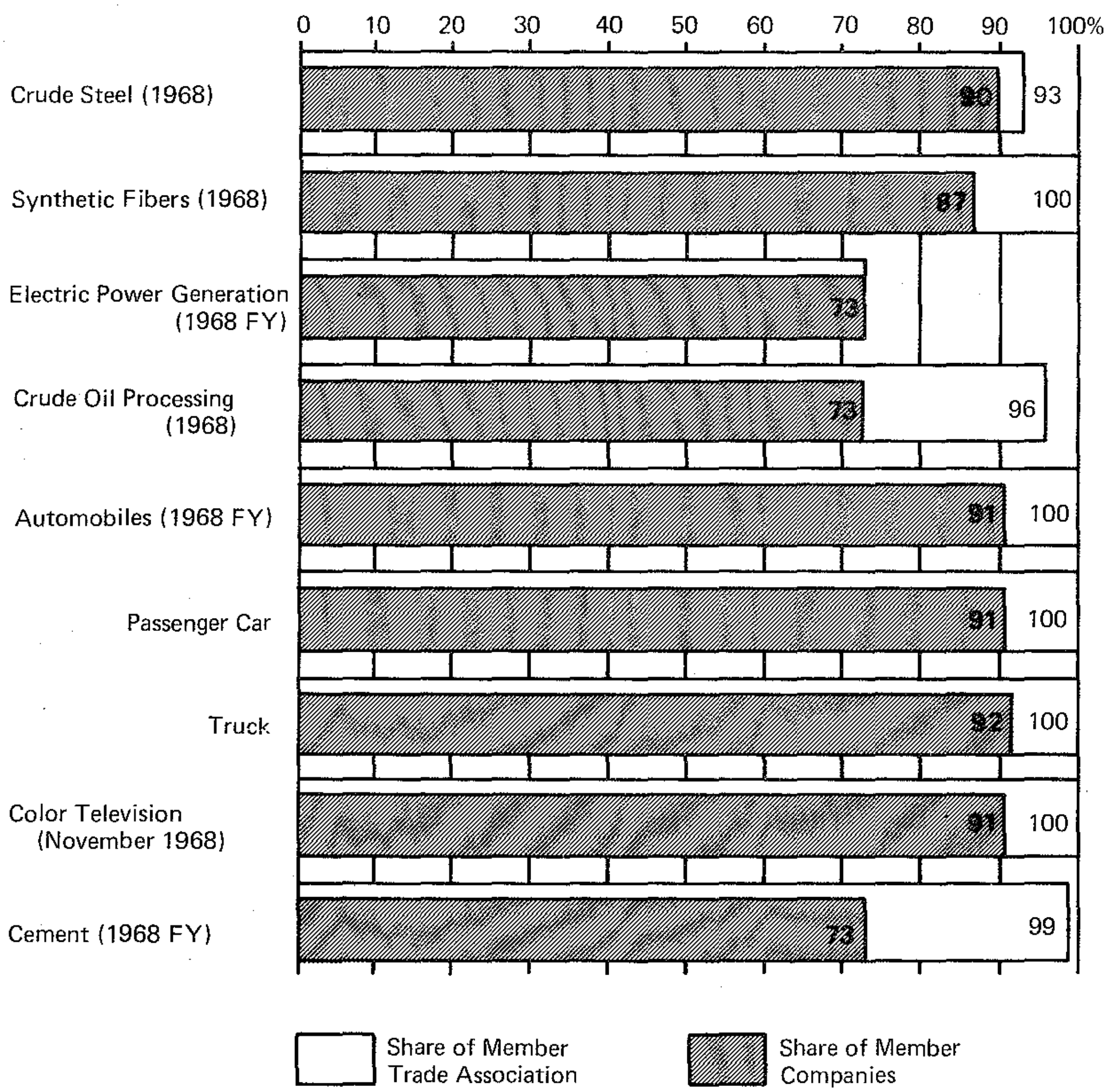
[14/] Ibid, p. 30.

[15/] Ibid, p. 19.

FIGURE 6

Representation of Keidanren in Japanese Industry

– Relative Shares Taken by Member Companies and Trade Associations in Major Industrial Sectors –



typical of Japanese society. Controversies and disagreements among these three agencies are plentiful, but differences are invariably resolved through compromise and, to all intents and purposes, the "issues" never surface.

As stated earlier, STA participates in formulating S&T budgets in the various ministries. The agency interacts closely with the Ministry of Finance in establishing funding priorities for ministerial programs, as it also does for funds assigned <u>en bloc</u> for special research work to be conducted in several ministries simultaneously. The same is true about funds to be allocated by MOF for the work of the research establishments operating under STA. The Ministry's position in these deliberations is influential, although not decisive.

The Ministry of Finance also interacts closely with MITI, although MITI seems to have greater persuasive powers than STA. MOF has a strong voice in determining the level of funding for the continuation of the National R&D Projects and the designation of new ones, all of which are subsidized entirely by the government. As will be described in more detail later, MOF also carries much influence on all issues involving the granting of incentives which, of necessity, affect the volume of public revenues. MOF and MITI review applications and jointly issue special certificates of approval which entitle recipients to take advantage of first-year depreciation allowance for use of a newly-developed technology. In essence, tax incentives are granted by MOF, which is the final decision-maker, whereas subsidies are granted by MITI after consultation with the MOF. MOF must also be consulted before capital investment loans involving tax incentives and made by the Japan Development Bank are consummated.

The strong influence of MOF is indicated in many other instances. The Ministry determines the amount of funding for the Research Development Corporation (discussed in Part II) as well as the maximum funding of two of the three lending institutions for small- and medium-sized enterprises. It is not clear, however, how much MOF influences technology imports by placing a ceiling on the amount of foreign exchange that can be used for such purposes.

9. Keidanren

The agencies and subdivisions discussed thus far are in the public sector, and represent the key government

- running and control of atomic power plant in electric power system
- flame-retardant resins and paints
- diffusion of industrial stack gas with wind tunnel
- mineral beneficiation and transportation of solid materials by pipeline
- prevention of gas and coal-dust explosion
- peaceful utilization of nuclear power
- renovation of pulp and paper mill effluent

This list indicates the broad range of R&D work currently being carried out in the AIST research institutes and laboratories, as well as the nature of competition in foreign trade in prospect.

8. Agency for Small and Medium Enterprises (ASME)

The Japanese government maintains an interest in the welfare of small and medium sized enterprises through the Agency for Small and Medium Enterprises, established in 1950. This interest stems from the facts that:

a. smaller business firms constitute over 99 percent of all business establishments in Japan, hence much of the country's future growth and prosperity is tied up with the economic soundness and prospects of these enterprises; and

b. smaller business firms exhibit problems peculiar to their size, e.g.,

   - rises in wages have always exceeded gains in productivity achieved through modernization;

   - they are particulary affected by business cycle fluctuations;

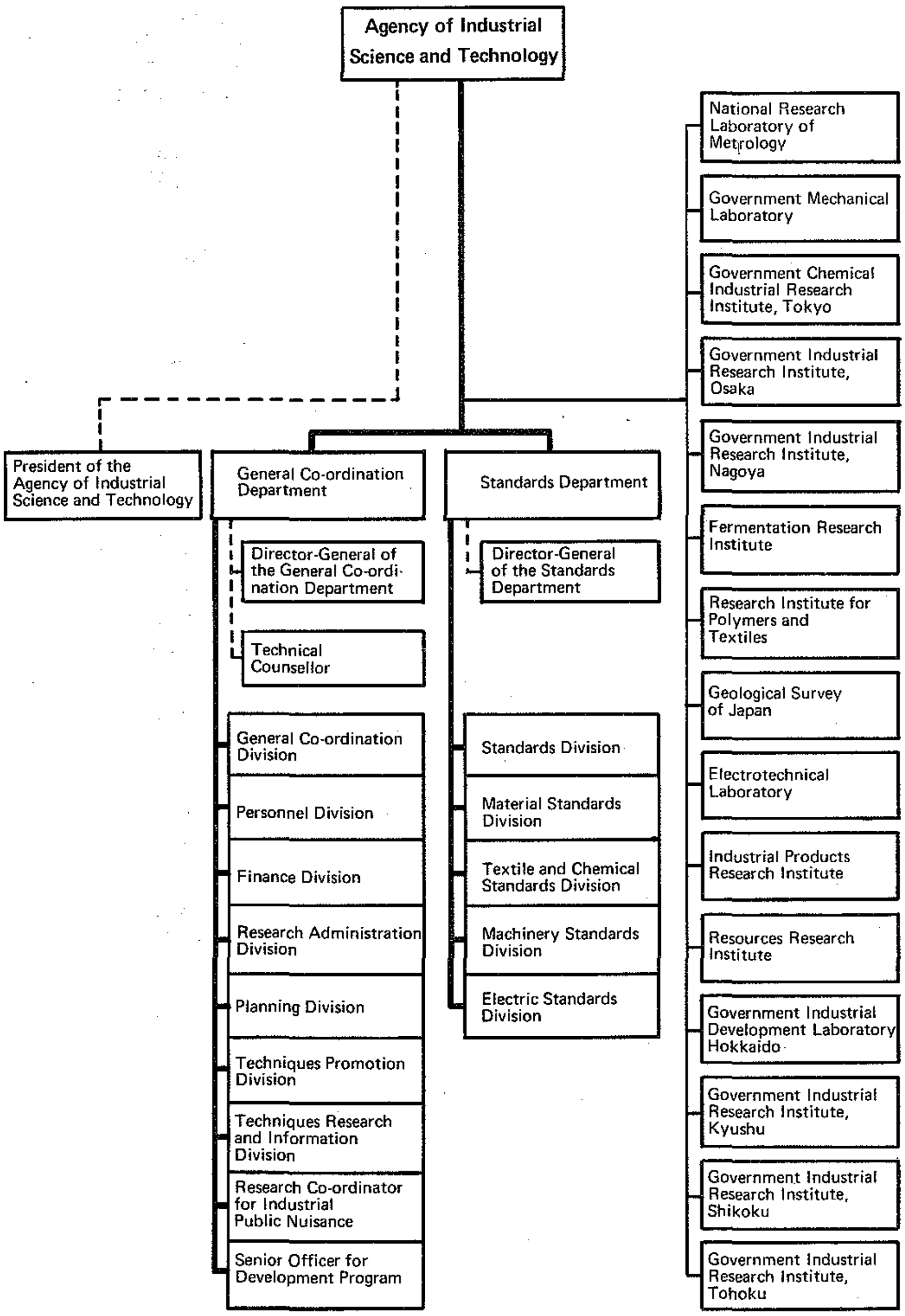
   - they have a higher bankruptcy rate than larger companies;

   - they are unable to obtain loans and credit at favorable terms at private financial institutions;

   - they do not have the technical staff nor the facilities to conduct research and development.

FIGURE 5

Organization of Agency of Industrial Science and Technology (AIST) (March 1970)



of MITI's activities on industrial science and technology. The Agency started the "National Research and Development Program System" in 1966, discussed in more detail below.

Figure 5 shows that the AIST is organized into two departments (General Coordination and Standards), with supervisory and coordinating authority over 16 research institutes and laboratories throughout the country. Within the General Coordination Department is the Office of Research for Developing Utilization, which is responsible for paving the way for the application of R&D findings.

Within MITI, AIST is the key policy-making agency for mining and industrial technology. Its functions include:

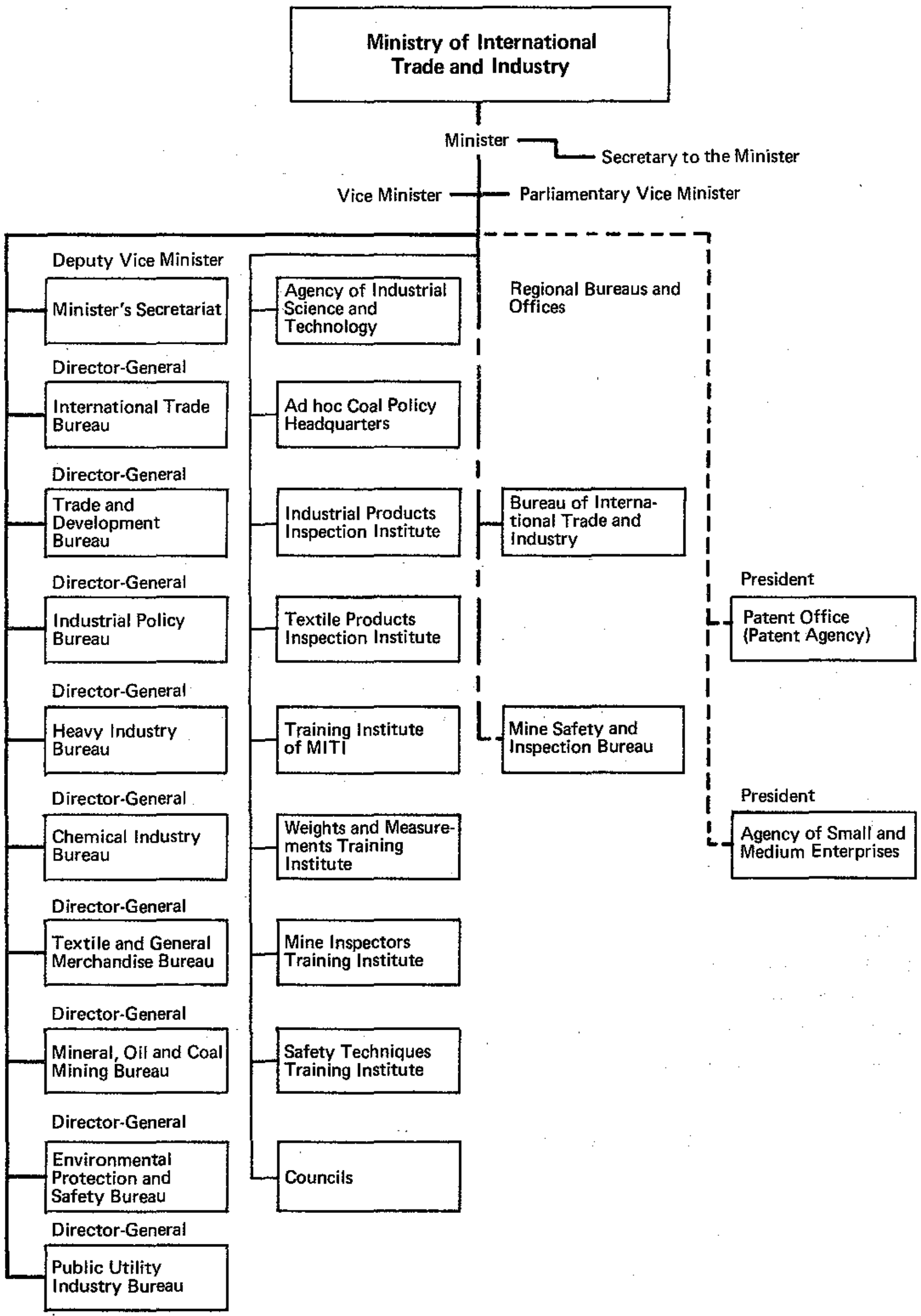
a. Promotion and coordination of R&D activities of the affiliated institutes and laboratories. The agency may designate "special programs," for which it allocates large amounts of funds for implementation. For other programs involving important technologies of high national priority, the agency refers to an in-house Conference of Industrial Science and Technology for clearance.

b. Management of the National R&D Projects. There are a number of R&D projects which the government considers to be of highest national priority, whose implementation is long-term, and which involve too large a financial risk for the private sector to undertake. Acting through AIST, the government underwrites such projects completely, from planning and staffing to completion of the work. Advisory groups within AIST provide guidance for the R&D work, which is usually shared among universities, the AIST institutes and laboratories, and the private sector. To date, nine projects have been singled out under this program as follows:[9/]

9/ ____________________, Agency of Industrial Science and Technology, MITI, Tokyo, Japan, 1971.

FIGURE 3

Organization of Ministry of International Trade and Industry (MITI)
(March 1970)



other being STA) significantly involved in S&T policy development and implementation, existed prior to World War II but became active in science and technology in the postwar period as part of the country's efforts towards industrial rehabilitation and growth. Even during the war years, MITI (then known as the Ministry of Military Supply) was exclusively concerned with the allocation of existing resources to industrial associations.

MITI's postwar involvement in science and technology has been direct and effective, but not always wholly acceptable either at home or abroad. Its broad mandate has been freely interpreted to signify authority to plan and coordinate efficient use of domestic and foreign resources in order to develop and maintain at a high level the industrial and international trade potentials of the country. To this end, MITI has exercised its authority to use a variety of measures, ranging from direct intervention and pressure to subsidies, loans, tax and other incentives, and protection from unrestrained competition. This last measure has caused MITI's actions to enter the realm of science and technology; the most efficient industrial development for Japan necessitates the use of the most advanced technology available, and this continues to require importation from foreign countries. MITI's policy has therefore been to balance the "need" of technology imports against protection of the domestic industry, ensuring the latter's steady growth and, insofar as possible, retaining control in Japanese hands.

MITI continues to interact with the private sector through industrial associations unless the private sector is one of the large industrial conglomerates. Naohiro Amaya, Director of the Planning Section, Ministerial Secretariat of MITI, describes the procedure involved as follows:

> "Interaction between bureau and industry can be illustrated by the case of the chemical industry ...The interests and problems of the chemical industry first discussed in the Association of the Chemical Industry are then presented when necessary, to MITI's relevant section of the Chemical Industry bureau, in order to implement coordination and/or compromise for the good of the whole industry. For instance, if several firms are competing for a foreign technology at the risk of pushing production well beyond demand, MITI will first try to persuade the firms to reach

Projects."[7] Funds are allocated for research programs which require special consideration, or to meet unforeseen circumstances.

d. Operational activities which are:

- research-related, inter-disciplinary in nature, and being carried out at research establishments under STA jurisdiction; also projects conducted under subsidy or contract;

- non-research related, e.g., awarding the title "consulting engineer," encouragement of new invention, control, surveillance and training of experts in the area of atomic energy development, and surveys conducted in various fields related to the utilization of resources.

These STA functions are carried out by the Agency's Planning Bureau, Research Coordination Bureau, and Promotion Bureau. STA's fourth Bureau, the Atomic Energy Bureau, has unique responsibilities and position, hence is treated separately.

3. Atomic Energy Bureau

Having been established as the secretariat of the Atomic Energy Commission, the Atomic Energy Bureau (AEB) predates the establishment of STA by several months. From an administrative perspective, the AEB is quite distinct from the other three STA Bureaus. Its functions, all within the area of atomic energy development and peripheral activities, parallel those of STA, from the formulation of basic policy to the actual operation of laboratories and supervision of industry.

More specifically, the principal functions of the AEB are:

- Planning for atomic energy development in accordance with the basic national policy set forth in the Atomic Energy Basic Law of December 1955. The AEB served the Commission in drafting "The Long Range Program on Development and Utilization of Atomic

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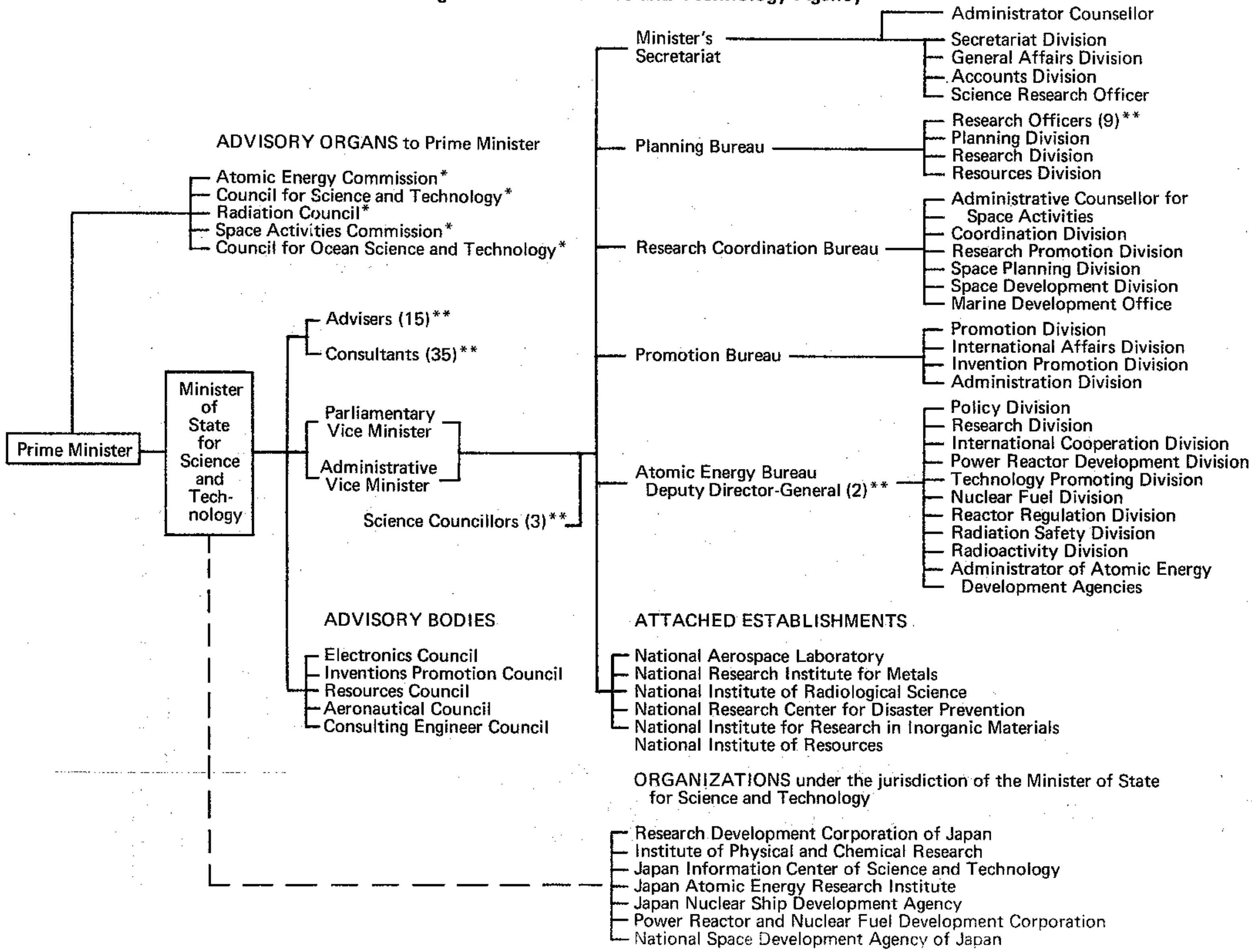
[7] Ibid, p. 10

FIGURE 2

Organization of Science and Technology Agency



* STA serves as an official Secretariat to these advisory organs.
** Numbers in parentheses indicate number of persons assigned to the post.

Every ministry in Japan to some degree promotes science and technology, but several agencies have this goal as their primary charter. These agencies are assisted by many Advisory Councils and Commissions. The ministries have substantial independence in all matters, including the formulation of S&T policy in their respective areas, but coordination of S&T objectives is exercised by the Science and Technology Agency. The Science and Technology Agency and the Ministry for International Trade and Industry are the two agencies on the highest level of the Japanese government which are most directly involved in S&T policy development and implementation.

The highly complicated administrative structure of interlocking S&T agencies and mandates is clearly indicated by the chart in Attachment 1 at the end of this appendix. In this study, however, only a few key agencies and the principal subdivisions directly involved in the promotion and administration of S&T activities will be considered. These agencies are: Council for Science and Technology; the Science and Technology Agency; Ministry of International Trade and Industry; and Ministry of Finance. In addition to these government agencies, the functions of the Japan Development Bank, which is partially financed by the Japanese government, and Keidanren, the Federation of Economic Organizations, will also be examined.

1. Council for Science and Technology (CST)

The Council of Science and Technology consists of four cabinet members, the President of the Science Council of Japan, and five appointed members of distinction and learning; it is chaired by the Prime Minister. Supplemented by 25 to 40 outside specialists for support at the subcommittee level, the CST serves as a Cabinet level S&T policy group, advising the Prime Minister.[5]

Despite its broad composition, the CST is heavily influenced by the Science and Technology Agency (discussed below), whose Director-General is chairman of the Council's Executive Committee. Major objectives include long range policy planning, identification and analysis of research projects, and coordination with the Science Council of Japan. The CST also sends observer groups to foreign

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[5] In addition to the CST, there are four other advisory bodies to the Prime Minister: Atomic Energy Commission; Radiation Council; Space Activities Commission; and Council for Ocean Science and Technology.

independent scientific capability in Japan.

In addition, the Japanese government is either already engaged in or is actively considering initiating a number of advanced technology programs. Purportedly, these programs will not only meet the needs for further economic expansion, but will also contribute to new industrial development areas or "growth" industries of the future. The government continues to rely on foreign technology imports for the successful implementation of these programs, but it is counting on the use of already acquired domestic technological expertise and creativity to a much greater extent than heretofore. These programs, to be discussed in detail later in this appendix, are cited below. They all involve the use of advanced technologies over a broad spectrum of areas of industrial development and technology enhancement.

B. Organization for Science and Technology Policy Development and Implementation

Japan's organization for promoting science and technology has, since World War II, grown in size and complexity in line with the government's expanding involvement in S&T activities. The result is a complicated system of interlocking agencies, advisory councils, quasi-public corporations, and industrial R&D laboratories whose mandates and functions must be delineated before the procedure for S&T policy development and implementation may be clearly understood. Furthermore, it is highly desirable to begin with a look at the country's overall governmental establishment because of the prominent place occupied by science and technology since the early postwar years.

Figure 1 depicts Japan's governmental organization. Executive power is vested in a Cabinet, consisting of a Prime Minister and not more than 18 State Ministers, which is collectively responsible to the Diet, the sole law-making body of the country and the highest organ of state power. The Prime Minister must be a member of the Diet; he is designated by that body and appointed by the Emperor (the Chief Justice is designated by the Cabinet). The Prime Minister has the power to appoint and dismiss the Ministers of State; all must be civilians and a majority of them must be members of the Diet. There are currently 12 ministers and five agencies in addition to the Prime Minister's office, as well as a National Capital Region Development Commission and a National Public Safety Commission.

and products, because of the continuously precarious balance of payments."[2]

Although MITI continues to have a great deal of authority over technology imports, the word "control" may be misleading. MITI's overriding concern has been to see that the "proper" industries are established, and that they are given every incentive and protection (including protection from foreign competition and imports) deemed necessary until they can compete internationally on a strong, continuing basis. In conformity with this concept, imports of foreign technology were decontrolled in 1968, except for seven items (which include electronic computers, aircraft, and petrochemicals). In essence, MITI's controls are less designed to inhibit technology imports than to contribute to the country's economic advancement.

A number of other points about foreign technology imports should be clarified. First, decisions concerning all aspects of technology imports were made by MITI only after protracted consultations with the private sector, although, admittedly, MITI's opinion and authority always carried considerable weight. Second, the majority of imported technologies had to be modified before being applied to Japanese conditions and needs. Many technologies were substantially improved before they were utilized and, in a number of instances, the technologies were first commercialized in Japan. Third, technology imports were not used to enhance exclusively the competitiveness of export industries; in fact, the immediate impact was on the domestic market, reflected in mass-produced commodities for the Japanese consumer. Since consumer commodities (such as automobiles, radios, television sets, washing machines and other home appliances) are normally associated with a higher standard of living, technology imports may be said to have contributed to the development of a strong middle class, the solid foundation needed for building a stable domestic market. In the long-run, many industries which started by producing for the domestic market became important export industries. Fourth, as industrial production expanded rapidly, the contribution of imported technology in relation to total sales declined, even though the cost of technology imports continued to be high. Thus, the contribution of foreign technology to total sales

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[2] Naohiro Amaya, The Ministry of International Trade and Industry (MITI); Sophia University Socio-Economic Institute, Bulletin No. 24, Tokyo, Japan, 1970, p. 5.

The first attempts were efforts to restore key industries, such as public utilities, heavy (primarily iron and steel) and chemical (primarily synthetic fibers) industries, and mining (coal, petroleum and nonferrous metals); these utilized technologies developed at home or acquired before the war. The government also encouraged industries, such as shipbuilding and, later, the optical industry, whose basic technologies had been further developed during the war years in response to military needs. The Korean conflict provided a significant boost, so that by the end of 1951 Japan reached its prewar level of production in mining and manufacturing.

Expansion of these and a number of other prewar industries (such as motor vehicles, aircraft, oil refining, and industrial machinery) proceeded rapidly during the 1950's, mainly through heavy support by the government and heavy imports of foreign technology. Wholly new industries (such as electronics, including computers, and petrochemicals) also appeared at this time. Technology imports continued to be encouraged on the assumption that they would be less costly than developing home-grown technologies in a relatively short time. In fact, the government "from time to time...published a list of manufacturing technologies which it recommended industrialists to acquire."[1] The statistics show that Japan's GNP increased by an average of 9.0 percent annually between 1950 and 1960, a rate two to three times that in principal industrial nations. In mining and manufacturing, production overtook the prewar level in 1951, and climbed to 3.5 times that level in 1960.

The industrial momentum of the fifties was carried into the sixties, marked by the advent of new high technology industries, such as atomic energy, information and data processing, and automation technology; at the same time, more capital and technology were invested in older industries to achieve even greater economies of scale and competitiveness in world markets. The 1960's also saw much independent R&D activity, as scientists and engineers were encouraged in creative activity to develop Japanese technologies and innovations. Mining and manufacturing production increased fourfold as the country's GNP steadily grew by an average of more than 11 percent annually, catapulting

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[1] Yoshihiro Tsurumi, "Technology Transfer and Foreign Trade The Case of Japan 1950-1966;" Ph.D. thesis submitted to Graduate School of Business Administration, Harvard University, June 1968, p. 134.

______________, *Richtlinien des Bundesministers für Wirtschaft und Finanzan für die Gewährung von Zuwendungen aus Haushaltsmitteln des Bundes zur Förderung von Entwicklung and damit zasummenhängender Forschung in der Berliner Industrie vom 1. März 1971*, Bonn, 1972.

______________, *Vorläufige Richtlinien für die Gewährung von Zuwendungen des Bundes zur Förderung von Erstinnovationen und der hierzu erforderlichen Entwicklung*, Bonn, 1971.

Der Bundesminister für wissenschaftliche Forschung (BMWF), *Bedingungen für Zuwendungen an Unternehmen der gewerblichen Wirtschaft (BMWF 1969)*, Bonn, 1969.

Der Senator für Wirtschaft Berlin, *Investieren-Produzieren in Berlin*, Berlin 1971.

Dölle, Prof. Hans, *Erfinderregelung in der Max-Planck-Gesellschaft*, Hamburg (undated).

Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung, e.V., *Beispiele angewandter Forschung 1970/1971, Jahrbuch der* Fraunhofer-Gesellschaft, München, 1971.

______________, Empfehlungen der Kommission des Bundesministeriums *für Bildung und Wissenschaft zur Förderung des Ausbaues der Fraunhofer-Gesellschaft*, München, 1971.

______________, *Satzung*, München, (undated).

Garching Instrumente Gesellschaft zur industriellen Nutzung von Forschungsergebnissen mbH, *Garching Instrumente*, Garching (undated).

Geimer, Reinhold and Geimer, Hildegard, *Science in the Federal Republic of Germany - Organization and Promotion*, Deutscher Akademischer Austauschdienst, Bonn-Bad Godesberg, 1971.

Gerwin, Robert, *MPG - Die Max-Planck-Gesellschaft und ihre Institute - Porträt einer Forschungsorganisation*, Max-Planck-Gesellschaft zur Förderung der Wissenschaften, e.V., 1972.

per year) for the promotion of new marketable products and/or procedures which would require a high financial risk for industry. This support goes mainly to small- and medium-sized industries. It will be given only in those cases where, without the support, the new product would not be introduced or would be introduced too slowly.

Support for projects in New Technologies is budgeted in 1972 at almost $60 million by the BMBW. Since the projects supported by this program are usually funded by industry in equal shares with government, it is estimated that expenditures in excess of $120 million will be made in 1972 as a result of the promotion of Technological R&D.

By expanding this program, which is designed to strengthen the industrial innovation potential and emphasize the promotion of applied R&D in the public interest, the government hopes to develop, on a scientific basis, the technological capabilities necessary for the solution of problems which will concern tomorrow's society.

- technological R&D for public administration, including

  --technical and scientific R&D in the fields of environmental protection and structures, particularly procedural and measuring techniques

  --technical components and systems for traffic and transport

  --new communications systems

  --biomedical techniques

  --biotechnology.

- research into the application of technology in biology and medicine, including

  --biological bases for biotechnology

  --medical bases for medical technology

  --ecological, chemical and toxicological bases for the protection of man and his environment

  --the biological and medical consequences of technical innovations.

Individual projects, which are most often initiated by industry, are selected (by procedures described earlier) and funded. Support is usually provided in grant form equally funded by government and industry, with the stipulation that the recipient must be willing to cooperate with other industries or scientific institutions.

In the category of industrial innovation, projects are currently supported in the physics-based technologies, such as semi-conductors, measuring and regulating techniques, applied optics (to replace the photographic optics business lost to Japan), cryogenics, super conductors, etc. Activity in chemistry-based technologies is just being started, generally in relation to environmental problems. Materials technology projects are supported in the areas of special metals, alloys, sintered and combination materials, ceramics with special magnetic, electrical, optical and corrosion-resistant properties, and procedures for production, processing and testing materials. Electrochemical-catalytic energy

- utilization of knowledge about the interrelationship between the ocean and atmosphere;

The program is still in its infancy, but some progress has already been made. The results to date include:

- intensification of basic research;

- extension of research potentials;

- increased knowledge of the effects of pollutants on marine life;

- new measuring techniques for marine environmental conditions;

- investigations of manganese nodules, ore sludge and mineral soap deposits;

- determination of biological bases for marine aquaculture;

- studies of measures for improvement, rationalization and automation of ocean fishery technology;

- measurements on sea motion for improved weather and coastal erosion prediction; and

- new knowledge on sand movements in coastal waters of the FRG.

Programs for the future include construction of new research vessels, development of marine environmental measuring networks, research expeditions for the investigation of mineral and fish resources, and studies through international cooperative programs.

The annual level of BMBW funding is increasing as the program progresses. Overall, $19 million were expended in 1969, including about $2 million of BMBW funds. The 1972 Federal budget allocates $28 million for oceanography of which the BMBW share is $13.5 million.

6. Technological Research and Development Program

A program to promote projects related to modern, growth-oriented technologies and fields which are expected to be on all levels. Research at the universities is to be advanced, and a supraregional research program "Informatik" (computer science) is to be expanded. This research program will be jointly financed by the Federal and State governments and, in cooperation with the Federal-State Commission for Educational Planning, will serve as the mechanism for improving special training of data processing personnel and the inclusion of data processing training in the curricula and programs for other scientific disciplines.

The use of data processing by public authorities is to be considerably increased in order to achieve rationalization and efficiency. Demonstration projects include the use of data processing in the German Patent Office, the investigation of crime, medical diagnoses, regional planning and the establishment of data banks.

The lack of standardized software packages had led to costly development of individual programs within industry. Industry is being encouraged to overcome this lack of development in order to bring about, as quickly as possible, a rationalization in a larger number of industrial firms through the application of data processing. Support for the development of application-oriented software is provided by the BMWF.

The development of large computer systems is to receive increased support since this will contribute to the overall knowledge of computer systems. Also, the smaller- and medium-sized industrial firms may use large computers for remote processing in order to increase their efficiency and rationalization. (Small-company owned computers could not be utilized efficiently.) The market for terminals and remote data processing installations will be more easily opened up for industrial use if appropriate facilities are available.

In addition to the support provided by the four Federal Ministries, supplementary programs will be undertaken in cooperation with the States, the DFG and the German Postal Service. These programs will cost about $280 million between 1971 and 1975. The bulk of these funds will be used to procure computer installations at universities, research programs for digital communication transmission systems and semi-conductor electronics, and reorganization of the Telex and Gentex networks. The DFG effort for these programs relates to the establishment of regional computation centers equipped with third-generation computers of domestic abreast of the standards of the leading countries of the world, enabling the industry in the FRG to become an equal partner in international cooperative programs.

The main effort is directed toward international projects, such as the AIRBUS A-300B and the VFW 614, which bring not only technological advantages, but also access to share in the world aviation market. Some domestic effort has been directed to the development of improved helicopters and business-class jet aircraft.

Federal funds support 90 percent of the FRG share of the development costs of the A-300B project and industrial funding makes up the balance. The helicopter and business jet aircraft projects are funded equally by industry and government. Since 1963, an estimated $300 million have been expended in support of civil aviation.

By means of an advisory committee composed of representatives from industry and research, the Federal government is currently preparing a program for aviation research including infrastructure, aerodynamics, flight mechanics, air frames, propulsion and equipment. When completed, this program should establish clear priorities in the aviation field and help to coordinate long-range research projects with a view toward future possibilities of industrial application.

4. Data Processing Program

Data processing was chosen as the third "big science" program to be vigorously promoted by the Federal government in 1967. The First Program (1967-1971), in reaction to the domination of the computer market in the FRG by foreign firms (principally U.S.), was directed toward the scientific, technological, and industrial development necessary to establish a domestic computer capability. Almost 60 percent of the funds went into industrial R&D. The remainder was used to establish working groups for the development of data processing applications, to create the Society for Mathematics and Data Processing (Gesellschaft für Mathematik und Datenverarbeitung, GMD), 58 research groups on computer science (Informatik) at 13 universities (within the framework of supraregional research programs) and four regional computer centers to meet the immediate needs of science.

The GMD is a non-profit corporation and receives three-quarters of its funds from the BMBW; the remainder comes had the scientific objective of performing extraterrestrial research and the economic objective of the application of satellite technology for telecommunications, television, navigation and weather prediction. In addition, cooperative programs in launcher development were undertaken through the European Launcher Development Organization (ELDO). These projects are included in the mid-term space program covering the period 1969 to 1973. Federal funding which amounted to $88 million in 1969, is expected to increase to $140 million by 1973.

Similar to the nuclear energy program, the space program is also implemented by means of non-profit corporations. The German Research and Experiment Establishment for Aviation and Space Flight (Deutsche Forschungs- und Versuchsanstalt für Luft- und Ramfahrt, DFVLR) includes all non-teaching, non-industrial aeronautics and astronautics research institutions into a single big-science establishment. The DFVLR plans and performs research projects, establishes and operates large testing facilities, serves as an advisor to government and trains scientists in cooperation with the universities. Independent research is carried out, as well as work requested by the Federal and State governments at five research centers operated by the DFVLR. These research centers include about 30 institutes and nine independent departments and working groups. The DFVLR is almost fully funded by the Federal government, supplemented by the States. Until recently, the Society for Space Research (Gesellschaft für Weltraumforschung, GfW), almost completely government-owned, handled the operational and technical aspects of the space program under supervision of the BMBW, implementing policy and translating it into action through supervision of contracts placed with private industry and non-profit organizations. The GfW has been incorporated into the DFVLR as the Section for Space Flight Projects (Bereich für Raumflugprojekte).

The German Society for Aviation and Space Flight (Deutsche Gesellschaft für Luft- und Raumfahrt, DGLR) promotes all aspects of aviation and space flight, mainly through exchange of experience between scientists and technologists (including the cultivation of international contacts). The bulk of the operating funds of the DGLR are supplied by the Federal government, with the remainder coming from the States and private sources.

per establishment per 15 year interval. The government also guarantees the loans secured by the industrial owners. To date, three prototype plants have been constructed at a cost to the government of about $11 million and electricity is being produced at competitive prices. Two plants show a profit, while the losses of the third are due to mechanical problems.

The Federal government is fully funding the area of experimental reactors. The goal is development of fast breeder and high-temperature reactor systems which will be utilized to generate electric power at considerably lower rates than is now possible.

The fuel cycle investigations are directed at uranium prospecting and ore processing technology, methods for enriching fissionable material, development of new types of nuclear fuel elements, reprocessing of irradiated nuclear fuel, flux control of fissionable materials and storage of radioactive waste.

To assist in uranium prospecting, Federal loans are available covering 75 percent of the cost. If a strike is found, the loan must be repaid unless the firm is willing to expend twice the original sum on additional prospecting. If no strike is found, the Federal government may excuse repayment.

Since 1956, the Federal and State governments have expended in excess of $3 billion on the three nuclear energy programs. About 40 percent has been used for R&D by the nuclear research centers; about 20 percent has provided for basic research; and the remainder has been spent on reactor development, the fuel cycle, experimental facilities, radiation protection and safety, and for FRG participation in international organizations, such as EURATOM, CERN and IAEA.

The FRG is also active in multi-national cooperation in the field of nuclear energy, such as the construction of a 280 MWe prototype power station using a sodium-cooled breeder reactor with Belguim, the Netherlands and Luxemburg, and the development of a gas ultra-centrifuge procedure for the enrichment of U-235 jointly with Great Britain and the Netherlands.

F. Priority Programs Supported by the Federal Government

The Federal government supports a number of major scientific programs directed toward national goals, primarily through the BMBW. Some reflect earlier goals while those being started now are addressed to current needs. The first priority program was in nuclear energy, reacting to the achievements of the great world powers, as was true of the program areas for space research and data processing and, to a lesser degree, civil aviation. More recent programs are less reactive to outside influences and are directed more toward the solution of national needs in oceanography, technological research and development and environmental protection. This new emphasis demonstrates the growing importance of science and technology for the solution of problems having sociological implications.

1. Nuclear Energy Program

The program for nuclear research and technology began in 1956 with the objective of producing electric power competitive with fossil fuel generation as quickly as possible. A strong nationalistic feeling attended the initiation of the project.

Three programs were established for the periods 1956 to 1962, 1963 to 1967, and 1968 to 1972; a fourth program is currently in the draft stage. The objectives of the First and Second Programs were to bring the FRG up to international standards in nuclear research and to develop first generation nuclear power stations. It was decided to utilize American technology, and cooperative efforts were undertaken between American and German firms (viz., General Electric-AEG-Telefunken and Westinghouse-Siemens). These were abondoned when AEG-Telefunken and Siemens jointly formed a corporation (Kraftwerkunion) to produce nuclear power plants. The American firms withdrew,concerned that one firm's proprietary information could pass to the other through the partners in Kraftwerkunion.

Early in the program, research centers were established by the Federal and State governments to provide the basic knowledge which would be needed later for industrial application. In time, eight research centers were created, two of which are funded fully by the Federal government; the remaining six receive 90 percent of their funds from the Federal government and 10 percent from the government

- Subsidiaries of domestic firms located in West Berlin must employ at least 25 in West Berlin and perform the research and production in the city; and

- Subsidiaries of foreign firms are not eligible.

As with other government-financed support, the firms initiate proposals for research which are evaluated at a hearing with all firms present. The evaluating committee has distinctive representation since one of the objectives of support is to keep West Berlin economically viable. In addition to the BMWF, representation includes the Berlin Industrial Bank (to evaluate economic feasibility) the PTB and BAM (to evaluate scientific feasibility), and the West Berlin Senate (to assess the impact on the West Berlin economy).

The firm must be able to fund at least one-third of project costs, the remaining two-thirds coming from governmental sources. The maximum level of government financing is in the form of a 10-year, no-interest loan which must be repaid whether the project is a success or failure. However, if the funding is shared equally, the firm must repay the loan within 10 years at no interest only if the project is successful; otherwise, repayment depends on the financial condition of the firm.

Supported projects may extend for no more than 3 years. Funding may be used as high risk capital and for projects through prototype development. In special cases, first-series production is also included. Research results do not have to be published and patents arising from the research remain with the firm.

In almost 3 years of operation of the program, about 125 projects have been supported. About 50 projects have been completed and loans for 15 projects are currently being repaid. In excess of $5 million in support of the program has been either spent or obligated through 1975 by the government. The total R&D expenditure is almost twice this, since most firms fund one-half of project costs.

Many small- and medium-sized industries appear reluctant to use the program, due largely to the amount of information firms must furnish to obtain support. They are required to perform a self-evaluation of business practices and to state clearly the purpose for which support is requested. They must also submit quarterly progress reports and, if a project fails, must justify to the Chamber of Commerce why it did not meet its goals. The smaller firms are generally unwilling to apply with all this "red tape," hence attempts are being made to simplify requirements so that more firms will make use of the assistance.

to scientific or educational institutions is also tax free. Furthermore, such property gifts can be written off for purposes of corporate tax. Legal entities, associations of persons and estates which exclusively and directly serve science are not required to pay corporate tax, trade tax and real property tax, and their real estate is free of the land tax.

Grants from public funds in support of science are exempted from the income tax of the recipient. Also, scholarships provided by governmental or supranational institutions of which the FRG is a member and by certain private donors may be exempted from income tax by the recipient under specific conditions.

An individual's supplementary income from scientific activities, on application, is taxed at one-half the normal rate provided that the predominant part of this income is not derived from independent or free-lance professional work. All expenditures for research are deductible as business expenses for the year in which were spent.

In addition to the usual linear depreciation for wear and tear, a part of the capital investment for R&D equipment subject to replacement can be deducted during the year of acquisition or establishment and in the following 4 years. This additional deduction amounts to 50 percent for movable goods and 30 percent for immovable goods, such as buildings. However, at least two-thirds of a building must be used for the R&D activity in order to qualify, and the movable goods must be exclusively used for R&D purposes. An amendment to the tax law in 1969 extended these deductions to include down payments and partial construction costs for qualifying investment.

As an inducement for corporate R&D investment, another 10 percent deduction can be taken under the income tax law if the investment relates to:

- basic research;
- new methods or products; or
- the extension of methods or products of significant importance.

This 10 percent is in addition to the 50 percent and 30 percent deductions cited above.

A tax allowance of 60 percent is given for the support which industrial firms provide to organizations like the AIF.

may make licenses available to third parties. Ownership of patents and compensation for inventions are negotiated between institute and inventor if the research was performed at an Institute with FhG funds.

To facilitate the examination of patent applications, the FRG Patent Office introduced a deferred procedure in 1968. (Until then, all applications were automatically examined for patentability.) Each application is checked to determine whether the subject warrants a patent and commercial utilization, and a full examination may be requested within 7 years of filing. A fee (about $100) is levied to initiate an examination for patentability, forcing the applicant or third party to weigh the need carefully. In any event, the applicant preserves his legal position since the priority date is established by the act of filing, and he can determine the commercial exploitability over the 7-year grace period.

Alternatively, the applicant can request a novelty search at the time of application to assess the chances of being granted a patent. The fee of about $30 can be later applied toward the fee for examination. The deferred procedure has removed a considerable burden from the Patent Office by reducing the number of applicants requesting examinations.

4. Inventor's Rights

The rights of the employee inventors are protected by the Employee's Invention Law, which defines ownership and rights to commercial protection. Generally, if an invention results from work performed within or using an employer's facilities, the patent rights belong to the employer, who must immediately file an application. If he fails to do so, the right to file reverts to the employee.

The law distinguishes between job-related and "free" inventions. The former arise from the normal activities of the employee or the experience gained therefrom; they must be reported to the employer and may be claimed by him. Free inventions, which do not involve the employee/employer relationship, are the property of the employee and subject to whatever actions he deems appropriate. If the employee/employer relationship applies, the employee must report the invention to his employer, who must determine whether the invention is free.

If an invention stems from existing or proposed effort of a company, the employer has first option for utilization. However, and prices cannot be fixed as a result of the joint venture. The government often suggests strongly that joint ventures be undertaken.

For smaller firms, joint ventures permit the partners to improve technological capability and thus establish themselves on government qualification lists. Generally smaller firms which enter into joint R&D ventures are non-competing, for example, an electronics firm and one performing mechanical design combine to develop an automatic ticket-reading machine for an urban transit system. Neither partner fears competition from the other resulting from their joint enterprise. Such industrially initiated joint ventures are often the basis of proposals for government support; neither firm being able to make the proposal alone. The government sometimes initiates joint ventures, particularly for large projects like nuclear power generation. A non-profit corporation may be established at the direction of government, drawing on the expertise of several competing firms, even large ones. Financing is provided by government, industry and, occasionally, other branches of the private sector. In joint venture R&D, each partner shares equally in the subsequent utilization of any patents which result. Government may encounter some difficulty in establishing joint R&D ventures with larger firms because of their fear of losing the competitive lead from acting alone. However, the government's view generally prevails. Furthermore, since many joint venture projects are initiated at government suggestion and since the cooperating firms maintain corporate independence, the resulting effort is not in violation of laws restricting cartels.

2. Contract Research

Corporate profit from contract research is limited, by law, to 5 percent on most contracts and 7 percent on R&D related to national programs. A 5.5 percent interest rate is also allowed on project-related capital investments. Related advanced research, which is not directly within the scope of the contract, may be performed independently by the contractor and allowed as a contract cost item, the proportion being negotiable and usually ranging from 3 to 10 percent of the contract cost.

3. Patents

West German patent laws protect the rights of inventors and serve as an inducement for creativity and the rapid introduction of innovative ideas into industry.

For projects supported more than the 50 percent, the grantee must, on request, concede to a domestic third party, under the usual conditions, a non-exclusive and non-transferrable right of use of protective rights which have been created during the implementation of an R&D project. (The grantee can, however, be exempted from this clause by the BMBW.)

If the level of support is greater than 50 percent but less than 66 2/3 percent, this provision does not apply when the grantee himself is willing and able to supply the items or services to a third party within a reasonable time and under reasonable conditions, thus obviating the concession.

For use of a protective right resulting from a project supported in excess of 50 percent, the remuneration is determined only for that portion of the work on which the protective rights are based and which was financed by public funds.

The grantee is required to report to the BMBW any significant innovations or improvements made after completion of the project whenever the BMBW provided more than half the support. These reports must be made for six calendar years if support exceeded 80 percent; four calendar years for 66 2/3 to 80 percent and three calendar years for 50 to 66 2/3 percent.

A number of additional stipulations relate to patents, described in a later section. The net effect, considering requirements for publication of results and follow-on improvements, is that most firms seeking assistance from the BMBW provide half of the project cost.

b. Levels of Support

The BMBW support of science and technology is becoming increasingly important since the States are unable to provide adequate funding. The rapid expansion of new fields of science, redirection toward improving living conditions, and the growth of the universities has resulted in large increases in appropriations for the BMBW. For example, the 1971 budget of the BMBW showed a 24.4 percent increase over the previous year (to about $1.27 billion), and the 1972 budget indicates a 28.6 percent increase over 1971 (to about $1.63 billion). These increases also demonstrate the importance placed on science by the Federal government since no other ministry received budgetary increases of this magnitude.

Projects receiving more than 66 2/3 percent support must submit interim quarterly reports; half yearly interim reports are required for all other projects. The interim reports must include information on new inventions or innovations coming to the attention of the grantee, as well as significant departures from the original plan.

A final report and a summary thereof must be submitted, including information about any failures encountered during the course of the project. Any knowledge gained and other items developed for the project (such as computer programs and prototypes, with their descriptions) must be reported. In addition, the BMBW may request that all relevant scientific and technical documentation be submitted with the final report.

The BMBW reserves the right to publish information concerning the project, including both the final summary and the entire final report if support was greater than 50 percent; if 50 percent, only the final summary may be published.

Grantees who receive more than 80 percent support (at which level the BMBW essentially owns the results) are responsible for determining the status of adverse protective rights (i.e., patents, announced applications, and design patents). These would include the rights of the third parties which are integral to the grantee's project proposal or protective rights of the grantee (pertinent to the project) if availability to the BMBW is encumbered in any way. The grantee must carefully examine his own patent applications and those of third parties in order to determine whether making project results available to others would place BMBW in jeopardy, reporting to the BMBW the likelihood of using these protected rights. Furthermore, a grantee must report to the BMBW whether or not his own patents, used in relation to the project, are encumbered in such a way as to prevent granting free, irrevocable and nonexclusive rights to utilization to the BMBW.

A grantee must immediately exercise his rights when the effort of one of his employees results in an invention. (The employee/employer relationship is described in the section on Patents.) When an employee makes a discovery, the grantee may apply for the patent at his own expense, and the BMBW may announce the discovery as soon as the application reaches the Patent Office. If the grantee is financially unable to apply or to pay renewal fees, he must report this fact to the BMBW, which can direct him to apply. In this event, the BMBW pays water (i.e. water works, water supplies, sewage, waste removal, etc.) devoting about 5 percent of its funds for these activities. Lastly, about 30 to 40 percent of the FhG funds, provide management assistance to industry.

5. Federal Ministry for Education and Science (Bundesministerium für Bildung and Wissenschaft, BMBW)

The BMBW plans and coordinates S&T activities, funds projects through organizations like the DFG and MPG, and also engages in funding projects directly.

The BMBW solicits proposals for the solution of particular problems through personal contacts and also receives unsolicited proposals. A committee of experts, consisting of independent scientists who are not necessarily connected with the BMBW, conducts an evaluation with all parties making proposals present and entering the discussion. In general, five to ten proposals are submitted and discussed at a review for a given problem but in rapidly growing fields, such as micro-electronics, as many as 40 proposals may be considered.

After a question period, the experts complete standard evaluating forms, summarizing their opinions and ranking the proposals. The individual evaluations are collated on a large standard form to facilitate selection. If the experts all agree in their evaluations and ranking, the selection process is finished; otherwise, the experts re-evaluate the proposals and repeat the comparison. Usually, about half of all proposals are accepted for funding.

The government is willing to support research for its own sake, including high risk projects as well as those close to the marketplace. In all cases, however, final product development following a supported project is the responsibility of industry. For this reason, the BMBW requires that the solicitor of project support reveal any R&D effort closely related to the proposed effort. In some cases (e.g., electronics), the BMBW requires that the proposer disclose his entire R&D effort. This information is to assure the government that the proposed effort will not be of direct benefit to other final development work being performed by the firm.

On occasion, the BMBW also supports parallel efforts by competing firms in order to obtain different approaches to a given problem. This procedure has been criticized as wasteful, by individuals in government, but the BMBW believes that it is and first series production. In some cases, Garching Instrument produces and sells the device. (Examples of items currently being produced and sold are tunable lasers, high-speed image converters and power supplies.)

4. Fraunhofer Society for the Advancement of Applied Research (Fraunhöfer-Gesellschaft zur Förderung der angewandten Forschung, FhG)

The FhG, like the MPG, operates its own research institutes of which there are 20, employing about 1,500. Whereas the MPG primarily performs basic research, the FhG is interested only in applied research and problems in the natural and engineering sciences. In a related area, the Institute for Technology and Innovation Research, established in May 1972, will study the mechanisms of industrial innovation, technology enhancement and technology transfer. The organizational structure and operational methods of the FhG are essentially the same as the MPG.

The FhG has more industrial representatives than do the DFG and MPG. Furthermore, its Institutes are more autonomous than those of MPG, more than half having their own Boards of Directors. These Boards have representation from industry in about equal numbers, (including the large industries), the State governments, and universities. Direct industrial participation assures that needed areas of industrial research are introduced into the programs of the Institutes. Personal contacts are paramount, with industrial and State liaison maintained through the Institute Directors.

The FhG performs much more contract research than the DFG and MPG, its customers including not only industry, but also the Federal and State governments. The individual Institutes are responsible for securing a substantial portion of their own funds. It is expected that funds will be derived equally from three sources; industrial contracts, contracts with Federal and State governments, and a share of the fundamental budget provided by the BMBW.

In the past, a substantial number of Federal contracts were obtained from the Federal Ministry of Defense, but this number is being reduced. The research effort which had been expended on defense contracts is now being redirected into such fields as air and water pollution control. These fields were selected not only because of talents within the institutes, but for the more important reason that they require work in areas which presently have few industrial customers.

As is customary, all research results must be published in the open literature. However, to the extent that contract research for

Max Planck Institute for Plasma Physics, which has almost 1,000 employees (of which about 200 are professionals), and the smallest is the Max Planck Institute for Astronomy, with less than 40 employees, 13 of whom are professionals. Due to the size and diversity of the MPG, its Senate has experienced difficulty in eliciting participation from the scientific members in directing the society and in evaluating and controlling the overall research effort. In the past, the President and Vice Presidents have reviewed the scientific publications of the Institutes when they appeared and, in addition, have examined the biennial research reports submitted by each Institute. Based on these reviews, the officers and their advisors then attempted to evaluate the research effort and to redirect programs in areas of weakness. This method has not been wholly successful, therefore, starting in the Fall of 1972, each Institute will have its own scientific committee to monitor and evaluate the research effort. Evaluations will be forwarded to the President; assisted by special advisory committees from the Senate, he will reevaluate the effort in light of the overall goals of the MPG. The President and the Senate will then be in a better position to make program adjustments.

When a new field develops in which research must be performed, the Senate determines whether there is a university research center which is qualified and equipped for the needed effort. If not, the Senate has the best qualified group of scientists assembled and recommends the formation of a new Institute, which is then established if representatives of the WR and the BMBW concur. In recent years, the number of Institutes has remained constant although the number of employees has increased.

The MPG, when re-established in 1948, was funded primarily by the States in which its Institutes were located. In 1964, renewal of the Königstein Agreement permitted the Federal government to assist the States in financing the MPG on an equal share basis. With the States having difficulty in providing the needed funding, the ratio of Federal-State support may be changed to 75-25. The States will undoubtedly retain a share of the funding and thus maintain some influence over the research performed in their territory.

About 72 percent of the total receipts of the MPG come from the Federal and State contributions. The balance of the funds are derived from contract R&D supplied by the BMBW or from foundations and the SV. The MPG submits its budget

In connection with these programs, one of the functions of the WR is to establish those areas which are of sufficient importance to warrant priority rating. Recommendation by the DFG is necessary before the WR will recognize a special area of research. The criteria used by the DFG for reaching a decision on which to base a recommendation are:

- a guarantee that the research will be pursued continuously on a long-term basis, usually about 10 years;

- a research program of sufficient importance must already have been developed;

- basic equipment, such as instrumentation and libraries, must already be available; and

- the special research area must be scientifically and/or socially relevant to national needs.

To date, approximately 150 special areas of research have been recognized as necessary, and about 100 of these have been recommended to receive funding. All research results must be published in the open literature. Further, no repayment of grants is expected since the supported basic research provides the new knowledge which will eventually be utilized in the production process. There is one exception, however, in the event that a discovery is patentable. Should a patent be obtained and eventually licensed, the DFG may get some return on the grant through license fees. Finally, title to any equipment purchased in connection with a supported project is held by the DFG and not the research institute.

3. Max Planck Society for Advancement of the Sciences (Max-Planck-Gesellschaft zur Förderung der Wissenschaften, MPG)

The MPG, also a non-profit corporation, differs from the previous two organizations in that it operates 52 research institutes which implement research. Like the DFG, projects are implemented primarily by means of grants from public funds supplied by both Federal and State governments. Also, all research results must be published in the open literature.

Some differences in organizational structure stem from the existence of the MPG research institutes, yet the same basic features remain. The Member's Assembly, composed of the research scientists of the institutes together with sponsoring and honorary

b. Public Information Program

In addition to the coordination and administration of grant support, the AIF carries out a program of public relations related to industrial research. Although this program is a new and small part of the AIF activities, it represents an attempt to publicize the programs and results of cooperative industrial research to Parliament and the public at large. This includes preparation of non-technical articles for use at the local and national levels (for example, through newspaper and magazine articles, respectively). For the benefit of the scientific sector, technical reports are published in the open literature.

2. German Research Society (Deutsche Forschungsgemeinschaft, DFG)

The DFG is a non-profit corporation which neither owns nor operates laboratories, but which implements basic research performed at university research institutes. It provides grant support with public funds derived from both the Federal and State governments.

The DFG is larger than the AIF and has a more complex organizational structure. It, too, has a Members Assembly which elects a Senate of 33 members and an Executive Committee. The latter represents the DFG corporately while the Senate, equivalent to the Scientific Council of the AIF, directs the operation of the organization. A Board of Trustees is composed of all members of the Senate, six representatives of the Federal government, one representative from each State, and five representatives of the SV. The Board of Trustees also forms part of the Executive Committee.

The Main Committee (Hauptausschuss) consists of 29 members of the Board of Trustees, with representation from each sector indicated above, and is equivalent to the Approval Committee of the AIF. There are also groups of "assessors," or committees of experts, elected by secret ballot to evaluate proposals.

The DFG makes available both normal procedure grants (Normalverfahren) and priority procedure grants (Schwerpunktverfahren). The former recognizes that creative research work is highly dependent upon the skills of individual scientists. Therefore, a scientist who wishes to have a research project supported submits a proposal with a cost break-down as described earlier. This type of grant has a maximum of 5 years allowable for obligation of funds and completion of the project (in contrast to the 3-year maximum for an AIF grant). This acknowledges that basic research problems generally require more time for solution than do applied research problems.

and economic aspects of proposed projects, including their cost-effectiveness. Projects may be rejected for non-technical reasons, such as limited benefits for the industrial sector, economic infeasibility, or too little support from the sponsoring research association.

After a proposal has been evaluated, a recommendation is made to the Approval Committee, which makes the final decision at its semi-annual meeting. Approved projects are supported equally by the requesting research association and the AIF.

Funding for AIF-supported continuing industrial research projects is obligated for 1, 2, or 3 years maximum. The level of funding and time period are fixed at the outset of a project and remain unchanged thereafter. Supplementary funds can be obtained to purchase equipment if the need was not anticipated when the project was established.

If a supported project yields a promising side line of research, a new proposal must be submitted, using the above procedures: the original proposal cannot be amended to increase either its scope or funding. However, the research association is given some leeway in adjusting expenditures while remaining within the specified limit. Thus, an association may have an overrun not to exceed 10 percent within one of the cost areas (e.g., salaries, equipment, overhead, and subcontracts) and balance it in another area without having to seek approval from the AIF. Any overrun in excess of 10 percent requires AIF approval before balancing. Furthermore, any equipment purchased with support funds becomes a part of the inventory of the DFG.

In general, the research association and the AIF share equally in the cost of a supported project, the AIF obligating (and thereby guaranteeing) funds for the entire period and at the level approved in the proposal. The AIF deposits funds for a project in a commercial bank from which the research association makes bi-monthly withdrawals to cover the effort of the previous 2 months.

An annual progress report is submitted to the AIF for review by the Scientific Council, and each year, based on this report, a decision is made whether or not to continue the project. A final report must also be published upon the completion of a project, giving detailed results of successes and failures and providing such items as computer programs and detailed descriptions of prototypes developed.

The member firms produce about 75 percent of the gross product of the FRG related to these industrial sectors. (The AIF does not cover the chemical and electrotechnical sectors which, because of their size and wealth, have their own R&D facilities.)

The AIF and each of its member associations are non-profit organizations. Each member association pays an annual membership fee to the AIF of about \$300 to \$1600, depending upon its own research budget. An additional fee is levied, based on the amount of grant support provided to the member association through the AIF; it is currently set at 2.7 percent.

The purpose of the AIF is to foster and assist in funding cooperative research performed by member associations. The AIF neither fully funds research programs of member associations nor does it directly control their R&D budgets. However, each association is required to submit a yearly statement detailing its entire research program.

The AIF is organized into six main groups: the membership, the Board of Directors, the managing office, the Scientific Council, the Experts; and the Approval Committee. The membership group, made up of the representatives of the 76 member associations, meets annually to elect or delegate members for the Board of Directors and Scientific Council; to approve corporate decisions made by the Board of Directors; and to discuss matters of importance. The FhG and the SV, among other parent organizations, are extraordinary members of the AIF.

The Board of Directors (Präsidium) appoints the staff of the managing office and the experts. High ranking representatives of the DFG, FhG and SV are "guest" members of the Board of Directors. The Board President represents the AIF corporately, interacting with representatives of the BMWF, BMBW and other "parent" associations of industry within the FRG on matters related to university, applied and cooperative research and the promotion of R&D in industry by the States. These interactions involve recommendations related to overall planning by the Federal and State governments in support of cooperative and industrial research, as well as methods for implementation.

The Scientific Council (not to be confused with the WR), composed of about 100 leading scientists from university and industrial research centers, directs and coordinates the technical activities of the AIF and forms the reservoir of scientific personnel from which part of the group of experts is drawn. The group of experts, equally representing scientists and industrial specialists and numbering about 80, are divided into six major expert opinion groups (Gutachtergruppen), or committees of experts.

and operation of bodies for planning and implementing scientific activities, and considerations pertaining to joint ventures, inventor's rights, patents and taxes.

B. Mechanisms for Implementing Science Policy

A major mechanism for implementing science policy is the "committee of experts," composed of the most highly respected and most knowledgeable individual scientists in a given field. The individual scientist may also serve focally as a connecting link between organizations by virtue of personal contacts. A third major mechanism, the research organization itself, encompasses the previous two. The activities and interactions of these mechanisms are fundamental to the implementation of science in the FRG.

1. Committee of Experts

Under various names, perhaps, almost every organization, whether Federal, State or private and regardless of level, relies for guidance on a group of recognized experts. Specific committees are usually formed from a sizable pool of experts established within an organization and comprising, insofar as possible, all areas of interest to that organization. A group might typically consist of representatives from education, industry, professional societies, private institutions and governments. For a particular problem, an ad hoc committee, composed of the most knowledgeable individuals from relevant sectors, would be selected to examine all facets of the problem. The results of the committee's deliberations would be forwarded to those responsible for making the decision or for forwarding a recommendation to a higher echelon. In some cases, a minority opinion may also be submitted to assure the availability of a complete representation of the deliberations when final actions are to be taken. In other cases, unanimity of the committee is required.

The nature of committee recommendations or decisions depend on the parent organization. For example, recommendations may impinge on policy, measures to improve the science structure, the selection of projects to be given support, or levels of funding for various programs. The heterogeneity within committees almost guarantees that all relevant points of view will be given consideration during the deliberations. Moreover, it is not uncommon for experts to serve on several committees of the same organization or on committees of several organizations. This promotes an interchange of opinions, information and ideas, transcending the organizational structure and providing a means for coordinating activities within and between organizations.

nuclear energy, industry is dependent on government support. Other industries, with the exception of modern ground transport systems, prefer independence. The industrial view toward government support considers such factors as the amount of capital a firm has to invest in R&D, the time required to gain a return on its capital investment, and the amount of capital required for a given project. Depending on its strength, one firm may desire the support which another may wish to avoid. In the case of a very large project which is beyond the means of a single firm, a large well-established firm will usually choose to seek a financially reliable multi-national corporation as a partner rather than have government as a partner. Under comparable circumstances, a smaller, newer firm would most likely accept the government as a partner.

With respect to the outflow of technology, industry feels that government may be too liberal. Industry would rather accomplish the outflow through export of manufactured items instead of through the sale of technology. Moreover, industry objects to the requirement to publish information about the results of supported projects. It is felt that proprietary technology is often involved and thus is made available to competitors. There is also widespread feeling that too small a proportion of public funds reaches the industrial sector, the bulk going to public research institutions.

The government recognizes that national priorities cannot be shifted abruptly if a viable industrial sector is to be maintained. Older projects closely related to earlier national needs continue to receive support, with modest increases of only 20 to 30 percent over a budget period of several years. In contrast, new projects which are deemed to conform to newer national priorities generally receive enormous increases, between 100 and 200 percent over the same time period. Thus, the government helps to maintain a good relationship with industry through close interaction and support, continuing older projects (perhaps with redirection toward newer needs) while building up competence in new areas and directing industrial effort toward national goals.

Federal Ministries. As further examples of the elaborate intertwining, it may be noted that the president of the KMK also serves as president of the educational commission of the DBR; representatives of the WR and the DBR are consultants to the BLKB; the DFG, MPG, and WRK recommend scientists for appointment by the Federal Chancelor to the science commission of the WR; the MPG, FhG and AIF are each members of the DFG, and the SV is represented in the management of the MPG and the FhG; representatives of the DFG and AIF serve on the research advisory council of the FhG; the managing directorate of the AIF presently includes the president of the BAM as a member as well as the president of the FhG and the general secretaries of the DFG, FhG and SV as "guest" members.

By means of this complex inter-representative mechanism, coordination is achieved. The mechanism also serves to direct the funds in support of science, derived from Federal, State, industrial, foundation and donor association sources and allocated by the DFG, MPG, FhG and AIF, in such a way as to meet overall national goals.

C. Government-Private Sector Relationship and Interaction

The structure of the industrial complex, dominated by a small number of large firms, is a major factor influencing government-private sector relationships. The government has difficulty in distributing support to firms other than the giants of industry. These are well-equipped and qualified to perform R&D, whereas the smaller firms generally lack such ability. Furthermore, if government supported all firms equally, regardless of size, the market for sales would be unable to support the resulting competition. The government also realizes the need to limit support to selected technological areas and, through that support, to direct technology toward specific national needs.

The general philosophy which prevades government support of projects has several distinctive features. For example, in order to receive support, a firm must be able to take the initiative, that is, it must be able to assume a part of the cost of the project. It is intended that new technology resulting from the supported project, including patents and information, remain in industry for further application. In many cases, the government insists that all information and results related to supported projects be published in the open literature so that all firms can benefit. In addition, once a firm has established capability in a particular area, through either industrially initiated projects or supported projects, the government feels obligated to provide additional projects as a means of maintaining specialized teams and desirable capability within the firm.

research problems should be investigated further; furnish advice concerning industrial research problems and direct investigations; procure and distribute funds in support of industrial research; and provide legal protection and evaluation services for research results and inventions.

About 70 percent of the funds available for allocation by the FhG come from the Federal government, through the BMBW, the Ministry of Defense and the Ministry for Housing, and the State governments. The balance comes from private contributions, donations and contract research placed with the institutes by industry. In 1970, the last year for which data are available, the turnover of the FhG was about $20 million. Several of the institutes get as much as 70 percent of their funds by contract research with industry.

Representation in the governing group of the FhG includes renowned individuals from industry and public life who are close to applied research and its promotion, in addition to federal, state and scientific representatives.

The FhG is currently being strengthened as the "parent" organization for applied research. The Federal government hopes to provide thereby a mechanism for the rapid transfer of new knowledge into industrial production on a widespread basis. It is the intent to benefit all industry, but particularly the small- and medium-size firms which do not have their own research facilities.

The Confederation of Industrial Research Associations (Arbeitsgemeinschaft Industrieller Forschungsvereinigungen, AIF), is the "parent" organization for industrial research. Membership in the AIF is restricted to industrial research associations (76 at present) which represent almost all branches of FRG industry except electrotechnical and chemical. These member associations are non-profit groups which were founded by their member companies. The functions of the AIF are to finance research projects of member associations, coordinate projects, provide the forum for exchange of experience between member associations, advise on the establishment of new industrial research associations and serve as an intermediary between the associations and the governments.

The AIF receives about two-thirds of its funds from industrial contributions and fees. The remainder is supplied by the Federal Ministry of Economics and Finance. The former amounted to $37 million in 1971, while the latter was about $10 million.

WR, the DBR is a high level organization representing leading educators, appointed by the Federal Chancelor and high-ranking federal and state officials.

The most influential advisory body for educational matters is the Federal-State Commission for Educational Planning (Bund-Länder Kommission für Bildungsplanung, BLKB). It was established in 1970 through joint Federal-State agreement and, like the WR and the DBR, is composed of high-ranking federal and state officials, as well as consultants from the WR and the DBR. It is in this body that all questions of common importance to the Federal and State governments on educational matters and research promotion in the education sector are deliberated. It is here that the long-range plan for the entire educational system is developed, together with plans for implementation. In all of these deliberations, account is taken of Federal government plans for special fields and the recommendations of the DBR and WR, as well as other organizations of state officials. Through the work of committees, the budget for the entire educational system is developed. One of these committees deals only with matters of research promotion at the university level and the establishment of the budget to implement this research.

5. Private Sector Research Promotion and Implementation Organizations

Through the mechanism of privately operated non-profit organizations which are substantially funded by the Federal and State governments, science policy is implemented. These organizations also serve in an advisory and coordinating capacity. In each organization, the Federal and State governments are represented along with leading scientists. Each has autonomy in the allocation of public funds transferred to it.

Chief among these is the German Research Society (Deutsche Forschungsgemeinschaft, DFG), which serves as the central organization for the promotion of science. Its primary functions are to finance research projects, support the training of scientists, enhance cooperation between research workers, and serve as point of contact for research units within the industrial sector. It maintains contact with numerous foreign scientific organizations and also represents the Federal government in non-governmental international organizations. It is also a major advisory body to both Federal and State governments.

Membership in the DFG is restricted to legal entities, such as universities and other research associations and societies

The states generally direct their attention to educational matters. There are two coordinating bodies, functioning primarily at the state level, for educational programs. Each focuses a part of its attention on matters related to research performed in the universities. These are the Permanent Conference of Ministers of Education and Cultural Affairs of the States in the Federal Republic of Germany (Ständige Konferenz der Kultusminister der Länder in der Bundesrepublik Deutschland, KMK), and the West German Rectors' Conference (Westdeutsche Rektorenkonferenz, WRK). The former deals with educational policy of supraregional importance, while the latter concerns itself with problems of common interest to the institutions of higher learning related to teaching, research and training. The latter body also serves in an advisory capacity to both the Federal and State governments and, because of its intimate knowledge of academic affairs, its recommendations generally carry considerable weight during governmental deliberations.

3. Research Establishments Operated by Federal and State Governments

In addition to planning and coordinating activities, the Federal and State governments are actively engaged in research performed at in-house establishments which they operate. Most of the in-house research performed by the Federal Ministries, is of little interest to this study. The most important activities which are of interest are operated by the Federal Ministry for Economics and Finances (Bundesministerium für Wirtschaft und Finanzen, BMWF) namely the Federal Physical-Technical Establishment (Physikalisch-Technische Bundesanstalt, PTB) and the Federal Establishment for Materials Testing (Bundesanstalt für Materialprüfung, BAM). The former is the equivalent of the U.S. National Bureau of Standards, while the latter is concerned with the properties of materials of importance to industry and science. The Federal Ministries for Transport, and Post and Telecommunications operate a number of establishments performing research in civil aviation, particularly safety, general communications research and automation technology for the postal services.

The BMBW performs its research at extramural installations, generally in cooperation with one or more of the states. These are generally formed as non-profit or limited liability companies working in the priority program areas of nuclear energy, space and data processing. There are also over 100 research establishments operated by the State governments, but most are of little interest to this study. However, some perform research in astronomy, data processing, oceanography and applied spectroscopy.

oceanographic research, technological R&D associated with public tasks or related to industrial innovation, research in areas which interface technology with the medical sciences, and research in environmental fields. The BMBW also provides the federal share of funds contributed for the operation of research establishments of supraregional importance (such as the institutes of the Max Planck Society) and for new construction and expansion of universities.

The BMBW is composed of five large divisions, concerned with:

- administration and international cooperation;
- educational planning and universities;
- research planning and technological research and development;
- nuclear technology and data processing; and
- space research and technology and aeronautical research.

In addition to the mission-oriented divisions, a separate staff is responsible for science planning, including educational matters, and for coordinating problems arising in science promotion.

The BMBW is assisted by a number of advisory bodies for planning and coordinating programs. The Advisory Committee for Education and Science Policy (Beratender Ausschuss für Bildungs- und Wissenschaftspolitik) is the main advisory body. It came into being as a result of a recent reorganization of the advisory system of the BMBW. Science policy is the prime interest, but the Committee will now consult on questions of educational policy, particularly as they relate to science policy. Membership currently represents scientists, university professors, industry and trade unions.

In the same reorganization, three large advisory bodies were abolished and replaced by four small committees to serve in the fields of nuclear research and technology, radiation protection and safety, space research and technology, and data processing and documentation. Similar committees in the fields of the new technologies and aeronautical research functioning prior to the reorganization continue to exist. In addition, large advisory bodies exist for some fields of interest, for example oceanography.

The reorganization of the advisory services to the BMBW also provides for continuing service by existing or new committees influenced by the competitive efforts and technological achievements of the great world powers. As the re-establishment of the educational, research and industrial base was accomplished and experience was gained by means of these initial programs, efforts were concentrated, particularly at the Federal level, on the development of a national science policy. Specific emphasis was on support of priority areas and programs in anticipation of future social and economic developments. Recently, the science policy has been redirected toward the greater application of science and technology to fields which not only contribute to the economic efficiency and international competitive position of the FRG, but which are at the same time of major importance for the improvement of overall living conditions.

B. Organization for Science and Technology Policy Development and Implementation

Due to the division of responsibility for science between the Federal and the semi-autonomous State governments, and the all-inclusive character of science in the German context, a number of organizations are concerned with the development and implementation of science policy in the FRG. A science structure has evolved in which education is inseparable from basic and applied research in planning and implementation, with strong interactions between areas. The large number and diversity of organizations within the structure also necessitate coordination of activities in all sectors. The need for improving coordination is well recognized, and the methods to be used for achieving it are under continual review.

The actual structure for planning and implementation includes governmental bodies, advisory and consultative organizations and autonomous institutions which are privately operated, yet publicyly funded. The organizations within this structure are multiform and their interrelationships complex, hence it is difficult to delimit responsibilities.

In order to facilitate description of the organizations for S&T policy development and implementation within the FRG, and their interaction, the discussion has been divided into seven groupings:

- planning and advisory bodies of the Federal government;
- planning and advisory bodies of the State governments;
- research establishments operated by Federal and State governments;

The largest proportion of financial support of science has been the responsibility of the State governments rather than the Federal government. Since 1949, about 68 percent of the total public expenditure for science, excluding defense, has been borne by the States. This includes not only education, but also the State support of local and supraregional research establishments. However, the amendments to the Basic Law and the increasing involvement of the Federal government in the support of science indicates a shifting of responsibility from the State governments to the Federal government in educational and related scientific matters. Because of the close coupling between education and research, this trend will undoubtedly influence the involvement of the Federal government in areas of applied technology as well as in areas of basic research.

Promotion of the priority programs in nuclear energy, space, aviation, data processing and, to a lesser degree, oceanography, has been under the direction of the Federal government since these programs usually transcend regional interests. These programs involve close cooperation and coordination of both research and industrial application activities. Generally, costly specialized facilities and multidisciplinary staff are required and these are not available at a single university research center or industrial firm. To overcome these problems, the Federal and State governments, either separately or jointly, have established a number of autonomous, non-profit or limited-liability companies to carry out research and application in these fields. These extramural establishments derive most or all of their funds from the Federal or State governments. In addition, Federal direction is necessary, since it is in these fields that the greatest emphasis on international cooperation is being placed. The importance of the government-supported autonomous companies and international aspects of the priority programs will be discussed in a later section.

The industrial complex is dominated by a small number of very large firms each of which is able and highly qualified to perform its own R&D. These large R&D intensive firms are concentrated essentially in three industrial groupings which in 1969 performed 86 percent of the total industrial R&D effort, namely: chemical and petroleum; automotive, machinery and steel; and electro-technical, optical and precision mechanics. The balance of the complex includes a large number of small- and medium-sized firms which generally lack, or have little, R&D capability. The Federal government carries out a number of programs for the support of industrial R&D with increasing emphasis on the encouragement of innovation, particularly by small- and medium-sized industries, and cooperative research by industries of all sizes.

though, the Western Sectors of Berlin are included in the FRG structure as the eleventh state. Moreover, it must be remembered that the states which now comprise the FRG as recently as 100 years ago, were autonomous states or principalities. Each had complete control of its cultural and educational affairs and, further, had established and maintained a number of scientific institutions. The first university within the present territory of the FRG was established at Heidelberg in 1386, and some of the scientific institutions date back to the mid-eighteenth century. The autonomous feeling of the States is therefore in tradition, and was manifested during the period of formation of the Federal government. It still affects Federal policy and legislative authority, hence, governmental involvement in science not only includes actions of the Federal government, but also those of the State governments.

Under the basic law, passed by the Constitutional Assembly in 1949, responsibility was jointly divided between the Federal and State governments in matters related to science. This was due in part to tradition, but more importantly was intended to avoid the impediments to educational and research autonomy resulting from a strong central government, as experienced prior to and during World War II. The State governments were given responsibility for education and science, including institutions of higher learning and research establishments, within the State. On the other hand, the Federal government was given concurrent legislative powers in the field of scientific research. However, Federal power is limited to those cases:

- where legislation by a State or States will not provide a satisfactory solution to an issue;
- where the action of one State will be detrimental to other States or to the Federation; or
- when it is necessary to maintain uniformity of legal status, of the economic system, and of living conditions throughout the States.

Several organizations have been established to enable the States to reach some accord on scientific and educational matters and to provide mechanisms for coordination of effort. Among these are: the Permanent Conference of the Ministers of Education and Cultural Affairs of the States in the Federal Republic of Germany (Ständige Konferenz der Kultusminister der Länder in der Bundesrepublik Deutschland); the West German Rectors' Conference (Westdeutsche Rektorenkonferenz); the Science Council (Wissenschaftsrat) and the German Education Council (Deutscher Bildungsrat). These organizations still influence education and science policy and will

SV	Stifterverband für die Deutsche Wissenschaft (Donors' Association for German Science)
WR	Wissenschaftsrat (Science Council)
WRK	Westdeutsche Rektorenkonferenz (West German Rectors' Conference)
VW-S	Stiftung Volkswagenwerk (Volkswagen Foundation)

This loan represented 25 percent of the total estimated cost of the project of reorganization. Specific goals for production, investment, and concentration were established.

According to reports in 1971, the production and concentration goals had been achieved and investments of approximately $1 1/3 million were only $100,000 short of that goal.

Government support for the industry continues, as illustrated by the major steel complex still under construction at Fos-Sur-Mer, near Marseilles. According to press reports, the government is expected to assume one-third of the total project cost estimated to be $1.2 billion.

5. Plan Mecanique (mechanical industry)

Formulated by the mechanical industry, endorsed by the government and incorporated into the Sixth Plan (1971-1975), Plan Mecanique is a multifaceted program designed to provide a favorable environment within which the mechanical industry can expand. The Plan includes a target real growth rate in output of 9 to 10 percent annually through 1975. To achieve this goal the industry must increase its investment by 12 percent per year from $440 million in 1970 to $780 million in 1975.

In order to improve domestic production in the mechanical industry, the government will make available increased credits to encourage expansion, modernization, or reform through several, as yet unidentified, credit mechanisms, in addition to supporting manpower training programs.

Since the machine tool industry is a key branch of the mechanical industry, the government plans to provide additional support by:

- establishing a program to train personnel in small and medium size firms in the use of special and advanced machine tools (e.g., numerical control equipment).

- making available special assistance to enable machine tool manufacturers to place in end-user plants, machines from trial runs made of new designs (prototypes), before those designs are put into mass production.

outset, at least, the objective appeared to be the establishment of an independent French computer industry. The impetus for this plan arose in 1964 with the failure of Machines Bull, the only French firm capable of producing large computers, and the refusal by the U.S. to grant licenses for exports to France of advance computers.

The plan was initiated in 1966 with the creation of an agency to coordinate a reorganization and expansion of the computer industry; the creation of an agency to train the necessary technicians; and the affiliation of two major French computer firms to form Compagnie International pour L'Informatique (CII).

An agreement between the government of France and CII was later signed whereby the CII would receive financial assistance in the form of a number of pilot projects amounting to $80 million, and a loan of $8 million, both over a 5-year period. Additional financing of $50 million was to be provided by private sources over the same period, with the State guaranteeing half.

In 1971, a second 5-year agreement was signed, providing for government assistance in the form of research grants to CII amounting to $140 million. Further support to CII is provided through preferential treatment in procurement by the government of France. This is significant considering that the preference extends beyond the usual government agencies to numerous nationalized enterprises in various industries.

While the success of the program is debatable, it is the opinion of one CII official that the plan is successful from a technical and a financial viewpoint, but not from the commercial standpoint. According to that official, CII was expected to produce a line of six computers by 1970, and production costs had to be such that the computers would be competitive price-wise; that was achieved. He felt that the plan is not yet commercially successful in that little attention has been paid to marketing. At present, CII has less than 10 percent of the total French market. IBM and Honeywell-Bull, their major competitors, have 60 percent and 20 percent respectively. The recent agreement with Siemens appears to be aimed at correcting the marketing deficiency.

- accelerated depreciation of the cost of construction of research facilities (i.e., buildings) is allowed up to 50 percent at the end of the fiscal year.[2]

- accelerated depreciation of the cost of research equipment is allowed up to 50 percent in the first year; the remainder of the cost can be amortized over the normal period of utilization.[3]

Despite these allowances, one government official involved in the study of government incentive programs did not seem to regard them as important from the standpoint of incentives. One explanation for this could be found in the opinion of this official that the tax advantage is not likely to be a deciding factor for any corporation considering an investment in research and development facilities or activities.

9. Societe pour le Financement de L'Innovation (SOFINNOVA)

Sofinnova is a private financial corporation created in January 1972, to provide venture or high risk capital for industrial innovation in small and middle-sized companies, and occasionally to private inventors. The innovations can be either in advanced technology or improvements to existing products, processes or services. The services Sofinnova will offer include: organizing small enterprises and buying shares in them; helping companies obtain loans from other sources; and creating a common subsidiary of two or more enterprises for the exploitation of marketable innovation.

Sofinnova with capitalization of $5 million has about 25 stockholders, including Credit Nationale, a quasi-public investment bank and 20 of some of the largest corporations in France. One U.S. venture capital corporation is a 10 percent shareholder. There are apparently two major reasons that the large corporations were willing to cooperate in the establishment of Sofinnova: to keep current with advances in technological innovation and to make a modest investment in innovation should Sofinnova prove successful.

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[2] Paraphrase from Memento Pratique de Contribuable 1971, Article 168, p. 135.

[3] Ibid, paragraph 163, p. 132.

Since there is no return to the government on its investments, it is difficult to measure the effectiveness of the program. It was implied that the availability of these funds required greater intra-industry cooperation, especially in the selection of one company to do the development work, and that this, in itself, was a worthwhile accomplishment. Generally, the development work is more concerned with procedures than with new products. The impression was given that the program is not considered to be of major importance, for the research involved is not the primary function of these Centers. This impression is supported by the fact that the government will spend only $1.2 million on the program this year.

6. L'Institut de Developpement Industriel (IDI)

Founded in 1970, IDI's objective as a financial institution is to accelerate the growth rate of French industry by temporary reinforcement of industries suffering from a lack of funds. Thus far, IDI has provided assistance totaling $50 million to 27 firms representing total sales over $600 million; 19 of the 27 firms had sales under $30 million, indicating a preference given to middle-size companies. The fact that IDI's funds have been and can be invested in increased research and development is merely incidental to its primary mission to improve productivity.

In order to qualify for assistance, a firm must have a quality team of directors, a developing market and a satisfactory cash flow. In other words, IDI will not help a company which is failing. If IDI decides to help a company, it does so in the following three ways:

- reinforcing the financial power, either through investing in shares or convertible bonds, while leaving the directors in complete control of business affairs;

- helping the company to obtain finances outside the Institute, either from the government or banks;

- counselling the management of the company on the problem of expansion.

IDI may also help the company to develop new companies abroad or to participate in multinational research efforts.

development of the Caravelle and in the computer industry, but there is increasing interest in this type of incentive.

Letters of Agreement are negotiated through the Directorate of Technology, the Industrial Environment, and of Mines (DTEIM), with final approval authority in the MDIS. Because the agreements do not require any initial expenditure (and might not require any at all), there is no fixed level of funding. However, demonstrating a renewed interest in the mechanisms, DTEIM will begin this year giving $2 million annually to the Caisse National Des Marches D'Etat (CNME) to be set aside specifically for Letters of Agreement.

Generally, a Letter of Agreement is initiated when the government has a special interest in the success of a project which a company is reluctant to undertake because of substantial initial investment and concomitant risk. By a Letter of Agreement, the government usually guarantees to the company the difference between actual sales and the company's break-even point if the sales are lower. In other words, the company is insured against loss. If the break-even point requires the sale of 100 aircraft, for example, and the company only sells 95, the government will buy the remaining five. The company will also receive the difference between actual sales and the break-even point even if it has not produced the required units.

In addition to the guarantee, the Letter of Agreement also serves as a method for obtaining low interest credit to help finance production. Considering that the company can suffer no loss up to the break-even point, banks are more willing to finance production up to that point, and at a lower than usual interest rate because there is no risk.

Letters of Agreement may also be given without any guarantee to the company. In this case, the bank from which the company with the Letter of Agreement seeks the loan requests the CNME to co-sign a note allowing that bank to acquire the necessary funds from a state bank at a very low interest rate. Essentially, the bank increases its working capital, and is therefore more willing to make the loan.

The fact that they are assuming a risk of non-payment by the company still induces reluctance on the part of the banks to make loans without a guarantee. It is this reluctance that DTEIM is trying to eliminate through the $2 million two-thirds of which will be government funds and the remainder from license revenue. The proposed budget for 1973 is $4 million, $1 1/4 million of which is expected to be derived from licenses. Eventually, this agency is expected to become self-supporting, relying solely on the income from licenses.

In order to establish a nexus between technological advance and industrial needs, ANVAR relies heavily on its scientific staff. It maintains contact with government and university laboratories to locate useful inventions, while at the same time keeping abreast of the needs of various industries. Inventions are also submitted by independent inventors and private laboratories, but the public sector is ANVAR's primary source of technology. Of the 1,000 files of possible inventions considered each year, only 250 are retained for possible use, and 200 of these are from government laboratories. This is significant in view of the fact that government laboratories account for only one-third of the files considered each year.

Once a good idea is found, ANVAR first determines if it patentable. This requires, that it be new and unpublished prior to the time the application for patent is made, that it be inventive in the sense that it is not an obvious technique, that it be complete, and that it be useful and applicable to reality. The requirement that the idea be unpublished has presented problems in the past where the inventor is more concerned with being the first to publish (thereby improving his standing in the scientific community) than he is in economic gain. Since no firm can acquire an exclusive license unless a patent exists, it becomes more difficult to find a firm willing to assume the cost of development and marketing of such inventions.

If the idea or invention is patentable and commercial applicability is identified, ANVAR proceeds with a market survey to determine the economic worth. If the market appears favorable, then ANVAR will file the necessary patent application either in its own name or the name of the responsible company or person, depending upon the agreement. In some cases, ANVAR becomes the owner of the invention, in others , it only helps the owner to obtain commercial development. The next stop is to find the most competent firm to handle development and, if possible, the marketing as well. ANVAR is more likely to grant an exclusive license if the firm is willing to assume some of the cost of development.

MDIS in 1965. It has since received legislative recognition in the Sixth Plan and in the annual budget. The projected government costs for 1972 is $42 million. Since the government never pays more than 50 percent of the total cost of any one project, industry expenditure may be expected to be at least $42 million. While the program provides for reimbursement in the case of success, returned money is not fed back into the program, but goes into the general treasury.

The DGRST considers four factors in deciding whether to undertake a particular industry program.

- The degree of foreign competition and the level of foreign government support of competitors. (Where the competition is keen and other governments are providing substantial support, as in the case of micro-electronics, the DGRST is inclined to favor an Aid to Development contract for that industry.)

- The degree of fragmentation of the industry. (Where the industry consists primarily of numerous small companies, the DGRST favors a contract to that industry in the interest of rationalization and consolidation. The machine tool industry is an example of this situation.

- The degree of risk. (The DGRST gives special attention to high risk projects since other funding is difficult to obtain. Naturally, they weigh the risk against benefits attainable with success. However, high risk projects receive preferential treatment in line with the principle in Concerted Actions of assuming only those tasks which are not likely to be undertaken otherwise.)

- The societal benefits (especially in an ecological sence).

Not all of these factors are essential for DGRST project approval. However, the more there are present in a proposed project, the greater the likelihood that it will be approved. The successful development of a two-solvent process for the patch-dyeing of textiles was cited as an example of a project with more than one of the above-described features when first considered by DGRST: the textile industry in France is highly fragmented, the process did not offer a

The Concerted Action program was referenced in a 1959 law which mentioned only that funds were to be allocated, but which contained no details about its mode of operation. The actual procedures were established through Inter-Ministerial decision.

The cost of the programs for 1972 is expected to be $35 million. Since none of the programs are reimbursable and all expenses are assumed by DGRST, this figure represents the total cost to the government.

The main prerequisite for the initiation of a Concerted Action program is that the research project under consideration by the DGRST cannot be undertaken satisfactorily by any existing government apparatus. The guiding principle of the DGRST is to avoid any undertaking which could be done by another agency. This usually means that the project under consideration is interministerial in nature and the simultaneous responsibility of several agencies, or else an action which could be attached to an organization which is not yet ready to assume responsibility.

Individual Actions are assigned to a committee appointed by the MDIS. It is the committee's responsibility to prepare requests for proposals for specific research contracts, to make contract recommendations to the DGRST, and to oversee the fulfillment of the contracts. A criticism leveled at this arrangement is that the committee members are often associated with the university and industry laboratories which are competing for the contracts. The government response is that, since the members are selected for their competence in special fields, it should be expected that their laboratories would be concerned with that field and would submit proposals to do research work. Furthermore, the DGRST, not the committee, negotiates and approves all these contracts.

An ancillary program, called "Complementary Coordination Action," is designed to facilitate the launching of, or the conclusion of, Concerted Actions which are particularly difficult. For this activity the head of the DGRST appoints a small group of experts who work under his direction and control until the desired results are obtained.

Exploitation of the results of Concerted Action is attempted through dissemination and utilization of the information. Dissemination is accomplished by publication, whereas utilization depends greatly upon whether the research is basic or applied,

6. IDI (Industrial Development Institute)

7. Government Procurement

8. Tax advantages

9. Sofinnova

10. Credit for Launching New Products

11. Urgent Actions

In addition to the programs generally applicable to all industries, the French government has separate plans to promote specific industries, such as Plan Calcul in the computer field. Despite the fact that these plans provide for substantial research and development funds, they are not strictly industrial R&D programs. For example, the plans may call for consolidation and/or reorganization of an entire industry on a more rational basis, with increased research and development being but a single part of a total industry plan. Selected industry plans will be described briefly in Part II following the description of the above-listed general programs in order to provide some understanding of their operation and their relationships to the overall economic scheme.

C. Government-Private Sector Relationship and Interaction

French industry relations with the government, which had been traditionally fairly close, have evolved into a much closer cooperation within the last decade. The major reasons for this change have been developments in the foreign economic policy and the initiation by the government of badly needed domestic reforms. With these reforms and with exposure of French industry to foreign competition, first through trade liberalization within the OECD and later through the EC customs union, the industry, which had been accustomed to chronic stagnation, was forced to adapt to an era of economic growth and of competition.

The industry, however, has been and continues to be closely consulted on trade policy matters, such as European integration or trade negotiations, generally through contacts with top technocrats in the relevant Ministries. Consultations with business and other economic groups have been institutionalized within the framework of economic planning. More specialized business committees have been also established to cooperate

Consistent with an increased emphasis on aid to the industrial sector, the DGRST also has an important role with regard to science policy implementation. As outlined above, the DGRST is instrumental in the process of elaborating science policy; in addition, it is responsible for the administration of two important R&D support programs: Les Actions Concertees and L'Aide au Developpement. In fact, these two programs (and to a lesser extent, the operation of ANVAR, the National Agency for Research Development) represent the thrust of the government policy to promote industrial technological advance.

The largest single government-civilian R&D program is operated by the French Atomic Energy Commission (CEA). (Its non-military budget of nearly $300 million for 1972 is approximately one-third of the total Civilian Science Budget of $1 1/4 billion.) Most of the money is allocated to research conducted within the agency, with major emphasis placed on electrical energy production. CEA does provide some financial support to private industry in the form of research contracts, but that is only incidental to the CEA mission. For the most part, CEA supports industry by supplying expertise, in both nuclear and related non-nuclear fields.

The CNRS receives the second largest portion of the civilian science budget with $250 million: one-third used to maintain government laboratories, one-half to support university laboratories through research contracts, and the remainder is disbursed to private research laboratories, also through research contracts. Most of the research supported by CNRS is in the areas of the basic sciences (such as physics and higher mathematics) and the engineering sciences, with rather little funding devoted to support of applied science.

The National Space Agency (CNES) has a budget of $144 million. It provides more support to private industry through research contracts than CEA, but for the most part finances research within the agency. As with the CEA, the outside research which is supported by CNES is usually in fields related to the agency's sphere of interest, for example, electronic components.

In general, the other agencies whose budgets provide components of the "Recherche Enveloppe" (such as the Institute for Agricultural Research (INRA), funded at $80 million and the Institute for Medical Research (INSERM), funded at $50 million) do not support research to be conducted by outside groups. Two notable exceptions are the Post Office and Telecommunications Agency (P&T) and the Center for Oceanographic Research (CNEXO).

The government organizational structure for S&T policy development and implementation is rather complex, as is indicated in Attachment 1. A partial representation of that structure is shown in Figure 1. The General Delegation for Scientific and Technical Research (DGRST), under the Ministry for Industrial and Scientific Development (MDIS), is the central government agency concerned with S&T policy formulation. With respect to the research portion of the Plan, the DGRST receives submissions from all research establishments, both public and private; coordinates and elaborates these submissions; then transmits them to the Research Commission of the Plan, which serves as an arm of the National Planning Board. The National Planning Board has final authority before the Plan is submitted to Parliament by way of the Council of Ministers (the Cabinet).

The DGRST also serves as the coordinating agency for the annual Civilian Science Budget requests from agencies within the MDIS, as well as requests from other ministries which are to be incorporated into that budget. In sequence, the DGRST combines all requests into a single package, collaborates with the Ministry of Economic and Finance (MEF), then forwards the proposal to the Advisory Committee for Scientific and Technical Research (CCRST). A report on the proposal is prepared by the CCRST; this report is then submitted along with the proposal for discussion by the Interministerial Committee for Scientific and Technical Research (CIRST). Under the chairmanship of the Minister of Industrial and Scientific Development (MDIS), the CIRST discussion is, in essence, a defense of the proposals made by the cognizant ministries to the Minister of Economy and Finance (MEF). After agreement has been reached, the budget is transmitted to the Council of Ministers (the Cabinet) prior to submission to Parliament.

The national science policy, as outlined in the Plan and delineated in the Budget, is implemented by those government agencies which conduct or finance scientific research. Among those which receive the highest priority and greatest levels of funding are those concerned with atomic energy, space, oceanography, telecommunications, and the government research laboratories. Each of these conducts fundamental research in its own specialty; however, the government laboratories and research centers which make up the National Center for Scientific Research (CNRS) have much more general areas of interest. It is noteworthy that three of the five key research activities (namely atomic energy, space, and oceanography) are under the aegis of the MDIS. Telecommunications is the responsibility of the Minister of the Post Office and Telecommunications (P&T) while the CNRS is assigned to the Minister for National Education (MNE).

rather than being mandatory. With respect to research and development, in particular, the plans cannot be considered statements of science policy; instead, they should be viewed as an expression of government intentions. Undoubtedly the preparation of the Plans is an important aspect, but other factors affecting science policy also deserve attention.

Throughout the DeGaulle decade (1958-1968), science and technology were viewed as extremely important elements of international competition, as well as an expression of national power and prestige. In consequence, French science planners, under the strong influence of DeGaulle, placed much emphasis on the development of expertise and production capability in such high technology areas as atomic energy, space and computers. As a result, developments in many other areas of France's widely diversified industrial structure were relatively neglected.

The current science and technology (S&T) policy appears to have become more pragmatic, with a set of goals better specified and more likely of attainment than the superseded goals from the DeGaulle era. The emphasis on nationalism and prestige has also been decreased. International cooperation is no longer considered to be inconsistent with the national objectives of increased productivity and an improved position of French industry in international trade competition. The shifts in emphasis in the computer, atomic energy, and space programs serve as examples of recent trends away from isolation and total independence.

Previously (and especially under DeGaulle), the government of France struggled to create a viable independent French computer industry in an effort to avoid dependence on foreign countries, especially the U.S. The government has more recently directed its efforts toward developing a strong European computer manufacturing capability, rather than an independent French industry. A recent agreement between CII, the French nationalized computer company and Siemens, a major German electronics company, seems to reflect this change in policy. In the field of atomic energy the French government has decided to construct enriched-uranium reactors under U.S. license, thereby abandoning reliance on natural uranium reactors of French design. As for its space program, France has decided to join with the Europeans, while at the same time pursuing bilateral programs with a number of countries, including the U.S., USSR, Germany and India.

Concomitant with a leveling off of support for "prestige" programs, support for industrial productivity and technological advance is increasing sharply. High technology industries, such as

IDI - Institut de Developpement Industriel
(Industrial Development Institute)

INRA - Institut de la Recherche Agronomique
(Institute of Agricultural Research)

INSERM- Institut National de la Sante et de la Recherche Medicale
(National Institute of Health and Medical Research)

MEF - Ministre de Economie et Finance
(Minister of Economy and Finance)

MDIS - Ministre du Developpement Industriel et Scientifique
(Minister of Scientific and Industrial Development)

MNE - Ministre de Education Nationale
(Minister of National Education)

P&T - Ministre des Postes et Telecommunications
(Minister of the Post Office and Telecommunications)

ORF is supported by the funds received through contracted research with industry; in addition the Ontario government invests an equivalent amount, dollar for dollar, to that spent by industry for ORF research. The government's investment allows the foundation to maintain its facilities and perform the research necessary to maintain its technical capabilities.

3. Sheridan Park Research Community

The Sheridan Park Research Community is a 350-acre research park located outside Toronto. All research performed at the Park has one basic objective: to keep the participating companies competitive in world markets.

The Park was established and developed by the Ontario government and the Ontario Research Foundation in 1963 at a cost of more than $36 million. Sheridan is operated by a Board of Directors composed of representatives drawn from its community of members including:

- the Ontario Research Foundation, which serves as the nucleus of the Park;
- the development laboratories of Atomic Energy of Canada, Ltd.; and
- the research and development laboratories of seven independent companies, four of which are U.S. subsidiary companies.

D. Income Tax Allowance

The earlier examples presented in this chapter are specific programs sponsored by the government in the interest of enhancing technology through the support of R&D activities. Less direct support is also provided by legislation, such as that concerning income tax allowances.

Under the Canadian Federal Income Tax Act, a corporation may reduce its taxable income by the amount of all expenditures of a current nature made in Canada for scientific research and all capital expenditures for property (other than land) for scientific research. The Act excludes expenditures which are incurred for market research, sales promotion, quality control and preparation of specifications.

a. "Venture Capital for Canadians" Fund

The "Venture Capital for Canadians" Fund provides financial assistance to small Canadian-owned firms for the purpose of introducing new technologies or processes into industry; establishing or expanding foreign markets; and entering into joint ventures. New technologies, processes or inventions are screened by a joint committee of representatives from ODC and the Ontario Research Foundation.

The maximum loan allowable under this program is $100,000. Typically, a debenture will be taken by ODC; however, under certain circumstances, alternative forms of security are permissible. Repayment is arranged to meet the needs of the firm.

b. Pollution Control Equipment Loans

This program provides funds for the purchase and update of pollution control equipment to firms which are unable to draw funds from their own resources. Applicant companies are required to detail the equipment to be used, and to show that it has been approved by the pollution control authorities. The maximum loan allowable is $250,000, and repayment terms are set according to the company's ability to repay. The period for repayment may run for as long as 10 years. Funds are not disbursed until the installed equipment is approved by the pollution control authorities and certified to be in satisfactory working order.

c. Tourist Industry Loans

Term loans up to a maximum amount of $75,000 are available to resort operators in areas where tourism is the major business, for the purpose of upgrading and improving facilities and carrying out anti-pollution measures. The repayment of the principal may be extended over 15 years.

d. Industrial Mortgages and Leasebacks

Term financing is available for the construction of new manufacturing, buildings or extensions of existing facilities, and for the purchase of new manufacturing equipment which will add to employment. Financing is accomplished in the form of mortgages or debentures and

IDAP was introduced in 1970-71 in response to studies conducted in 1969 which revealed that too little attention had been given in the manufacturing sector to the state of product design. IDAP grants are made for product innovation projects, and are limited to a maximum of 50 percent of the industrial design operational and administrative costs. Eligible costs include wages and salaries for direct labor. The expenditures under this program amounted to $321,162 in Fiscal Year 1971-72.

The program is only a year old, thus a determination of its effects and benefits cannot yet properly be made. The Department expects a sizable increase in the program's use, and has estimated that its expenditures will be $1.5 million in its second year.

4. Program to Enhance Productivity (PEP)

PEP provides grant assistance to companies to aid in undertaking feasibility studies to determine whether productivity can be improved by introducing new methods, changing operations or rearranging the plant. Grants of $50,000 or less are awarded to cover not more than 50 percent of the cost of the study. Capital costs are not included; eligible costs are those incurred for salaries for direct labor, administrative and operational costs, and consultant fees, if any.

Payments are made on a monthly basis as costs are incurred, and projects cannot be funded in retrospect. Applications for PEP assistance must be filed and approved before commencement of studies.

Monies disbursed through PEP in Fiscal Year 1971-72 amounted to $200,222. The Department has estimated that Fiscal Year 1972-73 expenditures will amount to $500,000.

PEP projects assess only whether or not an improvement in productivity can be accomplished, but not how to accomplish it. It is a relatively small program.

C. Provincial Programs

Each of the provinces has technology enhancement programs administered either by a provincial research council or by a government department which is assigned the responsibility for matters related to industry, trade and commerce. For the most of some of the financial burdens of maintaining research and development facilities.

In 1962, the Canadian government enacted legislation for an Income Tax Incentive in response to its concern over the lack of R&D performed by industry. The Industrial Research and Development Incentives Act in 1967 replaced the Tax Incentive because the latter:

- complicated the already complicated tax regulations; and

- lacked means for determining the actual cost of the incentive to the government.

Applications for IRDIA assistance are submitted retrospectively as late as 6 months after the fiscal period. Assistance may be provided by IRDIA in an amount equal to 25 percent of capital expenditures for research in the year of application and 25 percent of the average increase in expenditures over a base period of the immediately preceeding 5 years.

Applications are reviewed to determine (a) eligibility of expenditures claimed by the company for "scientific research and development" and (b) the benefit of the research and development to Canada.

Scientific R&D is defined in the Act to be:

> "...(the) systematic investigation or search carried out in a field of science or technology by means of experiment or analysis, that it so say, basic research,...applied research, ...and development."

Benefit to Canada is also defined in the Act as follows:

> "...Where a corporation has certified and the Minister is satisfied that...
>
> (a) the scientific research and development was carried on for the purpose of strengthening the business of the corporation or facilitating an extension of such business,
>
> (b) the corporation is free to exploit the results of all such scientific research and development in Canada, and

part of the costs involved in the development of patents which are of particular interest to the submitting agency or to the CPDL.

The standard distribution of royalties on CPDL patents which have resulted from government research is 15 percent to the inventor and the remaining 85 percent retained by CPDL. The inventor also receives 15 percent of the royalties from university research patents but the remaining 85 percent is divided equally by the university and CPDL.

B. Programs of the Department of Industry, Trade and Commerce

1. Program for the Advancement of Industrial Technology (PAIT)

The overall objective of PAIT is to promote industrial growth and efficiency. It is a general program aimed at prototype development, and is designed to provide direct financial assistance to industry for the development, manufacture and marketing of new or improved products or processes.

Companies which apply for PAIT assistance are required to set cost and time limits for project completion; in general, projects are expected to run for at least 1 year. Companies are also expected to exploit the results of a project "within a reasonable time." It is not known, however, what time frame is considered to be "reasonable."

PAIT was established by the Department's general mandate, hence no special legislation was required. It was originally instituted as a forgivable loan program, but was modified in 1970 to provide cash grants.

The estimated government expenditures for the PAIT program for the Fiscal Year 1972-73 are $36.4 million. PAIT expenditures in Fiscal Year 1971-72 were approximately $22.6 million. To date, government expenditures under PAIT have exceeded $57 million. The total cost of this industrial growth promotion is more than double that amount since under PAIT the government provides at most 50 percent of actual costs.

The DITC reviews all applications for funding, using the following criteria for project selection:

- nature of the project and the marketing feasibility of results;

total cost. University professors and government scientists, acting as liaison or project officers, follow the courses of research, offering valuable assistance and also serving as a medium for communication and exchange of information among government and university sectors. In many cases, the staff funded by IRAP is eventually absorbed into the company on a permanent basis.

NRC has been pleased with the degree to which IRAP has been accepted in industry and the employment opportunities it has afforded to scientists and engineers.

2. Industrial Post-doctorate Fellowship Program

The purpose of this program is to afford new Ph.D.'s the opportunity to gain working experience and to perform research in industry following completion of their university education. The program provides for grants of up to $7,200 per annum to the employing company as partial reimbursement of the individual's salary for a maximum of 2 years. Individual salaries are negotiated between the candidate and the company; however, the NRC does require that the company pay a salary which is at least the amount granted under the program.

Fellowships for employment in industrial organizations in Canada are awarded on the basis of the candidate's scholastic achievement and a demonstrated interest in a career in industry. To apply for an NRC fellowship, the following criteria must be met: (a) the candidate must have completed (or will complete within 6 months) the requirements for a doctorate degree; (b) the candidate must be a citizen of Canada or a landed immigrant who has received (or will receive) a doctorate from a Canadian university; (c) the candidate must be younger than 35 years of age; and (d) the candidate must be unemployed at the time of application and must not have received an offer of permanent employment from the prospective employer.

Companies which wish to participate in the program notify NRC of their interest. The names of participating companies are published, and candidates make direct contact with a company of interest by filing an application and a record of academic transcripts. Once mutually satisfactory arrangements for employment are made by a firm and a candidate, the company submits the candidate's application to NRC, nominating him for a Fellowship.

The extent of government involvement in activities of the business world would seem to suggest abundant communication and interaction between government and industry. However, government policies and programs relating to industry are, in fact, sometimes formulated with little industry participation. While there are undoubtedly several reasons for this, industry's reluctance to cooperate may be at least partly responsible. Whatever hesitancy there is on industry's part to interact with government apparently stems from a fear of government control and intervention.

Government officials are aware of, and industry generally admits to, the need for improved communication between the two sectors. The seriousness of the Federal government's intention to close the communications gap is evidenced by the creation of a new Ministry (the Ministry of State for Science and Technology) to resolve existing problems and remove any obstacles to the successful promotion of science and technology.

At the provincial level, the "research park" arrangement has been employed in an effort to bridge the communication gap. Of particular interest is Ontario's Sheridan Park Research Community outside of Toronto, described in Part II.

jointly with industry, undertaking research which is (1) of particular interest to the government in areas of fundamental or basic research, such as atomic energy; or (2) unattractive to or difficult for private industry due to high risk or high cost, such as Arctic oil exploration.

2. National Research Council (NRC)

The NRC, which is a Crown corporation, is influential in matters of science policy to the extent that it conducts in-house research and also finances, through contract arrangements, research performed by universities and industry.

The annual budget for the National Research Council totals approximately $134 million, the largest single budget of science funds among all government departments and agencies. For the most part, these funds are applied to NRC laboratory activities and university research. Approximately $6 million is directed to the Industrial Research Assistance Program detailed later in this report along with other NRC activities.

The NRC considers its major purpose to be the serving of industrial applications, and estimates that about 70 percent of its laboratory research effort pertains to items which will have industrial use. Examples of areas in which the search for new technology can be expected to apply to industry include: food biology, building research, transportation research, uses of computers, wind tunnel studies and marine life studies.

3. Department of Industry, Trade and Commerce

The Department of Industry, Trade and Commerce (DITC) is the Federal Department which is assigned responsibility for the stimulation of Canada's industrial growth and efficiency. It provides for a number of programs of financial assistance in addition to information services. For the purpose of this report, the following four programs are discussed in Part II of the appendix:

- Program for the Advancement of Industrial Technology (PAIT)
- Industrial Research and Development Incentives Act (IRDIA)

dinate efforts. Since the release of the Commission study, a new Ministry of State for Science and Technology has been established, with the responsibility to review current science policy and programs. This new Ministry has authority to formulate a plan for the future and to foster coordination of R&D efforts in the Federal and provincial governments, universities, and private sectors.

It should be noted that the term "Science Policy" as used in this appendix does not denote any formal or informal national plan; rather, it pertains to trends and to the encouragements expressed by the government through the budget with regard to research and development and science and technology. The Canadian government is currently reflecting on its past experience and is seeking to generate a viable "strategy" or "plan" for future national efforts in the broad field of science.

The following factors are expected to receive major attention during this deliberation:

1. the importance of a rational utilization of Canada's natural resources from an ecological as well as an economic standpoint;

2. the need for greater reliance on Canada's industrial production capability to achieve economic growth;

3. the need for decreased dependence upon foreign subsidiary companies for reasons of nationalism as well as economy;

4. the importance of research and development to an improvement of Canadian industry; and

5. the need for improved coordination of government programs in support of research and development.

Although data on current federal expenditures for research and development are not available, earlier figures and estimates provide some perspective. In 1968, the Canadian government spent $390 million on R&D, $63 million of which represented work performed by industry. Total expenditures on research and development by all sectors during that year were approximately $700 million. In 1969, Federal government spending increased to almost $450 million. Projections for 1970 and 1971 anticipated an annual increase of $50 million per year in government expenditures. Extrapolating from these figures, Canadian government spending on R&D in 1972 should be approximately $600 million.

In return for this aid, the government receives, by levy on sales, a share of the estimated margin based on the proposed selling price and the estimated manufacturing costs. The total earnings of foreign exchange from these projects has been $1.87 billion, and the combined total of foreign exchange earnings and import savings is expected to reach $3.34 billion. Although firms assisted by Launching Aid have produced a number of types of aircraft and engines which have been successful in the domestic and world markets, the program has not been considered successful by government. The merits of the program have recently been debated and an alternative form of support is being sought.

The government also maintains several Programs of Assistance to the Computer, Electronics, and Telecommunications Industries whose purpose is to establish and maintain viable industries in these three areas. The majority of the programs are short-to-medium term, for the government policy is to avoid continued support for these industries.

The National Research Development Corporation (NRDC) was established in 1949 as an independent public corporation and has become a major force in the sphere of technology enhancement. Its principal objectives are to develop and exploit inventions resulting from publicly financed research as well as inventions which are not being sufficiently developed and exploited, and to support research which is likely to lead to an invention. The NRDC acts commercially in pursuing these objectives, expecting its investment back, with a profit, if the venture is successful. NRDC licenses industrial firms to exploit public sector inventions. It pays the full cost of further development if it considers the prospects of recovering the investment to be good. It also enters into joint ventures with private firms to which it provides financial assistance for developing new products, processes or techniques. NRDC generally contributes 50 percent of the development cost. A royalty payment is usually required, most often as a percentage of sales.

The NRDC program has almost universally been considered to be a success. Over 25,000 inventions have been submitted since 1949. Of these, about 6,000 have been accepted for development and/or licensing. In the recent past, NRDC has been assessing about 2,500 proposals annually, and has become involved in about 500 per year. Of these, about 120 qualify for financial development support. Because the NRDC has recently become a profitable undertaking, the level of government funding has steadily decreased each year and is now practically nil. NRDC's level of expenditure is about $18.6 million a year, while its borrowings from DTI policy are under DTI's responsibility. The National Research Development Corporation (NRDC) is a quasi-government organization designed to stimulate invention and innovation and the commercialization of technology.

Development of S&T policy has been directed by the government for the most part. There has been some input from the private sector, but not to any great extent. Industry assumes a much more active role in the implementation of technology enhancement programs, and cooperation with the government is much more evident than in the policy development process.

There are trends evident whereby many older programs which provided investment grants on capital expenditures for machinery, plant, computers, and prototype development, are being replaced by programs of tax allowances. Such allowances indicate the new direction for policy under the present government. The major thrust of the programs has been to improve the technology base of the full industrial spectrum.

The objective of the Preproduction Order Support Program is to accelerate the adoption of technologically advanced equipment (especially machine tools) by helping to reduce the period between development of a new machine and its commercial acceptance. Under this program, DTI is prepared to buy advanced machine tools and lend them without fee to potential purchasers or users. The number purchased has been approximately 3-4 percent of the predicted production orders of the model over the next three years. The machines are loaned free to selected users who evaluate them in a service environment. At the end of an agreed evaluation period (usually less than 2 years), the user has the option of "purchasing" the machines at substantial reductions or returning them to DTI. Both the machine tool industry and the user industries have benefitted. Approximately 85 percent of the machines under evaluation have been purchased by users, an excellent indicator of success.

The Investment Grant Program was a part of an effort by the government to increase the long-term rate of growth in the economy. It offered an incentive for increased capital investment in machinery and plant related to specific qualifying industrial processes and for investments in computers, ships, and hovercraft. In the period from April, 1967 through March, 1971, about $5.3 billion was expended by the government on investment grants. The program is now being phased out as a result of the change in government in 1970. It is being replaced by a new program of tax allowances which are designed to promote conditions likely to stimulate higher investment. The present government has expressed

through three government-owned and controlled corporations chartered to permit the use of private funds. Main projects in the program include the development of power reactors, nuclear fuel, and uranium resources, the reprocessing of spent fuel, and the construction of a nuclear ship. The purpose of Japan's Space Program, for which the government allocated $77.9 million in FY 1972, is the development, launching, and tracking of scientific satellites and the development of rockets for the launching of satellites. In February 1970, Japan successfully orbitted a satellite around the earth. The principal projects under the relatively new, multi-faceted Ocean Development Program include the remote-controlled undersea oil drilling rig mentioned earlier, a comprehensive survey of Japan's continental shelf, development of acquacultural techniques, establishment of experimental facilities, and development of engineering techniques for marine structures. The FY 1972 appropriation for this program was $29.2 million. All of the projects under the aforementioned programs have been moving ahead on schedule, except for a few projects under the space program which is behind schedule by almost a year. A number of projects have already been completed and others will be completed soon. All three programs have been receiving substantially increased appropriations each year.

The mechanism for the initiation of projects depends on the size and complexity of the project. Large scale projects, such as the ones discussed above, are normally originated by the government, which invites a number of "appropriate" companies to submit proposals. Invitations are generally extended to companies (often the large Japanese conglomerates) with which the government prefers to deal because of their expertise in particular R&D areas. More often than not, work related to the definition and dimension of the project is accomplished informally between government and industry representatives prior to solicitation of proposals. All major companies in Japan are somewhat loosely "classified" as being competent to engage in designated areas of research and development, sometimes narrowly defined. Smaller scale technology projects merely "evolve" out of the government's day-to-day contact with the private sector. Industry officials who serve on one or more of hundreds of advisory bodies to government agencies keep abreast of specific needs as they are identified and encourage their companies to submit proposals.

Project funding generally covers costs through development of a final prototype (i.e., up to the pre-production stage), including the construction of prototype plants. Throughout the duration of the project, the government works closely with the

Although government guidance and direction of the economy has been unmistakable and pervasive, government-private sector relationship has been highly cooperative. The government has a paternalistic attitude toward the private sector, and undertakes programs only after reaching a "consensus" with the other side. This often requires extended time in consultations during which differences are slowly ironed out and a mutually agreeable course of action is charted. The initiation of new technology programs, business consolidations, technology imports, etc., have all been effected in this manner, with the government guiding matters, rather than imposing its authority.

Large scale technology enhancement programs involving active support and participation by the central government did not begin in Japan until 1961. Since then, the Japanese government has initiated a large variety of projects and mechanisms for the development and application of new advanced technologies, too many to be discussed here. In addition, the government has utilized a large number of tax and other incentives for the commercialization and diffusion through industry of newly-developed technologies.

The Research Development Corporation of Japan (JRDC) was established in 1961 as a government mechanism to stimulate invention and innovation and the commercialization of research findings through selection and implementation of high-risk scientific projects with industrial application potential. Each year, JRDC selects 10 to 15 projects out of as many as 150 applications for funding it receives from more than 100 national, university, and other public research laboratories and from private research institutes. The Corporation normally funds from 60 to 80 percent of the cost of a project. If the project is judged to be a failure, the JRDC investment is written off as a total loss; if successful, the commissioned firm is given a period not to exceed five years to commercialize the newly-developed product or technology and to repay the full amount of money advanced by JRDC, but interest-free. The firm is also required to pay the agreed royalties, half of which is retained by JRDC and the other half is turned over to the original researcher and his institution. The Japanese government feels that JRDC has been exceptionally successful in its mission. The ratio of success in development exceeds 90 percent, and two-thirds of its current operating budget derives from returns on earlier investments (repayments and royalties). JRDC's operating budget for FY 1971 was about $6.5 million.

State governments, the academic community and the private sector. To achieve unified goals and to minimize duplication of effort among the many public and private organizations which implement science and technology, coordinating bodies have been formed. These bodies, at the Federal-State level, lay down long-range plans for education (which inseparably includes basic research) and science promotion, and make recommendations to the Federal government for the establishment and implementation of policy. Additional cross-fertilization of ideas comes about through numerous advisory bodies and evaluating committees, which also provide inputs for policy decisions. Based on information derived from these sources, the Federal government establishes science policy which directs effort in broad areas, such as university expansion and reform (in order to provide the personnel and research base) and fields of scientific endeavor which are to be pursued in the national interest.

Science policy is implemented by means of privately-operated publicly-supported organizations such as the German Research Society, Max Planck Society, Fraunhofer Society and the Confederation of Industrial Research Associations (dealing in basic research at universities, basic research within its own laboratories, applied research and industrial research, respectively) and within industrial laboratories.

Within the emphasized program areas, projects are initiated either by government or by industry. Selected projects receive support, usually in the form of grants, from public funds. Industrial initiative is maintained by requiring industry to provide a portion of the funding, usually one-half. The technology which results from supported projects is owned by the performing firm. However, government reserves the right to make the results, including protected rights, available to other industrial firms. The government is not in the licensing business, however, and negotiations for the use of protected rights are made directly between firms.

Other direct support includes low-interest or no-interest loans for which repayment may be excused in case of failure and which are available to support projects initiated and carried out by small and medium-sized firms. Special programs in the Western sectors of Berlin act to assure that industry there remains viable.

Government supports science and technology indirectly by permitting joint ventures for research, development or production; firms developing a prototype as a means of demonstrating the feasibility of an idea and convincing some company to undertake production. Whenever ANVAR does grant an exclusive license, a minimum guarantee is always required. Since royalties are in terms of percentage of sales (usually between 5 and 10 percent), the guarantee is also in terms of total sales. If the company fails to fulfill its obligations, the contract may be renegotiated and the license made non-exclusive. At present, ANVAR holds patents on about 660 inventions, but some of these had previously been held by other government agencies and turned over to ANVAR. Of these patents, only 300 have been licensed. Most people feel that ANVAR is doing as well as might be expected and are convinced it is fulfilling an important role. Some criticize it as trying to fit industrial needs to existing technologies rather than the other way around.

There are several other mechanisms discussed in the appendix such as Aid to Pre-Development designed to aid industrial development of ideas coming from laboratories of Technical Professional Centers; L'Institut de Developpement Industriel, a financial institution providing loans to help accelerate the growth rate of French industry; Government Procurement which is used as a method of obtaining advance credit to finance research and development; and as a means of protection from foreign competition of industries selected for special research and development effort; Sofinnova created in January 1972 to provide venture capital for industrial innovation in small and middle-sized companies; and Credits for Launching New Products. In addition, the government has initiated special programs to support and promote productivity in several designated industries, e.g., Plan Calcul (computer industry), Plan Composants (micro-electronics), Plan Peripherique (EDP peripheral equipment), Plan Software (EDP Software), Plan Electronique Civile (electronics), Plan Mecanique (mechanical industry), and Convention Etat-Siderurgie (steel industry). Tax incentives offered are primarily designed to promote industrial R&D activities.

Government-private sector relationship and interaction are influenced by the fact that a significant portion of the business enterprises is owned by the government, either wholly or in part, and that 10 percent of all industrial output in France is produced by government-owned companies. Some of these enterprises are nationalized. Overall, about 30 percent of French investment is government-funded. As a consequence of this involvement by the government, the private sector is regularly consulted, both formally and informally, on matters of national science policy while the Plan is being developed. Industry's cooperation with government and acceptance of intervention dates back to the devaluation of the franc in 1959 and the ensuing period of inflation, and to the imposition of strict price controls in 1963 and the subsequent signing of price stability agreements between government and industry.

DGRST's Concerted Actions Program is aimed at improving industry's international competitiveness by helping it intensify its research through a program of cooperation with university and government laboratories. The duration of an individual Concerted Action, which provides a 100 percent grant for research, is usually not more than 5 years, although it can be extended for a second 5-year period. The main prerequisite for each program is that the research project under consideration cannot be undertaken satisfactorily by any existing government apparatus. This means that the project is interministerial in nature and the simultaneous responsibility of several agencies. Exploitation of the results of a Concerted Action is facilitated through the granting of a development loan, which is reimbursable only if the project proves successful. Measurement of program success is extremely difficult. DGRST officials feel that program success is illustrated by the continued cooperation between university and industrial laboratories after their contracts with DGRST have expired.

The objectives of the Aid to Development Program are to facilitate the development of new products, procedures, materials and techniques that appear promising from an economic point of view. The program, which is managed by DGRST, pays 50 percent of the total cost of a project and provides for reimbursement in the case of success. Returned money, however, is not fed back into the program, but goes back into the general treasury. Factors considered in lending support are the degree of foreign competition and the level of foreign government support of competitors, the degree of fragmentation of the industry, the degree of risk, and the societal benefits to be derived from the project. The program

In the area of tax incentives, a corporation may reduce its taxable income by the amount of all expenditures of a current nature made in Canada for scientific research and all capital expenditures (other than land) for scientific research. Expenditures for market research, sales promotion, and quality control are excluded. Other tax incentives include accelerated depreciation allowance for machinery and equipment acquired for manufacturing and processing in Canada and exemption from sales tax for scientific research equipment purchased by manufacturers for use in testing or developing new products.

or partially, as well as maintains a capital equity interest in joint ventures with industry. However, government policies and programs relating to industry are, in fact, sometimes formulated with little industry participation. Industry's reluctance to cooperate may be at least partly responsible for this, stemming from its fear of government control and intervention. Both government and industry officials admit to the need for improved communication between the two sectors.

The National Research Council (NRC) is a Crown Corporation influential in matters of science policy. Its annual budget totals approximately $134 million, the largest single budget of science funds among all government agencies. The NRC considers its major purpose to be the serving of industrial applications, and estimates that about 70 percent of its laboratory research effort pertains to items which will have industrial use.

NRC's Industrial Research Assistance Program (IRAP) is designed to provide assistance in the form of grants for salaries of professional scientists and engineers who are assigned to approved R&D projects. NRC has invested approximately $44 million in this program since its establishment in 1962. Nearly 230 projects are currently being funded through IRAP in which the pharmaceuticals, chemicals, food products, aircraft, and iron and steel industries are participating. Both industry and NRC are satisfied that IRAP is a successful program.

Canadian Patents and Developments Ltd (CPDL) is a subsidiary company of NRC and acts as the government's primary patenting and licensing agency. It handles patent matters associated with research in government departments and agencies, research councils, and Canadian universities. Patent proposals are assessed for originality, market feasibility, scientific value, and cost of development, production and marketing. Patented inventions are licensed to industry for manufacture. CPDL may fund part of the costs involved in the development of patents. The standard distribution on CPDL patents resulting from government research is 15 percent to the inventor and 85 percent to CPDL.

The Program for the Advancement of Industrial Technology (PAIT), which is managed by the Department of Industry, Trade and Commerce (DITC), is designed to provide direct financial assistance to industry for the development, manufacture and marketing of new or improved products or processes. Companies receiving assistance are expected to exploit the results of a project "within a reasonable time." Approved projects are awarded a cash grant not to exceed 50 percent of the estimated total cost of the project.

were similar in degree of complexity, but the responsibilities and interactions between agencies within national structures differed greatly.

6. The number and quality of U.S. foreign embassy reports, the degree of cooperation and participation which embassy staffs could afford to allocate to this study, and the relevance of the contacts provided for interviews with the team members, were all good to excellent. Although the embassy staffs cooperated with the team members to the fullest extent possible, their understanding of the basic objectives of the study (hence their response) was different from one another. Nonetheless, it must be emphasized that the amount and quality of material gathered for this report would have been much more limited without the valuable cooperation received from embassy staffs.

<u>Scope</u>

Defining the scope of the study proved to be more difficult a task than expected because of the interdependence and synergistic effects that a multitude of factors have upon technology and economic growth. Except in special cases, decided individually, consideration was not given to technology enhancement and incentives applied to the more traditional sectors of the economy, such as agriculture, forestry, fisheries, and mining, as well as all incentives (such as profit-sharing and bonuses) tied to labor productivity and incentives for export promotion not directly related to technology enhancement. For similar reasons, the examination of the S&T organizational structure of each country was restricted to analyzing the interrelationship and interaction of those agencies directly involved in formulating S&T policy as a basic element of their mandates. However, attention was not given to the functions of government agencies closely related to technology development and implementation, such as those promoting or supporting the development of standards, legal metrology, basic research or pure science, industrial location, tariffs and non-tariff barriers, and technological manpower training. Moreover, only the technology programs deemed to be the most important in each country (by virtue of their scope and the amount of resources devoted to them by the national government) are discussed in Part II of each appendix.

The constraints of time did not permit comparison of technology enhancement programs, mechanisms, and incentives among the five countries under study; the plethora and variety of programs were later on appropriated $31.5 million for the program - $10.8 million for NBS and $20.5 million for NSF. A number of experiments will be conducted during FY 1973 to test the validity and effectiveness of some selected mechanisms and incentives.

While the foregoing were going on, the Department of Commerce (DOC) in December 1971, undertook a quick study to identify the principal enhancement programs underway in a number of advanced nations. That study indicated the mechanisms and incentives used in relation to the efforts of those countries at export promotion, product and prototype development, and innovation and productivity enhancement.

Description of the Study

The present document is a more analytical continuation of the DOC study of last fall. The purpose of this follow-on study was to obtain a more intimate knowledge of existing and prospective technology enhancement programs in Canada, France, Japan, the United Kingdom, and the Federal Republic of Germany. In addition, it was directed at learning how these programs are being administered, the mechanisms and incentives used, the areas or types of technology being fostered, the extent of government participation, and any other relevant information. It was anticipated that knowledge gained about sustained experience elsewhere might be valuable to the United States should it decide to initiate comparable programs in conjunction with (or following completion of) ETIP.

The study was conducted in three stages under the Office of the Assistant Secretary for Science and Technology, Department of Commerce, with support from the Technical Analysis Division of the National Bureau of Standards. A team of six professionals was assembled, and the first stage (about five weeks) was devoted to acquainting them with pertinent material that could be obtained in written form. They also consulted with knowledgeable persons in Washington, D. C., such as officials of foreign embassies, the State Department, international organizations, and the country desks of the Department of Commerce. In the second stage (also lasting about five weeks), teams of two visited each country to discuss programs with cognizant government officials, as well as business executives of domestic and U.S.-affiliated companies, and scientific and commercial attachés in the U.S. embassies. (The latter had arranged for interviews with appropriate individuals in government and the private sector.) The third stage (about 10-12 weeks) was spent assimilating the material gathered earlier and preparing a final report, including checking of the material by the U.S. embassies abroad for accuracy.

Notwithstanding these reservations, the government felt obliged to investigate the concept of technology enhancement because of several important developments:

1. The country's declining balance of trade has turned into a serious deficit for the first time since 1893; it shows no signs of leveling off, let alone reversing itself. In contrast, comfortably favorable balance of trade in the past made it possible for the United States to finance foreign economic aid and other commitments abroad.

2. Even exports of high-technology products other than computers and aircraft have declined recently in terms of world market shares, suggesting that the nation's lead in those products is slowly being eroded.

3. Imports of high-technology products have been increasing, suggesting that foreign countries have been catching up with the United States in commercial applications of technology and presaging stiffer competition ahead for U.S. products in international markets.

4. It has become apparent that many business, legal, and institutional practices and regulations in the United States act as barriers to the commercialization (or even the development) of many potentially beneficial technologies.

5. There is burgeoning public awareness that many social, environmental, health and other problems of national concern will have deleterious consequences on society unless resolved through the application of modern technology.

6. The modernization and technology enhancement programs undertaken by foreign countries have contributed to the advancement of the technological capability of those countries, increasing the competitiveness of their products.

7. The very substantial transfer of U.S. technology abroad, through patent licensing and other arrangements, may have had an adverse effect upon this competitive position.

8. Discriminatory and protectionist practices followed by many advanced nations may have had similar adverse impact on U.S. foreign trade.

Concern over the aforementioned developments led several government and quasi-government agencies, inter-agency committees, the more private firms is generally encouraged and supported whenever such action is likely to stimulate greater R&D activity or develop a needed new technology. Such arrangements are condoned in the interest of avoiding duplication of R&D, pooling resources, and spreading the risks. In cases involving the development of new expensive technologies the usual procedure is to create a quasi-government, special charter corporation. In Germany, such corporations may or may not be profit-making organizations. In Japan, they remain under government control during the development period of the new technology, and in Canada a number of consortia are currently in operation in which the government, industry, and a university are participants. The U.K. operates a special Grant Program to Research Associations to encourage cooperative industrial and product research among groups of firms with similar interests. In France, the Technical Professional Centers for which the Aid to Pre-Development Program has been designed are in reality industry associations.

A high level of funding provided for the implementation of a specific technology enhancement program does not necessarily ensure success or accomplishment of objectives. Several technology enhancement programs in the five countries have not been particularly successful in spite of the availability and spending of large amounts of money; e.g., Investment Grant Program, Financial Support for R&D in Industry, and Launching Aid (U.K.), Plan Calcul (France), IRDIA (Canada), New Process for Olefin Products (Japan). Fear of government interference and excessive "red tape" were the principal reasons given by the private sector.

Success or effectiveness of a technology enhancement program is not necessarily a function of the time that the program has been in operation. The average duration of projects under the majority of programs discussed in the report is around three years, and it takes at least twice as long a time to identify and correct any defects that may be inherent in a program. Consequently, it is said that no assessment of the success or failure of a program can be meaningful unless the program is allowed to operate a reasonable amount of time; e.g., NRDC and Preproduction Order Support Program (U.K.), JDB (Japan), IRAP and PAIT (Canada), Concerted Actions Program (France). On the other hand, several technology enhancement programs have been successful after only a short period of operation, suggesting that, more than anything else, the inherent characteristics of a program rather than either duration or level of funding determine its effectiveness; e.g., the National R&D Program and the Atomic Energy Program (Japan), Investment Grant Program (U.K.), ANVAR and IDI (France), Industrial Post-doctorate Fellowship Program and IDAP (Canada), Garsching Instrument and New Technologies Program (Germany).

enhancement programs. In Canada and Germany, these programs are administered by other agencies equally high-placed in the governmental establishment. Technology enhancement programs that cross ministerial boundaries are normally administered by the S&T planning and coordinating agencies as in Japan and France.

Open channels of communication and mutual trust between representatives of government agencies and the private sector are essential elements for effective operation of technology enhancement programs. This is illustrated by the experience of Germany and Japan where representatives of the private sector sit on countless advisory councils and evaluation committees of government agencies, the exchange of views between the two sides is open and forthright, and all programs are planned and implemented through close cooperation with the private sector. In France, the Concerted Actions program is especially designed to stimulate cooperation between industry, universities, and government laboratories.

Technology enhancement programs designed to improve the technology base and raise the productivity of the entire industrial spectrum are maintained in all five countries. These programs offer a variety of generous incentives such as tax credits, accelerated depreciation allowances, low-interest loans, and outright grants for the performance of research and development; e.g., Preproduction Order support program and Financial Support of R&D in Industry (U.K.), IDI and Aid to Predevelopment (France), and IRDIA (Canada). The interpretation of research and development is generally rather liberal, and R&D expenditures include the cost of capital equipment and new buildings, but not land.

Technology enhancement programs initiated for the purpose of supporting designated program areas and industries seem to be substantially the same in four of the five countries considered. The principal program areas supported are atomic energy, space and ocean development, computers, electronic data processing, and telecommunications. Basic reason for the establishment of these programs has been the high risk and great cost involved in developing the relevant technologies, well beyond the capabilities of private companies. In those instances in which the government felt that industrial "rationalization" and increased competitiveness in world markets required the merger of several small companies, as in the case of the computer industry in Japan, France, and the United Kingdom, and the marine transportation industry in Japan, the government has had to offer substantial benefits and incentives to the private sector in order to accomplish its objective.

Several factors account for United States interest in recent years in government technology enhancement programs in the civilian sector. At the risk of oversimplification, the following factors have been rather dominant:

1. The enormous U.S. investment in research and development since the early fifties, both in basic research through NSF and in connection with the country's space program through NASA. This investment benefitted U.S. industry greatly and gave the U.S. a nearly unchallenged lead in technology and foreign trade until the late sixties. Many analysts, including several prominent business leaders, now recommend that the government establish a national policy with regard to technology development and application to parallel the support given basic research.

2. The declining U.S. balance of trade position which in 1971 turned unfavorable for the first time since 1893. Even in the trade of technology-intensive products, the mainstay of U.S. foreign trade, the United States has been experiencing a decrease in its share of the world market. These developments have led many leaders in the government and the business community to the conclusion that not enough of the country's technology is being translated into products and processes because of the existence of institutional, legal, business and other deterrents to investment in new technologies.

3. The inexperience of the United States, relative to other advanced countries, in the use of technology enhancement programs in the civilian sector, and the lack of clear evidence of the effectiveness of such programs in other countries. As a result, there has been considerable hesitancy on the part of the government in undertaking any such programs because of uncertainty of how the programs operate, which ones to consider, what may be their impact on the economy, and the reaction of the private sector.

Consideration of the aforementioned factors led the government recently to initiate an experimental incentives program to examine the types of mechanisms and incentives that are likely to have a stimulating effect on private research and development in ways that would contribute to the competitiveness of the country's foreign trade and the solution of national, social and environmental problems. At the same time, the government is looking at the impact and effectiveness of technology enhancement programs undertaken by foreign industrialized nations in the hope of learning from their

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- the Department of Commerce country desks for the five countries examined

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The Study Team members, all from the Technical Analysis Division of the National Bureau of Standards, who participated in the review and analysis of the material and the preparation of the individual country sections were: Suellen Halpin (Canada); Donald W. Corrigan (France); John C. Schleter (Germany); George C. Nichols (Japan); and Stephen S. Karp (United Kingdom).