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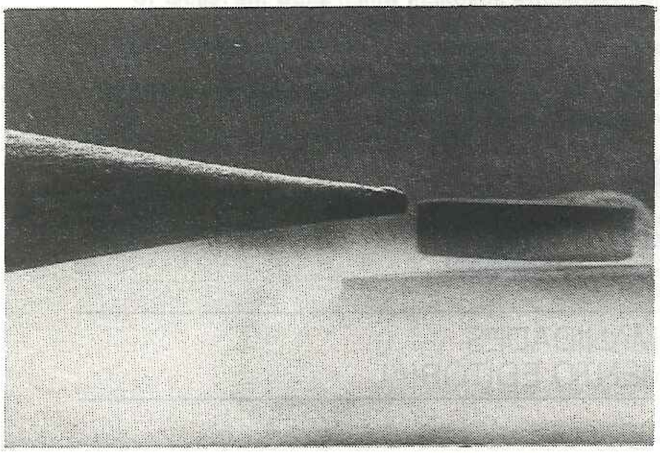
SCIENCE AND TECHNOLOGY IN MEXICO: LOOKING FORWARD

Introduction

During the past 15 years, Mexico has made some progress towards developing its own science and technology. The National Council for Science and Technology (CONACYT), created in 1970, has contributed in a number of ways, by promoting interest and support for science, developing scientific and technical infrastructure, and emphasing the relevance of science for development. Yet an explicit science and technology (S&T) policy, related to the country's overall national development plans was only recently defined. The process that led to this policy is closely related to the country's perception of its economic reality.

For many decades, industrialization was based on foreign technology. Correspondingly, technical education, higher education and research were poorly budgeted. More recently, from 1970 to 1982, Mexico invested considerable resources in its scientific and technical infrastructure. The number of students in higher education increased from a few hundred thousand to about one million. The budgets, laboratories and general facilities of universities and technological institutes grew even faster, and important advances in basic research were made at several of those institutions. Technical information systems for industrial needs were created, and more than 20 centers for research and development were established throughout the country. The end result —on the supply side— was a significant increase in technical services and scientific activities.



Magnetic levitation achieved by high temperature transition superconductors.
(Photo from the Instituto de Materiales, UNAM)

Yet a comparable demand for these services from industry never materialized, despite tax and loan incentives. The prospects of abundant petro-dollars and easily obtainable technology, capital goods and intermediate products from abroad made the national effort rather extraneous.

During the last few years, however, there has been a turn-about in Mexico's views on its own future. From the optimistic expectations of an economic take-off propelled by oil revenues, the country soon came to the conclusion that there are no short cuts to modernization.

Not all of the consequences of this shock were undesirable. In fact, the shortage of hard currency has brought about some unexpected benefits. Most important among them is that government, industry and academia have all come to the conclusion that technical skills, scientific knowledge and the will to develop and apply both of them are among the missing links in the Mexican economic system.

This consensus gave rise to the National Program for Technological and Scientific Development 1984-1988. This new S&T policy is defined within the framework set by the National Development Plan, and the interrelationship between them is very close. The Program is the main instrument —though not the only one— now being used to guide the advancement of science and technology in Mexico. The Program and other policy instruments, which will be described later, were designed to take full advantage

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of the country's scientific and technical infrastructure in the quest to improve the current technological situation.

The Present State

Mexico's technological backwardness is expressed in the lack of vertical integration in industry and the weakness of its capital goods production. This sector of industry has been unattractive to local entrepreneurs because, unlike finished goods and intermediate products, capital goods are not covered by protective trade measures. At the same time, they require more complex technology, more highly-skilled labor and larger markets than those available in the the country.

Most of the technology currently used in industry comes from abroad, either directly or as part of imported capital goods. In addition, most of the technology used in industrial plants is obsolete or lags behind state-of-the-art innovations. Even industrial sectors with a tradition of high quality in Mexico, such as the construction industry, need technological revitalization to reduce their costs for the internal market and to compete successfully abroad.

In all branches of industry, small and medium-sized enterprises are unable to improve their products and production processes due to poor management, a lack of technical capacity or inadequate local services for technological adaptation and development.

The country's scientific and technological infrastructure has expanded and improved noticeably during the past 15 years. However, it has barely been used by industry due to the lack of communication between the latter and academic institutions. As a result, not only has industrial growth relied excessively on imported know-how, but technological assimilation has also been very limited. The present challenge to Mexican industry, then, is to develop in such a way that imported technology and local innovative capacities are combined, with the latter increasing progressively.

The following are the most important obstacles to meeting this challenge:

— limited capacities of small and medium-sized industrial enterprises to manage technology;
— excessive protectionism, which isolates many sectors of Mexican industry from the demands of international competition;
— poor relationship between industry and academic research centers, and a lack of institutions concerned with building links between them;
— few highly qualified scientists and engineers;
— lack of innovation in industry;
— poor documentation and assimilation of technology in many industrial enterprises;
— work by the strongest R&D groups is mostly in the basic sciences, and they rarely participate in projects of a larger scope linked to problems of national interest;
— disparity between Mexico's needs and the national capacity for R&D in areas like earth and marine sciences;
— limited local supply of basic engineering services.

Quantitative indices of some of these constraints are the following:

— There are some 7000 full-time scientists, less than one per 10,000 inhabitants. In contrast, the index for industrialized countries is 10 to 25.
— Expenditures for science and technology are about 0.55 percent of the GNP. France, Japan, Great Britain, the U.S. and the USSR spend from 1.8 to 4.2 percent of their respective GNPs.
— 90 percent of the national expenditure for S&T is publicly financed, revealing the weak links between research and industrial needs.
— Among the population of graduate students (31,000 in

Fire rescue vehicle. (Photo from the Unidad Académica de Diseño Industrial)

1983) only 3 percent were pursuing a doctoral degree, and more than three-fourths of all graduate students were studying in the humanities, social sciences and administration.
— More than half of the country's S&T activities are concentrated in Mexico City and its environs, most of them in four large institutions.

The Current Policy

In the context described above, the current S&T policy has been designed to:

1. Strengthen the national system of science and technology, with the commitment to contribute solutions to Mexico's major technological and social problems, thus reducing the country's dependence on foreign technological sources and services;
2. Foresee social needs and technological changes in order to design timely policies or preventive measures;
3. Promote awareness throughout society of the nature and role of science and technology in the nation's integral development.

The ways proposed to achieve these objectives are the following:

— conduct scientific and technological development with the broad, active participation of scientific organizations, industry and other economic sectors;
— encourage industrial organizations to increase their vertical and horizontal integration and to identify and manage technology as an explicit variable;
— reinforce the capacity of industry to assimilate and adapt imported technology, so that it stimulates rather than substitutes the national technological effort;
— increase systematically the investment in science and technology in accordance with the country's needs and possibilities (a growth rate of 15 percent per year during the period 1984-1988 has been set as a goal);
— encourage industry and other enterprises to finance

research projects oriented toward meeting their own needs;
— promote decentralization of R&D activities as in other economic activities;
— encourage graduate education that improves the quality of higher education and fosters technological innovation in industry;
— link science and technology programs to those for industrial development;
— develop mechanisms that promote cost-sharing for technological innovations between government and industry.

The main instruments designed to implement such policies are:
— The Plan for National Development (PND) 1983-1988;

NEW DISCOVERIES IN SUPERCONDUCTORS

For the first time in its history, Mexico has established itself on an equal footing with other countries at the vanguard of superconductor research. Mexican researchers developed new superconductors at the UNAM's Institute for Materials Research, just a few days after Physics Nobel Prize winners, Karl Alexander Muller (Switzerland) and Georg Bednorz (Germany), announced their own recent discoveries in this field.

Dr. Tatsuo Akachi, academic secretary at the Institute and a member of the team which carried out this feat, told us that they first heard of research on superconductor materials at the Winter Meeting on Low-Temperature Materials, held in Mexico City in January 1987. With this scant information, they began to work on synthesizing new materials, finally managing to do so by mixing copper, barium and itrid oxides.

According to Dr. Akachi, the new material is a kind of ceramic with two basic properties. The first is that below a certain temperature (known as the critical transition temperature) its resistence to energy conduction is zero, meaning that it possesses an infinite conduction capacity. Its second property is that it prevents external magnetic fields from entering its own, a phenomenon known as the Meisner Effect, making it a perfect diamagnet.

The new material developed by Mexican researchers at the UNAM achieves superconductivity at a temperature of 90 degrees Kelvin. The same team produced another material exhibiting similar properties at 150 degrees Kelvin, but it is unstable, and they have been unable to reproduce it.

Research at the Materials Institute has gone away beyond the mere reproduction of experiments. In fact, Mexican discoveries are contributing to a better understanding of superconductivity. Its causes are still unknown, as is the mechanism by which crystals are paired from the mixed materials.

The team reported its findings in *Fisica Review B*, an important scientific journal. Basically, these involve the discovery of certain vibrations of the network at very high frequencies, a phenomenon they believe may be related to superconductivity. As part of their research, the Mexican scientists added trace amounts of iron to their previous mixture of copper, barium and itrid oxides, thus creating a very strong magnetic field in the crystal (what is known as the Mosseuer Effect). A further aspect of their research involves the problem of the extremely short life span of the materials in question. In general they deteriorate rapidly, and for commercial purposes, they will need to be made more stable.

Dr. Akachi believes that we are at the dawn of a new industrial revolution. The use of superconductors has implications for all aspects of electricity and electromagnetism, that is, the generation, storage, transmission and general use of energy. Superconducting cables will be created which will be able to use electricity more efficiently. Faster and more sensitive machines will be designed, for example in the case of computers. In medicine, it will be possible to develop sensors capable of detecting small magnetic fields indicating the early beginnings of disease, as well as other instruments related to human magnetic fields. Normal superconductors are already used in medicine for brain scans, and new possibilities are still being imagined.

In terms of energy storage, the potential is boundless. At present, it is not possible to store energy in large quantities, beyond that for car and regular batteries. In the future it will be possible to store solar and oil- derived energy, as well as that derived from other non-conventional sources, such as hydrodynamic magnets or nuclear power.

Dr. Akachi added that in many of the cases given above, the technology has already been developed, although it has yet to be released on the market. All that is missing are superconductors suitable for commercial use, meaning that research in this field in the more developed countries is a race against the clock.

The research at the Intitute's Low-Temperature Laboratory demonstrates that Mexico has the scientific expertise and personnel needed to make such discoveries, and thus needs not lag behind in technological development. Nevertheless, as the superconductor specialist admits, it is impossible to compare the research infrastructure in advanced countries with Mexico's. Here it is very difficult to obtain financial support for such work because research is not tied to industry, as it is in many other countries. According to Dr. Akachi, however, this situation may be changing. Although the effort is still insufficient in relation to the needs, private firms and research centers are now joining forces in superconductor research.

The main difficulty lies in the lack of infrastructure for using the new materials. According to Dr. Akachi, Mexican industry is not equipped to take advantage of them. At present, Mexico does not produce generators, motors, computers or their components, all of which could be improved greatly with the new discoveries. Nevertheless, he believes the country is at the point that it can make plans for applying the findings in the future.

— The Program for Technological and Scientific Development 1984-1988;
— Other mid-term, sectoral programs linked to the PND;
— The National System of Researchers;
— The Law for Promoting and Coordinating Scientific and Technological Development.

Each of them will be briefly discussed below.

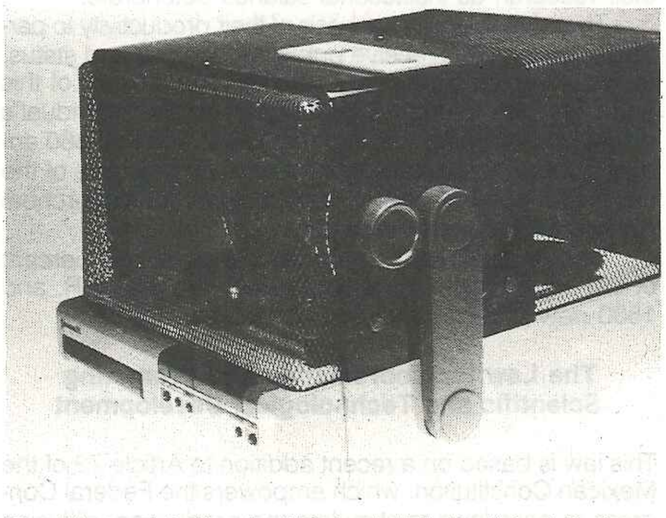
The Plan for National Development

In January 1983 the Planning Law went into effect. It established procedures for designing federal government plans with the participation of groups to be affected by them or who have expressed interest. The government was also mandated to formulate and issue a six-year Plan for National Development (PND), setting the framework for specific programs to promote the development of sectors, regions and strategic fields of activity across economic sectors. A typical example of the latter is that for science and technology.

In May 1983 the PDN for 1983-1988 was approved and issued. It established the country's objectives and priorities, decision-making procedures, working mechanisms and organizational responsibilities for the various areas of activity covered in the Plan. Also included are the policies for global, sectorial and regional development.

The PND delineates general policy for science and technology. It differs from previous global plans in an important way, namely science and technology are no longer dealt with in an isolated chapter, but rather are a constant component of most aspects of the Plan. This is an obvious pre-condition for the effective contribution of science to development.

Laboratory for the characterization of amorphous silicone materials. (Photo from the Institute of Material Research, UNAM)



"Comalli" automatic tortilla-maker. (Photo from the Unidad Académica de Diseño Industrial)

The Program for Technological and Scientific Development

In 1984 the government established this Program for the period 1984-1988. Since the Program derives directly from the PND, its provisions are intimately linked to those for a variety of economic and educational activities.

The National Council for Science and Technology (CONACYT) coordinated the design and integration of the Program. Ten major government departments, representatives from industry and academic institutions also participated. The resulting Program adds specifics and details to the PND's guidelines, with the aim of making science and technology an integral part of Mexico's development. The responsibility for implementing the Program lies with each of the participating government departments and agencies, while follow-up and evaluation fall to CONACYT.

Each of the Ministries most closely involved in the production or demand for technological development contributed a chapter to the Program. Other chapters were prepared by CONACYT, although often in close collaboration with academia and industry. Their participation was important for technical, as well as political reasons, given that the Program's ultimate success depends on having research centers, their potential beneficiaries and the government join their efforts and resources toward meeting common objectives.

The country's scientific and technological infrastructure has expanded and improved noticeably during the past 15 years

The Program is divided into five parts. The first defines the purposes, priorities and strategy for the science and tecnology policy. Part two contains specific programs for improving the national system for science and technology (a system including everything from research centers to engineering firms, from graduate schools to agencies that disseminate and popularize scientific information). Part three defines development programs for specific sectors of the economy: agriculture; communications and transportation; urban development and ecology; education; energy, mines and state-owned industry; fisheries; and health.

Part four establishes research priorities directly related to the country's major needs. These are a greater knowledge of Mexico's natural resources and environment, as well as its society; research on nutrition and health; R&D on the use of renewable and non-renewable resources; and technological deveolpment for a whole range of industries: agriculture, electronics, pharmaceuticals, petrochemicals and construction. Finally, the fifth part defines mechanisms for implementing the Program, including ways to involve industry, research institutions and local governments.

The federal government invested 700 million dollars to implement the Program in 1985. If its provisions are met, this amount will increase at least 15 percent each year through 1988. This means that the portion of the GNP devoted to science and technology will grow from 0.55 percent in 1984 to 0.78 percent in 1988 (assuming the GNP grows at an average rate of five percent per year).

Sectorial Mid-Term Programs

The Program for Technological and Scientific Development and the mid-term programs for the development of various economic sectors are mutually complementary. Each of the latter is aimed at achieving integral development within its sector, and thus includes the technological dimension among other relevant variables. In a sense then, these programs actually define portions of the science and technology policy. From this perspective, the most important mid-term programs are those for Industrial Development and Foreign Trade, Communication and Transportation, Education, Health, Ecology and Urban Development, Rural Development, Fisheries, Energy and Mining, and Forestry.

The fact that these programs all derive from the PND and are oriented toward managing technology in each sector, in accordance with the Program for Technological and Scientific Development, gives the national S&T policy unity and relevance, making it not only compatible with, but essential for overall development.

BIOTECHNOLOGY ON THE HORIZON

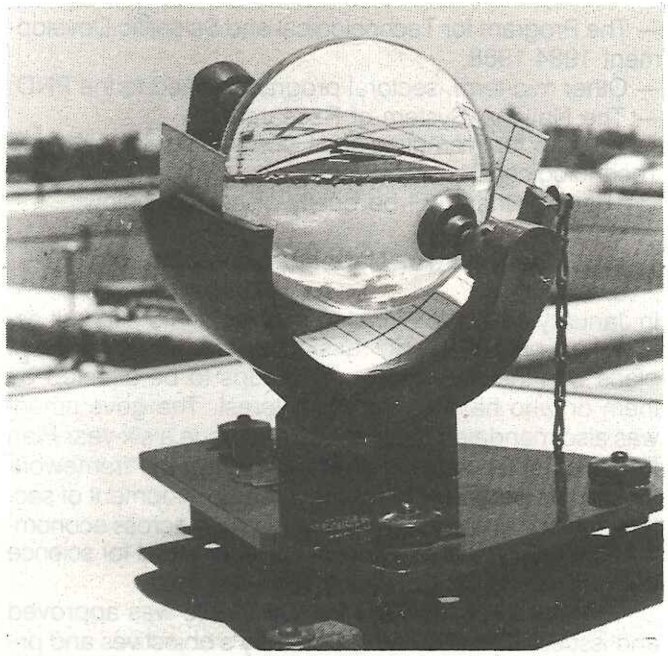
Conclusive results of research in the genetic engineering of food plants will not be known until 1990. In the meantime, several large firms are moving to monopolize initial findings in an attempt to get patents on the new products as they are developed.

It is believed that new scientific research in this field will lead to revolutionary changes in agriculture in the industrialized countries. They will be able to produce a greater variety of goods, on a larger scale, making it possible for them to eliminate imports of such products once and for all.

A similar process is already underway with sugar cane. The United States has been the largest sugar importer in the hemisphere, while the crop has been the main export product —and the basis of the economy— in many countries in Latin America and the Caribbean. One day scientists in the U.S. discovered they could make a sweetener by modifying corn starch, corn being produced in great abundance in the U.S. That discovery marked the beginning of bankruptcy for sugar producing nations.

In fact, all the agricultural products of the less-developed countries run the same risk. Likewise, this possibility increases the danger of new political and economic struggles for control of the new surpluses, which will likely be created. The most immediate danger, of course, lies in the economic problems facing the countries which will no longer be able to rely on income from traditional exports.

Mexico's situation is alarming. While other countries such as the United States, Germany, Belgium and Holland, and particularly the large multinationals, invest millions of dollars in biotechnology research, this country has only two research centers working in the area: one at the UNAM and the other in Irapuato, Guanajuato.



Solar radiation deposit, Institute of Geophysics. (Photo from La Gaceta, UNAM)

The National System of Researchers

In July 1984 another important S&T policy instrument was created, the National System of Researchers (NSR). Its aim is to encourage the best individuals working at government-supported research institutions to pursue their careers and concentrate full-time on their scientific activities. Since more than 90 percent of Mexican research institutions are funded by the government, the NSR has had two immediate positive effects. The first is the practice of evaluating all researchers simultaneously, with uniform criteria, regardless of their specialty or institutional affiliation; the other is to keep the best scientists from leaving their research as institutional salaries deteriorate.

Those selected on the basis of their productivity to participate in the NSR receive public recognition and status, as well as a supplementary income. The amount of this additional, tax-free stipend depends on the individual's professional stature, varying from US$1,560 to 9,360 annually. To promote decentralization —an objective of the current S&T policy— the stipend is higher for researchers working outside of Mexico City.

During 1984, some 1400 people (about 50 percent of the applicants) were incorporated into the NSR, and 1500 new applications were under study in 1985.

The Law for Coordinating and Promoting Scientific and Technological Development

This law is based on a recent addition to Article 73 of the Mexican Constitution, which empowers the Federal Congress to pass laws to stimulate the production, diffusion and application of the technology and scientific knowledge required by the country. The Congress then proceeded

ADVANCES IN INDUSTRIAL DESIGN AT THE UNAM

The Industrial Design School of the National Autonomous University of Mexico (UNAM) is considered one of the best in the world. Its infrastructure competes with the best, and it is the only such school in Latin America offering a masters degree.

The high regard for Mexico's School of Industrial Design is shared by Horacio Durán, founder of the school and presently coordinator of its graduate program, Carlos Daniel Soto, full-time professor of the Design Workshop, and Oscar Salinas Flores, the general coordinator of the undergraduate program, all interviewed by VOICES.

The three professionals agreed that their students' creativity is highly- valued outside of Mexico. This, they believe, is largely attributed to their rich cultural heritage, the more than 7000 years of humanistic development of Mexican society. The sad proof is that the "brain drain" in this field is extremely high.

Some of the most renowned Industrial Design School graduates who have chosen that path, include Federico Díaz de la Peña, now living in Great Britain; Federico Hess, now living in Bilbao, Spain; Daniel Hernández, living in Chicago; and Lucía Montiel, hired by the Volkswagen Company in Germany to design auto parts. There are many more Mexican designers who have found better professional opportunities in other lands.

This profession is relatively new in Mexico; the School was founded barely 27 years ago. Since then the new professionals have had to overcome academic obstacles and others derived from the Mexican tradition of importing everything, from machines, to patents, to finished products. Thus, industrial designers in Mexico face the additional task of having to modify this practice, since imported goods are often not even compatible with the customs and culture of the people who wish to adopt them.

This was one of the main arguments which led Oscar Salinas Flores to state that industrial design is still in the process of being born in Mexico. Only now is it reaching maturity and recognizing that the role of industrial designers is not limited to designing furniture, but rather includes the creation of an infinite gammit of durable and capital goods.

The three men interviewed agreed that Mexican industrialists represent the main obstacle to the development of a national, industrial design profession. They believe part of the problem is that the young Mexican industry grew out of small shops tied to family enterprises, which lacked an adequate concept of how to organize a business along modern lines. In their opinion, this small family shop mentality persists and represents a serious obstacle for industrial development.

Nonetheless, this situation may change with Mexico's new membership in the GATT, which will demand that these businesses make major changes. More modern industries will certainly require designers, and the interviewees expressed the hope that industrialists will approach the School and use it to its full capacity. They insist that it is pssible to develop a great variety of products, which are potentially competitive on the international market. This would benefit the economy, as well as people seeking new areas of investment.

One of the more interesting examples of the high-level of creativity at the Mexican School of Industrial Design is the recent development of a blood oxigenizer, vital for open heart surgery. Many believed that such a machine could never be built in Mexico. The last in stock was imported in 1982, at a cost of $700, and could not be reused. As a thesis research project, Ricardo Torres designed a new oxigenizer using only Mexican materials and costing $100. The new design has the added advantage that it can be reused. Torres' oxigenizer is presently being perfected at the Cardiology Hospital of the Mexican Social Security Institute Medical Center.

Another interesting design developed at the School is a pisciultural calibrator, a breakthrough in its field, which won a prize at the Young Inventors' International Competition in Bulgaria in 1985.

Other original designs include special wheelchairs for athletes, various types of medical instruments and a prototype for transportation adapted to Mexico's specific needs. Mexican designers have also identified problems of over-design in imported machines and instruments.

Mexican graduates are now able to develop the most complex kinds of instruments, including the famous electronic guides for telescopes used at the San Pedro Mártir Observatory in Northern Baja California. UNAM designers participated in the multidisciplinary team that built them.

The three professionals interviewed expressed the hope that Mexican industrialists will soon value the importance of the School of Industrial Design and the training it gives students. In the meantime, they continue to seek multidisciplinary efforts, many of which are already underway.

More than 90 percent of Mexican research institutions are funded by the government

to pass the Law in December 1984. It is designed to:
— establish governmental procedures for the promotion of S&T and their application;
— define basic rules for planning and executing scientific and technological activities when these lie within the domain of government ministries;
— delineate rules for coordinating federal, state and local government efforts regarding the development and application of scientific solutions for problems;
— establish mechanisms to stimulate the participation of private and/or social organizations in the production, diffusion and application of S&T in the effort to accelerate overall development.

The Law consolidates the advances in S&T made by the federal government during the two previous years. Some of the immediate results of the Law are the following:

a) The consensus reached by government, industry and academia regarding the need to coordinate and promote S&T activities was incorporated into federal law.

b) For every presidential term (six years), the federal government is obliged to formulate a mid-term program for scientific and technological development.

c) Freedom and responsibility were established as the guiding principles of scientific research.

d) Resources allocated to specific S&T programs by the federal government are non-transferable unless specific permission is granted by CONACYT and the Programming and Budget Ministry.

e) The Planning Commission for Scientific and Technological Development was created with representatives from several government agencies. The commission will be an effective tool for comparing the positions of different sectors and reconciling them into unified proposals for formulating and evaluating S&T policy.

f) Guidelines for coordination were established to maintain a unified, multi-sectorial science and technology policy and to prevent its disintegration into an aggregate of independent, sectorial policies.

Conclusions

During the last 15 years, Mexico built a scientific and technical infrastructure which, despite its small size and specific weaknesses, is already a significant asset for development

MEXICO'S TRADITIONAL EXCELLENCE IN ASTRONOMY CONTINUES STRONG

The San Pedro Mártir Observatory in Northern Baja California recently installed new instruments that revolutionize earth-based observations of the firmament. With these new additions, designed by an entirely Mexican research team, Mexico hopes to keep pace with the most modern work in the field and continue its vanguard role in the study of the solar system, a tradition maintained for more than three centuries.

The Observatory was inaugurated on September 16, 1979, and its 2.12 meter diameter telescope was also designed by UNAM researchers. It is presently considered one of the world's 12 most potent telescopes, incorporating state-of-the-art technology. The new instruments, which will help make the Observatory even more efficient, are an astronomic detector and an excentric telescope guide.

A five-member team built a system to optimize infrared observation of stars, nebulae or any other stellar objects. The photometric and infrared spectrophotometric system (SIFEI), as the detector is called, is used to detect celestial objects despite the opacity produced by background radiation, which may be stronger that the signal emitted by the stellar body.

The system involves the following components (among others): a secondary oscillating mirror that makes it possible to discriminate the noise; a photometry box where the detectors are ledged; criogenic bottles that act as detectors; and a data collecting system. This equipment registers a signal and processes it in a micro-computer, a universal transmiter-receptor, which in turn can establish communication with a printer or a larger computer, and a pulse counter used to measure the light being received.

The Observatory is also equipped with an excentric telescope guidance system. This is a new instrument with high spatial resolution adapted to the telescope. It is special because it is much thinner than all the other guidance systems currently in use, barely 72-centimeters wide and 22-centimeters high. The new system can be used at the telescope's three positions, or mirrors, as well as on other instruments such as the photometer (measures the light emitted by the stars and identifies its magnitude with various colors), the Fabry-Perot interferometer (measures whether stellar bodies are drawing closer or moving farther from earth), and the Echelle-Cassegrain spectograph (determines a star's material composition and temperature).

The excentric guidance system is basically an optronic (optics and electronics) system which receives images and relays them to a color television monitor. It consists of a detection system made of a CCD-EEV-P4310 camera adapted to a second generation image-intensifier by means of optic fibers that guide the light from one end to the other without significant loss. Along with the camera, another essential component of the new system is an intricate set of mirrors, one of which is mobile.

The excentric guide acts as an auxiliary instrument for solar system observations. After locating the particular star under study, it searches for a near-by stellar object to act as a guide star and thus prevent atmospheric changes from affecting the measurements. The guide aligns the telescope, making the axes of symmetry of the primary and secondary mirrors coincide, thus preventing blurred images. After locating a star with the mobile mirror, it sends the light signal to the detection system, where the image-intensifier amplifes it one million times. From there it is sent to the television camera, and then to a 16-inch monitor.

The researchers involved believe that the new excentric guidance system will greatly benefit astronomical observations. Astronomers will be able to make their observations from a greater distance from the telescope, and from there, control the instruments in use.

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purposes. In order to put this infrastructure to full use, policy instruments have been designed and implemented. These are expected to provide orientation, purpose and effectiveness to the march of science and technology in Mexico.

In the past, some failures could be attributed to a lack of clarity as to who was responsible for what. This is no longer the case, since the new S&T policy instruments are quite specific in assigning responsibilities. This will doubtlessly add to the system's reliability.

Yet the final results of the current science and technology policy in Mexico are still very sensitive to a number of variables. Among the internal factors, the most significant are: 1) the degree of political commitment by government, industry and academia to their new consensus regarding the need for innovation in all areas of production and to concentrate S&T efforts on the key fields and objectives identified during the process that led to the current policy; 2) the degree of governmental commitment to increase the allocation of resources to S&T at a rate about three times that projected for the GNP; 3) and the decision by industry to understand technology as a mid-to-long-term investment and so invest both in R&D, as well as in measures to increase assimilative capacity.

The most important, short-term external variable involves export earnings, since they could well affect the availability of hard currency for investing in S&T projects that show a return only in the long-run.

A Closing Note

After this paper was presented, a number of questions and

"The Lord of the Mountain", observatory in San Pedro Mártir. (Photo from La Gaceta, UNAM)

comments were made by several symposium participants. The discusants and the author agreed on the following two points:

1. Latin America's development, and Mexico's in particular, require contributions from all scientific disciplines, including the social sciences. However, it is not enough just to create research groups or institutions; in addition, specific programs and actions should be implemented in each country to facilitate the flow of information and promote stronger links between the basic sciences (universal knowledge) and the local production of goods and services. Social scientists can contribute significantly by designing appropriate ways to build these links, such that they are compatible to national history, culture and conditions.

2. The migration of scientists and other highly trained professionals from Latin America does not follow a uniform pattern. Some countries are badly affected, whereas in others, the phenomenon barely exists. In Mexico, the migration of scientists and technicians to other countries has not occurred at any significant rate; nonetheless, internal occupational migration from research to other activities does occur and has increased in recent years. The need to reinforce the links between science and the production of goods and services (point 1, above) reduces the negative aspects of this phenomenon. In fact, this occupational migration reinforces industry, government and other sectors with scientifically-minded and trained personnel, thus opening the way to dialog between those sectors and the scientific community. To avoid the risk of debilitating research in the process, the rate at which new scientists are trained must be accelerated.□