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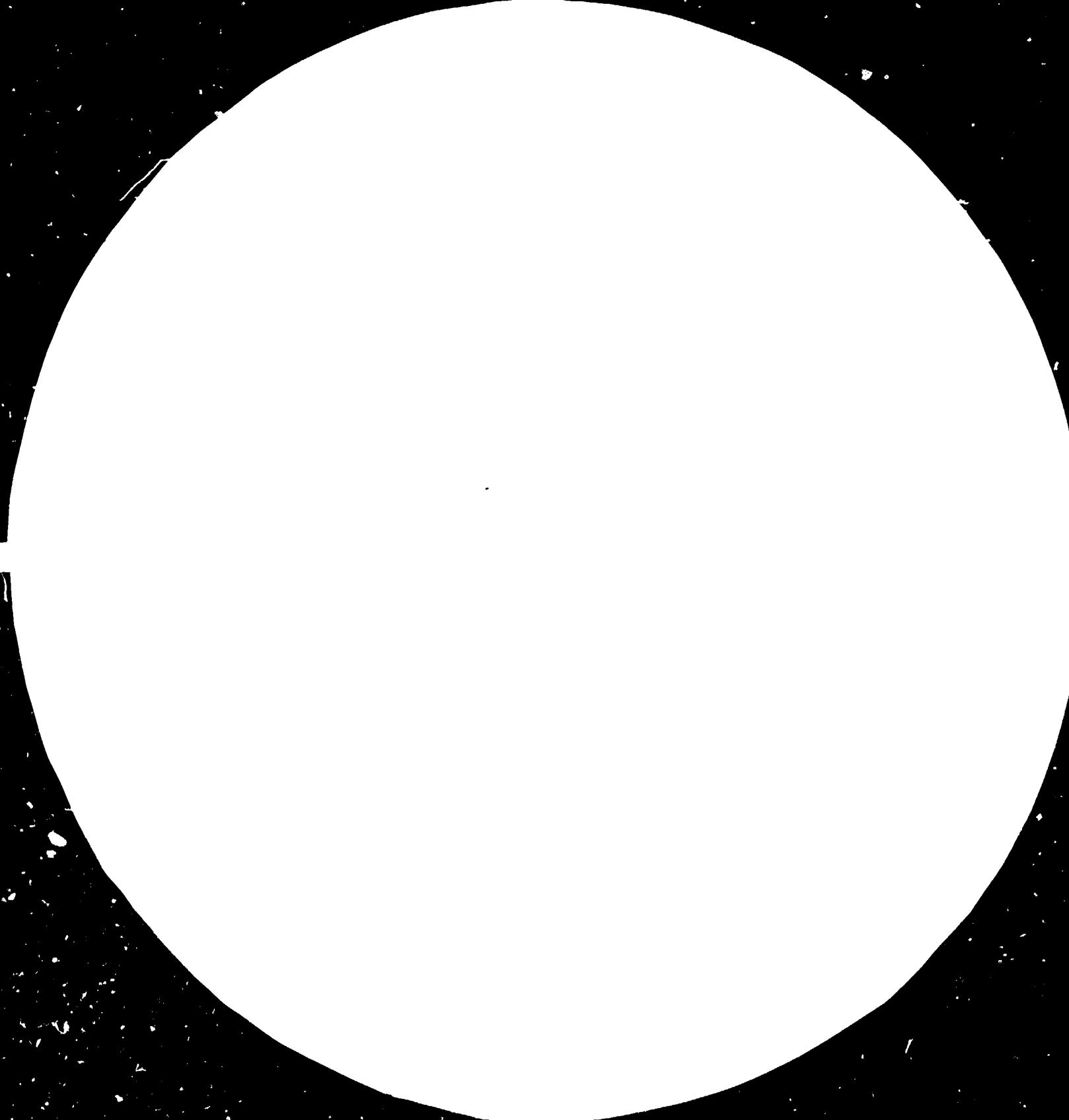

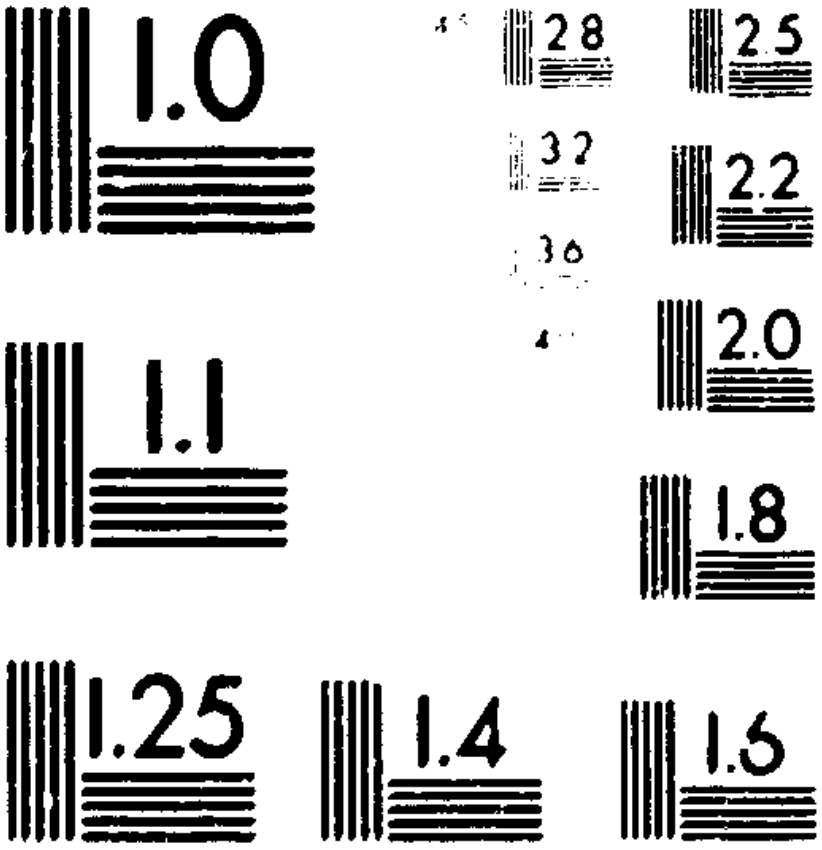

Distr.
LIMITED

ID/WG.435/11
16 January 1985

ENGLISH

United Nations Industrial Development Organization

Regional UNIDO/ESCAP Workshop and
National Consultations on the
Commercialization of Research
Results

Bangkok, Thailand, 15-19 October 1984

COMMERCIALIZATION OF RESEARCH AND DEVELOPMENT RESULTS - KOREAN EXPERIENCE*

by

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V.85-20904

Developing countries have generally come to realize that the availability of technological resources is essential to economic development. Accordingly, they have generated great demand for the transfer of advanced technology in the easiest and fastest way possible. However, because their technological infrastructures are not sufficiently mature to readily absorb such technologies, developing countries have not been able to achieve effective transfer. A technological infrastructure which will both modify and improve imported technology is needed, and can be developed by expanding the network of R&D organizations.

In the early 1960's, Korea's economic growth was achieved through the development of light industry, including the textile, plywood and wig industries. In the face of fierce international competition during the mid-1960's, however, Korea realized that it could no longer enjoy the comparative advantages of cheap labor. The Korean government concluded that the intensive development of science-based, technology-intensive industries, especially the heavy and chemical industries, was necessary for continued economic growth and competitiveness in world markets.

For the transition from light to heavy industry, Korea required advanced technologies from other countries. Because their existing infrastructure was inadequate for prompt absorption, Korean industry was not able to take full advantage of the available technologies. As a result, the Korean Government felt that an integrated research organization was needed to activate R&D* and to play a leading role in the nation's industrialization. Thus the Korea Institute of Science and Technologh (KIST) was established in 1966 as a non-profit, multi-disciplinary research organization. In 1981, KIST merged with the Korea Advanced Institute of Science, a graduate school of science and engineering, to integrate academics and research in one organization. The resulting Korea Advanced Institute of Science and Technology (KAIST), although it is an autonomous

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* Research and Development

juridical person, operates in close cooperation with the Ministry of Science and Technology (MOST).

KAIST, with a research staff of about 1400, is currently conducting more than 100 industrial research projects with a research budget in excess of 10 million U.S. dollars. Its major research fields are : applied chemistry/chemical engineering, polymer science/process engineering, biotechnology/ food technology, materials science/engineering, and electronics and computer science.

1. Government-Sponsored Lump-Sum Contract Research

In developing countries, there are many areas of science and technology which private industries can not or will not undertake research, even though these technologies may be basic to their development. To encourage this research, the Korean government contracts with KAIST to conduct R&D under a lump-sum basis. These lump-sum contracts have recently become more long-term and larger in scale to provide leverage against internal and external competition. These projects can be separated into several categories by their differing goals:

a. those projects that are comprehensive and with strong overall social and national impact,

b. those which require a long period of time before any conclusive results can be expected,

c. those aimed at aiding medium and small scale industries in problems resulting from insufficient capital, inefficient production methods and lack of management know-how,

d. those projects which private enterprises would consider extremely risky because of no immediate return on a massive initial capital investment.

The results of lump-sum in-house contract research must ultimately be used commercially through the licensing or selling of know-how. At the end of 1974, however, the research results had not been effectively commercialized and most had been buried as inventory, even though many could have been commercialized with added efforts. The delay in commercializing R&D results led KAIST to create the Korea Technology Advancement Corporation (K-TAC), as a subsidiary of KAIST, responsible for facilitating the commercialization of R&D results developed at KAIST.

2. Problems in Commercializing R&D Results

In general, for new technology to become productive in an economic sense, it must go through the following stages:

(1) Research, (2) Development, (3) Engineering, (4) Plant Construction, (5) Production and (6) Marketing. It is often misunderstood that a commercially valuable R&D discovery will immediately yield a profit. A frequent case of developing countries is when entrepreneurs fail to recognize that the latter four stages, which require higher investment, effort and patience than does the actual R&D, are indispensable for successful commercialization.

Technologies suitable for development by medium and small enterprises in developing countries are sometimes available. The large corporation of developing countries, of course, can acquire the capacity to commercialize these new technologies by themselves. However, medium and small scale industries are generally discouraged in such activities by the following factors:

a. lack of understanding on the part of entrepreneurs regarding the commercialization of new technology.

b. lack of managerial experience in the process of commercialization,

c. lack of specialists from both internal and outside sources,

d. heavy financial burdens during the plant construction stage, and

e. reluctance of local banks to finance the venture.

3. Establishment of K-TAC

As mentioned, delays in the commercialization of new technologies by Korean industry have made it necessary to establish a special body to facilitate the commercialization process. Consequently in 1974, KAIST invested $60,000 of its own funds in the founding of the Korea Technology Advancement Corporation (K-TAC) as an independent body. Since the steps of commercialization are quite separate from R&D, K-TAC took the form of a private corporation to have mobility and flexibility in operation, as well clearly defined responsibility. Additional investment was planned through the sales of KAIST know-how, with some additional cash infusions by KAIST if necessary.

K-TAC's major activities include the following:

a. commercial promotion of domestic R&D results and foreign technologies,

b. sales of know-how and related support activities,

c. sales of prototype equipment and byproducts resulting from R&D at various laboratories under MOST coordination.

d. R&D project sponsorship,

e. management consulting and other relevant activities.

The decision to accept new technologies for commercialization is made in consideration of the following factors after a comprehensive feasibility analysis has been performed:

a. technology aimed at medium and small scale industry,

b. probability of resulting import substitution and/or export promotion,

c. probability of good financial return (Profit potential).

4. K-TAC's Role in Commercialization

K-TAC accumulates capital in the form of cash and know-how from KAIST and other research laboratories. With this know-how and from other domestic and foreign sources, K-TAC conducts extensive feasibility studies. If a particular study shows promise, K-TAC then draws up a project plan, and recruits potential clients. When the technology is relatively small from business point of view, K-TAC prefers to sell know-how through a licensing agreement providing that the clients are capable of applying the technology involved. When potential clients insist on a profit guarantee rather than a technology performance guarantee, K-TAC provides an equity contribution to demonstrate its faith in the technology. If K-TAC finds that a given technology holds great promise and has a pressing need for commercialization but sees no potential clients, K-TAC may go into business on its own, hoping that interested clients will soon appear. In such cases K-TAC organizes a new business and initiates such commercialization activities as raising funds and constructing a plant.

K-TAC prefers to transfer operations and ownership of its

businesses to private entrepreneurs as soon as these firms have a stable foundation. The revenue generated by these sales are then reinvested in other commercialization projects. Thus, K-TAC's capital could be refered to as a revolving fund. The profits from commercialization are returned to KAIST. KIMM and other shareholders in the form of dividends of research funds.

K-TAC has established a close relationship with the Korea Long Term Credit Bank (KLB) as well as a concurrent cooperative relationship with the Korea Credit Guarantee Fund (KCGF). In addition, K-TAC is supported by the Government via such measures as the Technology Development Promotion Law. These conditions have all contributed greatly to K-TAC's success.

In addition to the commercialization of KAIST's know-how, K-TAC is also currently engaged in technology transfer by exporting the processes and know-how developed at KAIST. Over the years, KAIST has undertaken approximately 2,500 research and development projects. On the average, about half of the projects were sponsored by industry.

A considerable portion of these developments are presently being used by Korean industry. These processes are often suitable for other developing countries due to their appropriate production capacities and optimum process design, and can be competitively exported.

5. K-TAC Performance

K-TAC started with $60,000 in capital and began to seek know-how for commercialization from available KAIST technologies. K-TAC has, since then, been competently performing its duties. It has sold about 2 million U.S. dollars worth of KAIST-generated technology to Korean industries. Some typical items are fluorinated refrigerants, copper plated steel wire, modacrylic

fiber for wigs, antibiotics and agricultural chemicals. Beginning in 1976, K-TAC also created 11 joint venture with the business community in the fields of ceramics, specialty metals, agrochemicals, antibiotics and optical fiber communication. Holdings in three of these companies, were later sold to our partners after the companies attained a stable and profitable position. With the capital thus generated, K-TAC is in the process of creating more companies.

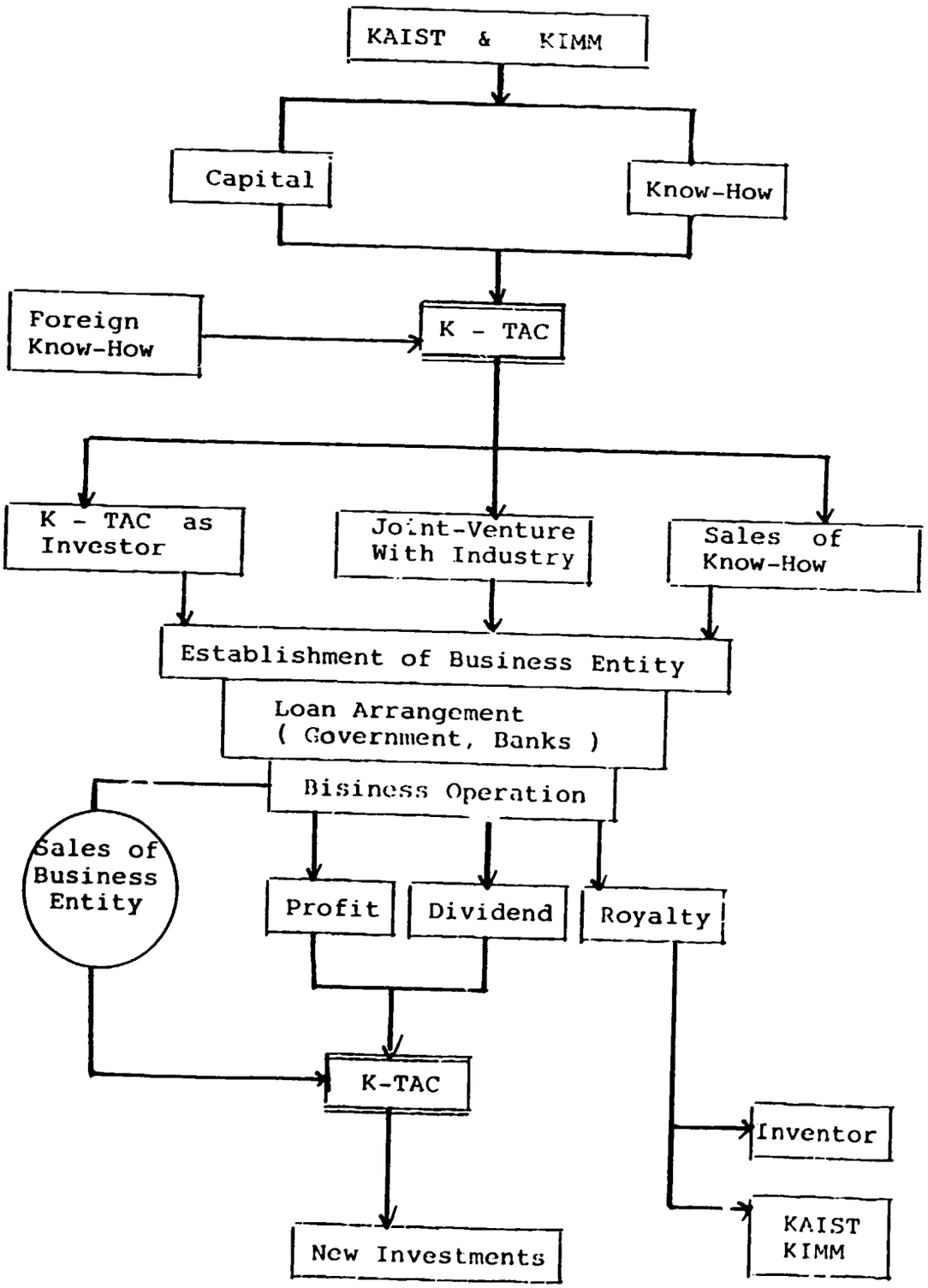
Through its successful operation over the last decade, K-TAC has grown to a corporation with paid-in capital of more than 1.2 million U.S. dollars, and has also become a project development company affiliated with most research organizations under the Ministry of Science and Technology.

6. Strategic Approach to Future Commercialization

K-TAC has accumulated considerable experience through trial-and-error in the commercialization of R&D results since its establishment in 1974. These years may be regarded as the experimental stage (1974-1980) of its operation, since K-TAC confronted many unpredictable problems under unique local business conditions. Most problems occurred during the process of managing capital and originated from a lack of experience rather than from a lack of technological capability. However, the experimental stage can now be considered ended, and K-TAC has entered its next operational stage, which might be called the developing stage (1981-1990). Sound progress in this second stage during the eighties is a prerequisite for the next stage of operation, which could be called the advanced stage (1991 and after), when investment will be aimed at the commercialization of highly sophisticated technologies accompanied by high risk and high potential returns.

As is common in other developing countries, commercialization projects are mainly aimed to decrease Korea's dependence on imports. These import substitution projects, since they have an existing domestic market, are more likely to be successful than those involving entirely new products. K-TAC's activities in the coming years will, therefore, be concentrated primarily on the development of as many import substitution projects as possible. In order to achieve this objective, K-TAC will endeavor to unite technology-based industries from abroad with businesses and entrepreneurs in Korea by offering a wide range of services including technical and managerial assistance : the sale, licensing or purchase of domestic and/or foreign technology, and the establishment of new enterprises based on appropriate technology.

K-TAC's activities are summarized in the following chart.



K-TAC's major performance in the field of industrialization of new tedhnologies during the past years are shown below.

Creation of New Companies

1976	Nam-Hae Cordierite Ceramics Company
1976	Korea Nonferrous Metal Powder Company
1977	Han-Jung Agrochemicals Manufacturing Company
1978	Jin-Hung Agrochemicals Manufacturing Company
1979	Sam-Woo Specialty Metal Wire Company
1980	Yuhan-Antibiotics Manufacturing Company
1982	Korea Fiber Optic Communications Company
1983	Korea Micro Precision Dies Corporation
1983	Kumha Fine Chemicals Manufacturing Corporation
1984	Han-Mi Pharmaceuticals Corporation

Sales of Know-How

1975	Fluorocarbons
1976	Modacrylic Fiber
1979	Artificial Diet for Silkworm
1984	2-Amino-4-Methyl-Benzothiazole

7. Other Financial Institutions to Assist the Commercialization

A best known financial organization which has worked with K-TAC for many years is Korea Long Term Credit Bank (KLB) which used to be Korea Development Finance Corporation (KDFC) with equity participation of IFC of the World Bank. KLB and K-TAC has participated in 6 projects initiated by K-TAC through equity investments.

Another financial organization which was created to provide fund for commercialization is Korea Technology Development Corporation (KTDC). KTDC which was created in 1981 has advanced

loans to the recently launched K-TAC company through partial convertible debentureinvestment.

KTDC provides sponsors of technology development projects with funds in the forms of conditional loans, conventional loans and equity investment. The projects that are eligible for KTDC financing are as follows:

- Research and development activities for the development of new products or new processes and for the improvement of existing products or processes.
- Manufacturing start-up of new products.
- Improvement of prcduction processes to increase productivity, to improve product quality or to reduce cost.
- Purchase of research facilities and equipment and activities related thereto.

In order to perform the above financing activities smoothly, KTDC will secure funds annually at fovorable terms from various sources which include the government, private firms and international financial institutions.

In general, technology development projects are subject to high risk and require a long gestation period, although they may bring about satistafctory returns in case of success. In this connection, KTDC's financing has some unique features which are not normally found in conventional financing.

Besides conventional loans and equity investments, KTDC employs the "conditional loan" program, under which the borrower is responsible for repayment of his obligations to the extent his project has succeeeded. By employing this conditional loan program for the first time in Korea, KTDC

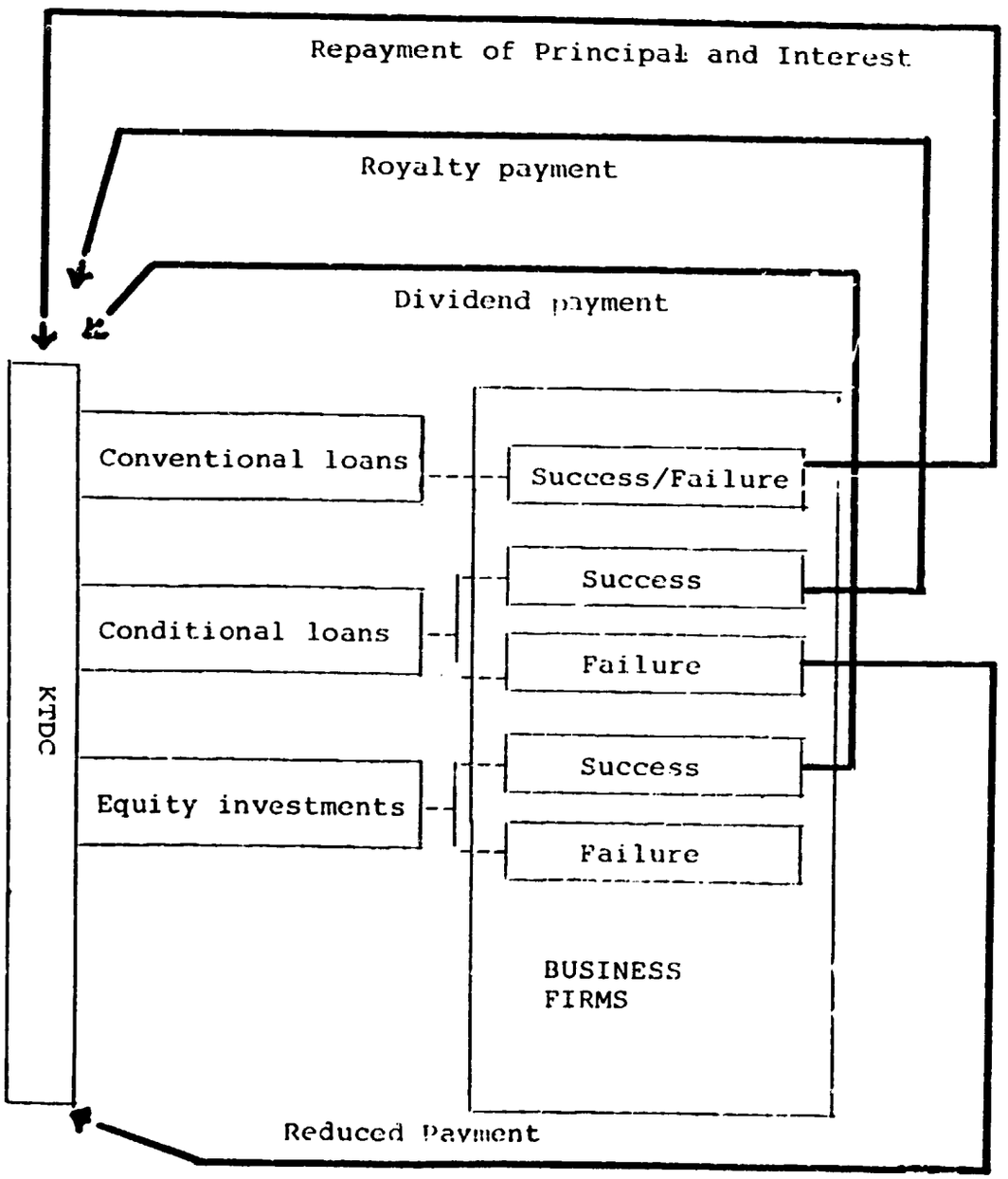
intends to lessen the borrower's burden and to induce more active participation of business enterprises in technology development projects.

By simplifying loan investment procedures to the maximum possible extent, KTDC meets timely the needs of the borrowers for technology development funds.

To ensure a balanced allocation of funds to a variety of technology development projects the following financing limits are maintained by KTDC.

- The maximum financing amount for a single project is limited to ₩500 million.
- The maximum exposure to a single borrower is limited to the amount representing 20% of KTDC's net assets.

KTDC's operational flow is shown below.



It should be emphasized that the basic difference between K-TAC and KTDC has to do with the proactive creation of R&D based company of K-TAC and the reactive banker like loan activities of KTDC. Both activities can be quite complementary since K-TAC has a lot of untapped commercial ideas while either KLB or KTDC has source of funds.

There are two other venture capital companies which are of recent origin. One is Korea Development Investment Company whose shareholders are six short term credit financial companies. The other is Korea Technology Finance Company, wholly owned by Korea Development Bank. These companies are under the jurisdiction of Ministry of Finance.

Researchers with shortage of funds can also seek financial assistance from these organizations.

8. Conclusion

It is well known that close cooperation between research organizations and industry is one of the most important ingredients for the successful commercialization of R&D results. However, the relationship has often been unsatisfactory because of the differences between the two parties. Though the research staff may be highly trained in scientific investigation, it may lack industrial experience. Under these circumstances, K-TAC has helped KAIST and Korean industry to understand and cooperate with each other. Because of the intermediary presence of K-TAC, KAIST has been able to collect needed industrial information and define the required follow-up research to ensure the R&D results in commercial terms. K-TAC has greatly facilitated the commercialization of KAIST's R&D results and, in so doing, has helped industry make significant steps toward implanting high technology in Korea.