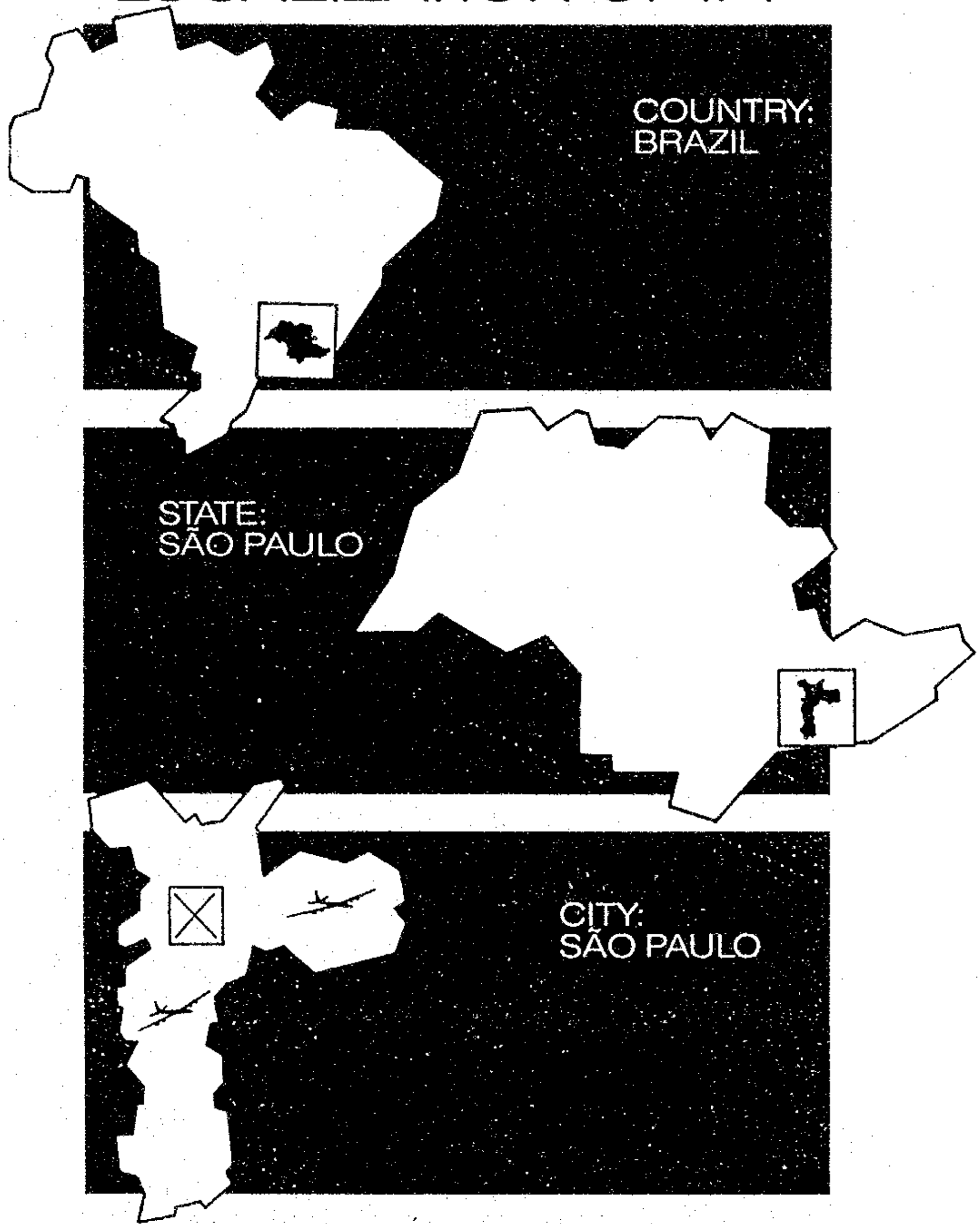
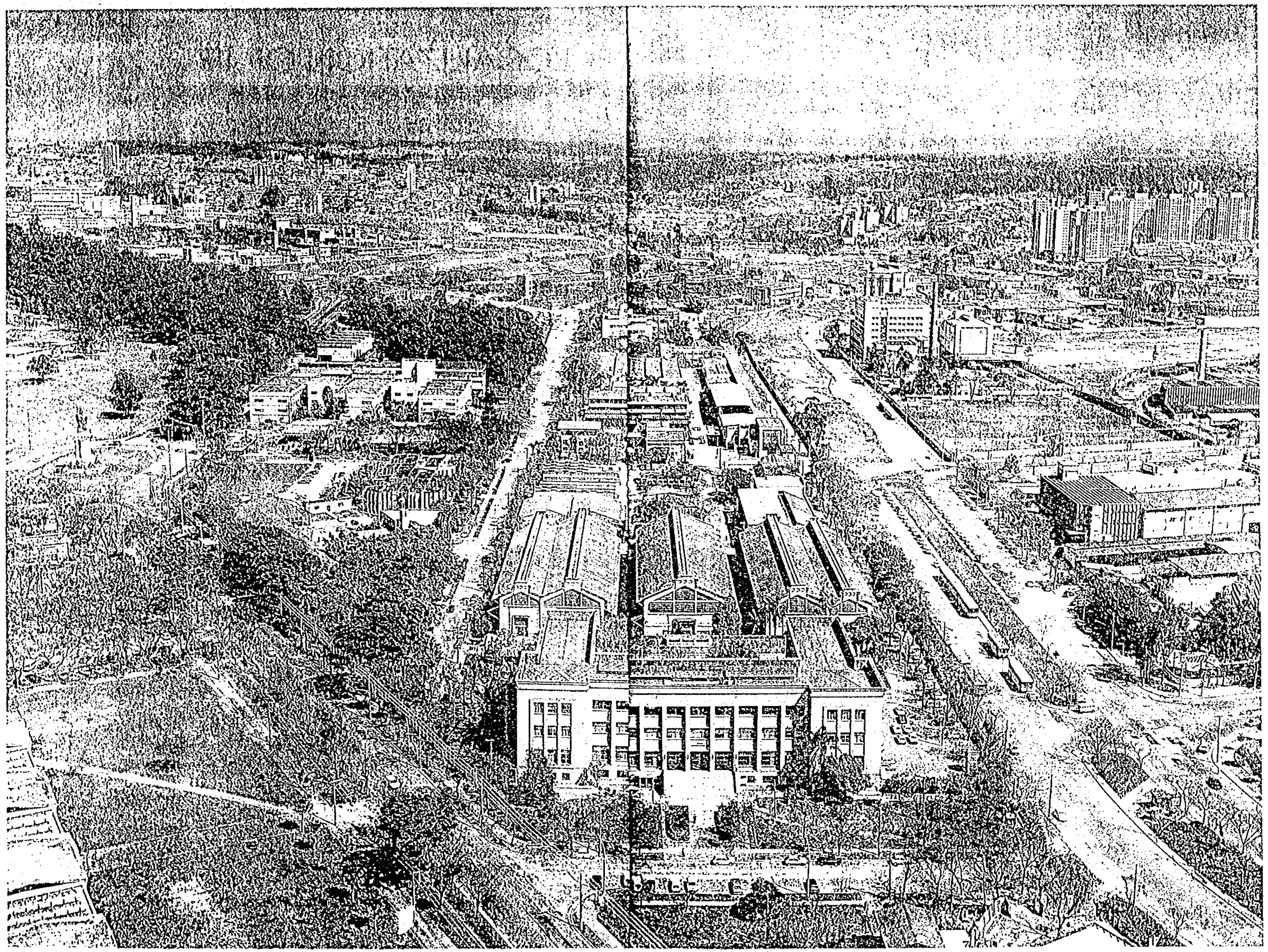
LOCALIZATION OF IPT



IPT is located on the Campus of the University of São Paulo in the Butantã region of São Paulo. It can be reached via a number of different routes: Avenida Nações Unidas (Marginal Pinheiros), Avenida Rebouças, Rua Alvarenga (Ponte Cidade Universitária), Avenida Francisco Morato (Rodovia Raposo Tavares), approximately 30 minutes from Guarulhos International Airport and 20 minutes from Congonhas Airport.



Opposite page:
aerial view

INTRODUCTION

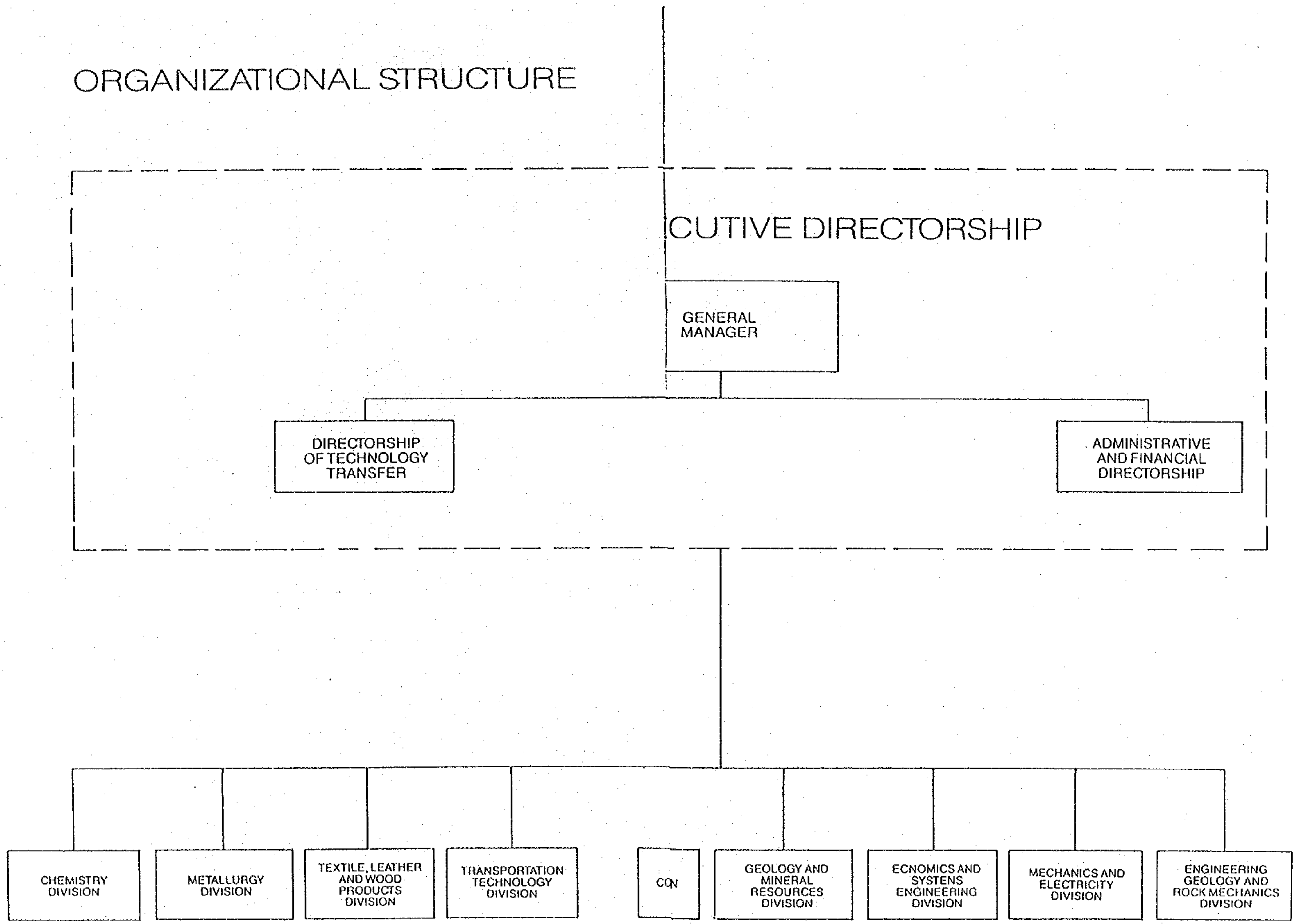
The Technological Research Institute of the State of São Paulo (IPT) has a more than 90 year history of research and application of technology to the questions of social end economic development in São Paulo and Brazil. Its history is intimately tied to the evolution of engineering and industry in São Paulo, whose needs it has frequently anticipated and also tried to meet.

The Institute began its activities as a laboratory in the Polytechnic School, founded at the end of the 19th century. Named the *Material Resistance Cabinet*, the *new laboratory concentrated* on the study of construction materials and demonstrated, early on, an undeniable vocation in the area of technological support services. This vocation resulted in successive increases in the laboratory's size in order to meet the growing demand in this market, as well as in a gradual independence.

Presently IPT still maintains ties with the Polytechnic School, as well as with the University of São Paulo, which incorporated the former as its engineering school. With an annual budget of approximately US $ 60 million, the Institute occupies a total area of 240 thousand m2 on the University of São Paulo's central campus. It employs two thousand and five hundred people and develops hundreds of industrial research projects and technical support contracts. It publishes hundreds of technical studies annually, prepares a large number of specialization courses, and promotes seminars and technical symposia, as well as playing an important role in questions of technical normalization and industrial quality in Brazil.

As its organizational structure (presented later on) reveals, IPT underwent a diversification process, creating new capabilities in order to serve the various sectors of the Brazilian industrial park.

ORGANIZATIONAL STRUCTURE



THE HISTORICAL EVOLUTION OF IPT

THE BEGINNINGS OF INDUSTRIALIZATION IN SÃO PAULO

THE MATERIALS LABORATORY OF THE POLYTECHNIC SCHOOL

Elevated to a State in the Federal Republic by the Proclamation of the Republic in 1889, São Paulo organized its administration in the last decade of the 19th century in order to translate into fact the autonomy granted in the new statutes. One of the first measures of the new São Paulo government-both Executive and Legislative - was to establish the bases for a solid public education structure in the State. Chronicles of the period shows that this was one of the central preoccupations of the leaders of the period, and the Polytechnic School of São Paulo was one of the results of this concern. The school was charged with organizing, as quickly as possible, a laboratory complex as good as those existing in other countries.

At this time, the expansion of coffee cultivation in São Paulo, developed primarily by European immigrants, was substituting the former aristocratic and slave-based system, bringing great wealth to the State due to growth in both production and exports.

The city of São Paulo, the tenth largest in the country in 1875, grew so rapidly that by the end of the century it had risen into second place in terms of population, behind Rio de Janeiro, then the national capital.

Also, at the end of the century, Brazil was developing an industrial energy potential for the first time. Hydroelectricity would allow industrial growth without total dependence on coal scarce in the country. One of the laboratories of the Polytechnic School, the Materials Resistance Cabinet, which began operations in 1899, was called upon to collaborate in two areas that were important to the development in the State. The first referred to building materials - it was important to guarantee building safety in a city that was developing very quickly. The second area was production orientation for the emergent industry, which provided basic inputs for the companies that were developing the State's infrastructure - electricity, railroads, urban transportation, water and sewers, telegraphs, etc.

The country continued to be an importer of component parts and equipment, although some degree of local production of strategic inputs proved to be a prudent measure during the foreign exchange crises and the First World War.

The short supply of electrical energy proved to be the most serious obstacle to industrial growth in São Paulo at the beginning of the century. By the early 1920's, however, the development of hydroelectric plants turned São Paulo into one of the best supplied cities in the world. São Paulo came to be known as "the fastest growing city in the world" and "the largest industrial park of South America".
The Materials Resistance Cabinet — renamed the Materials Testing Laboratory, with a significantly larger physical area — increased its role in industry. In the civil construction sector, it developed rational control techniques for concrete and offered laboratory support for the development of the first Brazilian cement. This allowed for the vertical growth of the city, based, as it was, on reinforced concrete.
In the public service area, the Laboratory helped to develop the first technical specifications publications. It supported manufacturing with laboratory tests, chemical analyses and material and process evaluations. It undertook in depth studies of certain industrial sectors, as well, such as metallurgy products, ceramics and wood derivatives, among others.

THE DEPRESSION OF 1930. THE CONSOLIDATION OF THE SÃO PAULO INDUSTRY.

The crisis of the 1930's brought foreign trade to a halt in Brazil. In the context of a complete disorientation, São Paulo industry was called upon to produce part of what could no longer be imported. This brought about a series of local developments, among them the substitution of raw materials or semi-finished products, which were imported up until this time.
The state government of the period recognized the need to expand the Laboratory, which in 1934, with the aid of local industry, became the Institute of Technological Research.
In the chemical industry sector, IPT increased its chemical analysis capacity, an essential base for nearly all types of industry. And it developed capacity in the areas of lubricants, combustion fuels, paint, varnish, rubber and others.
It increased its knowledge of metallurgy and began to offer support to industry in the important areas of heat treatment, casting, corrosion treatment as well as others.
IPT was a leader in timber preservation, the classification and identification of woods, and in the production of plywood and others. The progress obtained in this sector led to the local manufacture of gliders and small planes, which was only interrupted years later with the planning for a national aeronautical industry.
IPT undertook important studies in the late1930's with respect to the utility of clays and began to research the geology of mineral resources, through the Geology and Petroleum Section, created in 1937.
In the building sector, the Institute increased its capacity in the construction materials area, created a Structures section with the capacity to

test structures experimentally - both in miniature scale models and full scale on site tests. The Soil and Foundation Section was also established. It would guarantee the foundations of the city's new buildings as well as roadways, dams, airports, etc.

IPT, THE WAR EFFORT, AND POST-WAR INDUSTRIAL EXPANSION

In order to deal with the problems generated by the Second World War, the federal government created the Economic Mobilization Coordination and a large number of IPT technicians were called upon to integrate the Industrial Production Sector.

The objective of Brazil's economic mobilization was not the production of war material - except on a tiny scale. The intention was to guarantee the supply of essential industrial goods and promote exports of strategic materials to the Allied nations. In these two areas, IPT's activity was intense. It collaborated in the creation of a machinery and equipment industry of a significant scale which allowed for the natural expansion of the manufacturing capacity of the country.

Brazil's post-war industrial growth resulted initially in the import substitution growth model, in which formerly imported products are produced locally with imported industrial processes, projects, and machinery.

In this phase of industrialization, IPT's role was highly significant. It contributed with its experience in raw material and semi-finished products. On the other hand, these industries absorbed the Institute's specialized technicians, creating a gap in IPT's technical corps.

In the beginning of the decade of the 60's, the final years of the import substitution period were characterized by recession. The global strategy of the country continued to give priority to supplying the internal market, but it contemplated a growing role for exports, as well.

The new economic strategy focused on three different aspects. The first gave priority to economies of scale, by way of adequately sized industrial installations. The second sought a greater internalization of technology on the part of companies, and offered incentives for the development of engineering. The last aspect focused on the rational use of Brazilian raw materials, including mineral, forest, and agricultural resources.

IPT was able to contribute to the recovery of the Brazilian industrial development (which began in the second half of the 1960's) partly because it had moved to its new and ample installations on the University of São Paulo campus. Aside from this factor, the experience accumulated by the institution and its tradition in research and technical assistance fit together well with the country's economic development plans.

In this new phase of growth, IPT reevaluated its experience and background in order to re-direct its laboratory policy in a three-fold direction.

1 - Establish an experimental base for engineering in the country, within IPT's areas of specialization:

a) Provide support for product engineering in the field of materials specifications and in the experimental evaluation of models, prototypes and series heads.

b) The experimental development of productive process parameters for process engineering teams.

c) Provide support for production engineering, by way of metrology and analysis laboratories, collaborative testing, reference materials, process control assistance, quality control, the development of advanced systems production, including computer resources.

2 - Develop research to identify and characterize the use of Brazilian raw materials.

3 - Aid in the training of specialists in engineering and laboratory research.

This mission was facilitated by the existence of well prepared engineering teams in the government technical departments and firms with which the Institute maintained contacts. On the other hand, IPT was able to count on the collaboration of institutions in other countries for help in training its technicians.

The advancement of the Brazilian university training allowed IPT to diversify its research teams, recruiting specialized technicians together with engineers.

IPT AND SUPPORT FOR LARGE SCALE BRAZILIAN INFRASTRUCTURE PROJECTS

Between the end of the Second World War and the first years of the 1980's, Brazil developed successive plans to increase its transportation, energy and telecommunications infrastructure, not to mention other sectors. IPT's contribution was central to these efforts in the area of construction, thanks to its traditional capacity in the areas of construction materials, structures, soil, rock, pavement, geology and geological engineering.

IPT made a contribution in a variety of different areas of activity: local materials studies, empirical solutions research for projects, experimental determination of project parameters, instrumentation and monitoring of field work, laboratory training for technicians, and the dissemination of knowledge by way of professional associations, courses, symposia, publications, etc.

The Institute's role was best known in the area of construction, particularly in the area of hydroelectric dams and roadways, which, together, changed the physiognomy of the country. Different divisions of IPT made an equally important contribution in the areas of urban mass transportation, fluvial navigation in the Amazon Basin and the Tietê-Paraná rivers, in irrigation and underground water systems, in costal transportation systems, as well as several other areas.

In the field of mineral research, IPT intensified its presence in the 1970's, and, to a greater extent still, in the 1980's. It took part in innumerable subsoil investigations, making use of its expertise in Applied Geology, and undertaking studies in Petrology and Geology. Crowning half a century of work in the field of mineral studies, IPT undertook geological surveys and discovered a series of mineral deposits, notably in the state of São Paulo. Follow up research revealed that several of these deposits could be

exploited economically, generating new wealth.
Unlike the development of the industrial sector, plans for infrastructure enhancement were not retarded by the internal recession of the early 1960's. All sectors suffered an interruption of growth, however, with the stagnation and inflation that has plagued the economy of the country since the beginning of the 1980's, and which has yet to be overcome.

IPT'S NEW DIRECTIONS

In spite of Brazil's current problems, IPT is attempting to overcome present difficulties and develop plans that will result in new contributions to the state of São Paulo and the country. Therefore, the Expedite Analyses Center was established with an informatized structure to guarantee a fast reply to tests, analyses, and routine checks, maintaining IPT's traditional standards of quality.
IPT's organizational structure, detailed subsequently, was the result of a series of revisions carried out by its staff. Aside from the elaboration of a new structure, these changes permit an understanding of trends and objectives that are being taken into account in the institute's institutional planning.
In the first place, IPT continues to develop new areas of technical capability, although at a slower pace than before. The new CAD-CAM-CNC (computer science) Laboratory, the Optics and Film Laboratory, equipped by the East German Carl Zeiss company, and The Modelling Laboratory, initially designed to carry out materials and metallurgy experiments, are examples of IPT's recent growth in technical capability.
On the other hand, IPT is returning to an earlier tradition of collaboration with foreign institutions, offering them new experiences and receiving assistance in areas where the Institute is less proficient. It should be noted that IPT is fully capable of assimilating the contributions of more developed countries and of being understood by its less developed counterparts.
As the subsequent organizational chart shows, IPT recently created the Economics and Systems Engineering Division, divided into three different areas of expertise: Technology Economics; Prospecting and Technological Evaluation; and Systems Technology. These new areas of specialization were designed to provide information that will aid IPT to take decisions skillfully within an increasingly complex technological environment.
As a result of the Institute's experience, outside demands, and certain priorities of the state government, IPT's planning is based on the lines of inquiry described below.

INDUSTRIAL QUALITY - The Institute has been cooperating with the Consumer Protection Secretariat in quality testing of popular consumer products. This form of collaboration will be part of a much broader program designed to develop the concept of quality assurance in each sector of industry in the state of São Paulo.
In the light of the growing industrial internationalization, only those industries capable of guaranteeing quality will survive. One aspect that should be noted by the government and different institutions is that this

internationalization will de-nationalize local industry - small and medium sized firms included-unless there is solid technical support available to improve the quality of the products produced by Brazilian firms.

ENVIRONMENT - IPT's experience in the area of geology includes noteworthy studies of the physical environment, relative to urban settlements as well as to the impact of highways, dams, industrial plants, and port installations. On the other hand, IPT's different divisions backlog long-standing and diverse experience which is extremely useful in the evaluation of the impact of different sorts of industrial undertakings. Critical studies of this experience will generate a line of important contributions that IPT can offer the community.

URBAN TECHNOLOGY - Many of the Institutes areas of expertise can be used in effective collaboration with the cities of the state of São Paulo, and particularly with the city of São Paulo itself. Among these areas are: housing, urban transportation, mineral resources, water resources and sewage disposal, aside from engineering and geology. With the collaboration of the Secretariat of Science, Technology and Economic Development, IPT has developed a successful assistance program for inland cities, which could serve as the starting point for a large scale project in the future.

INDUSTRIALIZATION OF INLAND SÃO PAULO - IPT has several offices outside the capital city of São Paulo. A study of the experience of these offices, together with an examination of the possibility of increasing the municipal aid program and the development of activities linked to medium and small enterprises could accelerate inland industrialization and avoid predictable errors.

SMALL AND MEDIUM ENTEPRISE - In spite of the fact that the small and medium enterprises - essential to the development of the country - have a greater need for IPT's assistance, they did not receive direct collaboration from the institution up to the present.
With the establishment of the expedite Analyses Center, IPT is now able to provide a more direct liwe with this sector..

In short, IPT has found the means within its own experience and expertise to survive the difficulties of the moment while offering new and valuable contributions to the community.

IPT'S ORGANIZATIONAL STRUCTURE

In 1989 IPT underwent a process of administrative restructuring aimed at modernization and increased agility of action in order to attain a greater degree of technological efficiency.
The former units - eleven divisions and six centers of technological development - were regrouped into nine division in accordance with their research affinities.
The following is a technical resumé of each of these nine units, their objectives, main lines of activity, together with a succinct description of their laboratory and human capabilities.

CIVIL CONSTRUCTION DIVISION

The Civil Construction Division was constituted in 1989 as a result of the fusion of the Civil Engineering Division and the Construction Division. Its area of activity includes the field of civil construction in a broad sense: light and heavy construction, construction materials, project and planning techniques, and construction processes. It includes, moreover, environment questions related to construction and land occupation. The Construction Division undertakes technological research, consulting, specialized technical services, training, and the dissemination of technical knowledge.

ORGANIZATIONAL STRUCTURE

Components and Constructive Systems Group

- Components and Systems Laboratory
- Environmental Comfort Laboratory
- Construction Rationalization Section

Structures Group

- Structures Laboratory
- Vibrations and Structural Dynamics Laboratory

Geotechnical Studies Group

- Urban and Environmental Geotechnical Section
- Slope Stabilization Section
- Barrier Engineering Section

Transportation Infra-structure, Impermeability, and Works Group

- Railroad Infrastructure and Works Section
- Pavement and Impermeability Laboratory

Granulometric test for soil sedimentation

Fire Safety and Installations Group

- Building Installations Laboratory
- Fire Testing Laboratory

Civil Construction Materials Group

- Concrete Laboratory
- Physics and Chemistry of Materials Laboratory
- Durability, Pathology and Maintenance Section

Soil and Foundations Mechanics Group

- Soil Mechanics and On- Site Testing Laboratory
- Soil and Foundation Dynamics Laboratory
- Foundations Section

Technical and Support Sections Unconnected to Groups

- Computers in Civil Construction Section
- Instrumentation Section
- Documentation Section

MAIN AREAS OF ACTIVITY

• In the area of Geotechnics and Transportation Infra-Structure studies and analyses of engineering questions of an experimental nature are carried out, both in the laboratory and in the field, covering the area of civil engineering. These activities generally involve problems related to the stability of embankments and earth-fills, the risk of landslides in natural embankments and the risks associated with the occupation of natural embankments.

Aside from safety questions related to dams and retaining walls and complementary works, the interaction between soil and underground constructions - tunnels, foundations, galleries and buttressed excavation; the monitoring of foundation stake placement; the problems of railroad infrastructure and the paving of base structures; and questions of interaction between geotechnical engineering and the environment.

• The areas of Structures and Construction Materials contemplate questions related to the theoretical and experimental analysis of structures, their components and construction materials. These analyses focus on the static and dynamic behavior of structures and structural elements, on site and laboratory tests, as well as the conception and evaluation of prototypes. The construction materials studied include everything from the traditional materials such as asphalts, concretes and their components, as well as typical agglomerates, such as lime and cement, to alternatives, such as fibrous materials and diverse composites. Laboratory tests and studies of the long term behavior and pathologies of building materials are also carried out.

• In the area of Buildings and Components, the Division's efforts are centered on the rationalization of construction projects and processes, the technical evaluation of the performance of edifices and their components, as well as on the study - including laboratory studies - of various associated technical questions. Among these are questions of the hydrothermal and luminosity comfort of edifices, the acoustic behavior of edifices and urban noise levels, electrical and hydraulic building installations, the fire safety of edifices and their components (the circulation and toxicity of smoke and the reaction and resistance of construction materials to fire).

MAIN PROJECTS

- The geotechnical study of the Serra do Mar (SP) hillsides and the implementation of an emergency plan for the Cubatão (SP) region, subject to landslides.
- A computerized data bank of the works of art set along São Paulo's main highways and the establishment of alternative routes for oversized, extra heavy weight vehicles in these areas.
- The development of stabilization techniques, at a project level, for embankments along the SP-123 Highway between the cities of Taubaté and Campos do Jordão, as well as a performance analysis.
- The development of a Brazilian technology for offshore stake driving and its application the Campos basin and in basins in the Northeastern region of the country.
- The development of alternative agglomerates to Portland cement, using industrial furnace residues.
- Nationalization of laboratory test equipment and theoretical/experimental analysis of non saturated tropical soils.
- Development of new construction materials using metallic fibers, non-metallic organic minerals in cement and other matrices.
- Analysis of the safety of retaining walls and complementary

works - using soundings by geotechnical instrumentation, among other methods-and the establishment of technical directives for their maintenance and recuperation.

- The performance evaluation of various innovative construction methods for low cost housing developed for COHAB (Metropolitan Housing Commission) in São Paulo.
- Development and implantation of various prototypes of housing units constructed with wood, for use in the states of São Paulo, Paraná and Amazonas.
- The preparation of energy consumption rationalization plans for temperature control systems in buildings as well as the development of theoretical methods for their analysis.
- Technical assistance for studies, projects, and quality control in construction projects such as roads, railways, subways, retaining walls and dams, foundations, structures, residential complexes, buildings, silos, and others.

ECONOMICS AND SYSTEMS ENGINEERING DIVISION

The objective of this division is to offer support for technological projects and programs aimed at increasing industrial productivity, a goal that has been translated into four basic areas of investigation: the relationship between the economy and technical progress; prospection, evaluation and planning of technological innovations; market opportunity studies related to new products and processes; and the rationalization of industrial production processes.
With a highly specialized, full-time technical core, the Division attempts to approach its research from a multi-disciplinary perspective, developing projects that are capable of identifying the relationship between overall industrial behavior and the generation, transfer and incorporation of specific technologies in each productive segment.

ORGANIZATIONAL STRUCTURE

The Technology Economics Group

- Industrial Economics Section
- Industrial and Technological Policy Section
- Technical and Economic Project Analysis Section

Technological Prospection and Evaluation group

- Technological Prospection Section
- Information and Technological Evaluation Section

Systems Technology Group

- Systems Modelling Section
- Artificial Intelligence Section

Documentation Center

MAIN AREAS OF ACTIVITY

- Investigation of the dynamic of incorporating technological progress to economic activities.
- Analytical support of projects in which the technological variable is of crucial importance.
- Support of private or public policies and programs that involve technological questions.
- Development of technology analyses, with subsidies to formulate Research and Development strategies for Research Institutes and the Private Sector.
- Improvement of proficiency in the development of models and methods, mathematical and computer instruments aimed at increased efficiency and rationalization of industrial production.

MAIN PROJECTS

- Performance of technological and industrial research institutes in Brazil.
- Projection of fertilizer demand, 1987-1995 - National Fertilizer Plan.
- Support for a Thermal Plasma Strategy at IPT.
- Development and implementation of an integrated energy planning system: studies of industrial sectors.]
- Research and analysis of mineral production in the state of São Paulo.
- Cargo distribution in the National Steel Company (CSN).
- Perspectives for the supply of electricity intensive products: steel, aluminum, pig iron and iron alloys.
- Modernization of Industrial Technology - (PATI). Diagnosis and recommendations in the area of technological development of industrial segments.

GEOLOGY AND MINERAL RESOURCES DIVISION

Operates in the areas of Geosciences, Mineral and Water Resources, aimed at improving the understanding of the Brazilian physical environment; refining the available tools of mineral research and scientific investigation; carrying out basic and thematic research at a reference level in the various fields of Geosciences; testing and improving methods of materials and natural processes research; studying the dynamics of aquifers; developing and improving methods for the technological capacitation of natural resources; determining environments favorable to mineralizations, including the demarcation of reserves.

ORGANIZATIONAL STRUCTURE

Regional Geology Group

- Stratigraphy Section
- Tectonics Section
- Rocky Massifs Structural Modelling Laboratory

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Geo-dynamics Group

- Geomorphology and Sediment Dynamics Section
- Neotectonic and Seismicity Section
- Sedimentology Laboratory

Economic Geology Group

- Exploratory Models Section
- Prospection and Mineral Research Section
- Geochemical Laboratory
- Mineral Planning Section

Petrology Group

- Petrology Laboratory
- Mineralogy Laboratory
- Mineral Formation Characterization Laboratory

Applied Geophysics Group

- Seismic Methods Laboratory
- Electrical Methods Laboratory
- Potential Methods Laboratory
- Geothermic Laboratory

Hydrogeology Group

- Hydrogeology Laboratory
- Aquifer Pollution and Hydrogeochemical Section

Geo-mathematics Group

- Geology Data Bank and Specialist Systems Section
- Digital Cartography Section
- Image Processing and Cartographic Planning Laboratory

MAIN AREAS OF ACTIVITY

· Geological mapping, characterization of regional geological factors and the establishment of geological evolution models, perfecting current techniques or adapting them to the conditions of the country.

· Research on the geological processes responsible for the evolution of the surface of the earth crust in emergent or submerged areas.

· Development and adaptation of methods of prevision, localization, evaluation, characterization, and dimensioning of mineral deposits, in order to minimize the costs and risks inherent to the activity.

· Analyses in the area of mineral economics.

· Study, identification and characterization of mineral substances (rocks, sands, minerals or soils) with various objectives, including petrogenetic studies of rocky massifs.

· Application of hydrogeological knowledge to the analyses of subterranean water as a resource; evaluation and prevention of effects resulting from the interaction between human activity and the hydrogeological system.

- Application, improvement and interpretation of geophysical tests to the areas of Mining, Geology of Engineering, Rock Mechanics, Soil Mechanics, Hydrogeology and Basic Geology.
- Research and development of mathematical, statistical or computational models in the various fields of Geosciences.

MAIN PROJECTS

- Geological Map of the State of São Paulo -1:500 000 scale.
- Geomorphological Map of the State of São Paulo 1: 1 000 000 scale.
- Map of Mineral Occurrences and Ore Deposits in the State of São Paulo - 1: 500 000 scale.
- Studies of port area dynamics em Santos (SP), Guarás (Paraná), Sepetiba Bay (Rio Grande do Sul) and Foz de Itajaí (Santa Catarina).
- Regional geochemical prospecting in various areas of the state of São Paulo.
- Characterization of the potential utilization of carbonaceous rocks in the State of São Paulo.
- Reconstitution of the genesis of mineral deposits.
- Petrogenetic modelling of granite massifs in Mandira (SP) with the objective of reconstituting the evolution of mineral deposits.
- Evaluation of the potential utilization of geothermic energy in the Presidente Prudente region (SP).
- Systematic study of mineral exploitation in granite rock formations.
- Geological mapping of the Paraíba Valley region (SP), 1: 50 000 scale.
- Evaluation of mineral potential in various regions of the state of São Paulo, such as the Vale do Ribeira, Pilar do Sul, and Franca.
- Catalog of ornamental rocks of the state of São Paulo.
- Specialist System for mineralogical identification.

DIVISION OF GEOLOGICAL ENGINEERING AND ROCK MECHANICS

This division carries out research, services and technological development linked to the understanding and transformation of the natural physical environment to enable the occupation and use of its resources in a socially, economically, and ecologically balanced manner. The Division studies surface dynamics, investigates and characterizes the stress-strain state of the crust, as well as characterizes natural materials in terms of their properties, structures and behavior. This information is used as geological, geotechnical and geomechanical subsidies for the preparation of projects, and the implantation and occupation of civil engineering and mining undertakings.
The application of this information allows an harmonic integration between the use and occupation of the land and the preservation of the environment.

ORGANIZATIONAL STRUCTURE

Geology Applied to Civil Works and Mines Group

- Investigation Methods and Techniques Group
- Characterization and Classification of Rocky Massifs Section
- Rock Hydraulics and Rocky Massifs Treatment Laboratory.

Rock Mechanics Group

- Rock Mechanics Laboratory
- Instrumentation and Rocky Massif Sounding Section
- Rock Dynamics Section

Rock Engineering Group

- Rocky Massif Stabilization Section
- Modelling and Data Treatment Section
- Systems and Models Development Laboratory

Geology Applied to the Environment Group

- Landslides Section
- Erosion and Silting Section
- Geotechnical Cartography Section
- Environmental Impact Section
- Soil Physics Laboratory

MAIN AREAS OF ACTIVITY

- Engineering Geology and Rock Mechanics applied to the stability of civil and mining excavations in rock, hillsides and earth embankments.

- Geological and geotechnical studies applied to environmental impact, industrial use and land occupation.
- Research on fragmentation, perforability, and scarificability of rocks.
- Preparation of risk maps and seismic criteria, and mining safety.
- Preparation of geotechnical charts.
- Prevision and control of erosion, slide and wash processes.
- Data banks, modelling and simulation in Engineering Geology and Rock Mechanics.

MAIN PROJECTS

- Landslides in the Serra do Mar (SP) - Directives for the establishment of a Civil Defense prevention plan.
- Orientation for erosion control in the state of São Paulo.
- Development of a methodological outline and assessment of techniques for studies of the environment impact of mining activities in the state of São Paulo.
- Compulsory normalization, training and special services for the use of explosives in mining near urban areas or buildings.
- Special geomechanical tests in rock galleries — barrier support in the Tijuca Alto arc. Safety analyses, dimensioning and development of geomechanical techniques in gold mining (Morro Velho), copper mining (Caraibas), potassium mining (Petromisa) and carbon mining (mines in the states of Santa Catarina and Rio Grande do Sul).
- Directives and technical support for the stabilization project of the Itararé hill in São Vicente (SP).
- Geological/geotechnical studies designed to define the Funil and Batatais axes of CESP's (São Paulo Electrical Company) dam in the Ribeira Valley (SP).
- Follow up and inspection of the geological-geotechnical investigations of construction sites in Porto Primavera, Rosana, Taquaruçu, and the Alcohol Hydro-duct (all in São Paulo state).
- Geological engineering applied to Eletropaulo (São Paulo Electrical Company) dam construction sites in Rasgão and Pirapora.
- Technological support for agricultural irrigation in the municipality of Guaíra (SP).

FOREST PRODUCTS, TEXTILES AND LEATHER DIVISION

This division has more than 100 employees and one third of them are university graduates. It's basic strategy is to work with the productive sector in an effort in ensure constant technical progress and the improvement of its competitiveness in the areas of wood, textile, and leather. Consisting of six specialized technical areas, the Division's main objectives are: to develop and promote new technologies for production as well as for raw materials processing industries; to offer support for product improvement and the perfection of modern production techniques.

ORGANIZATIONAL STRUCTURE

Basic Wood Properties Group

- Wood Anatomy and Identification Laboratory
- Physical and Mechanical Wood Properties Laboratory

Wood Preservation Group

- Entomology Laboratory
- Mycology Laboratory
- Chemical Analysis Laboratory

Forest Based Industries Group

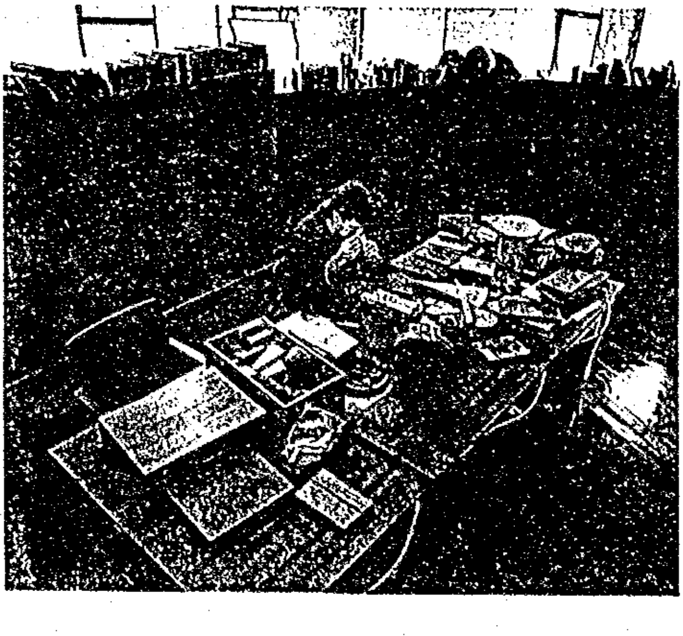
- Drying Laboratory

Cellulose and Paper Group

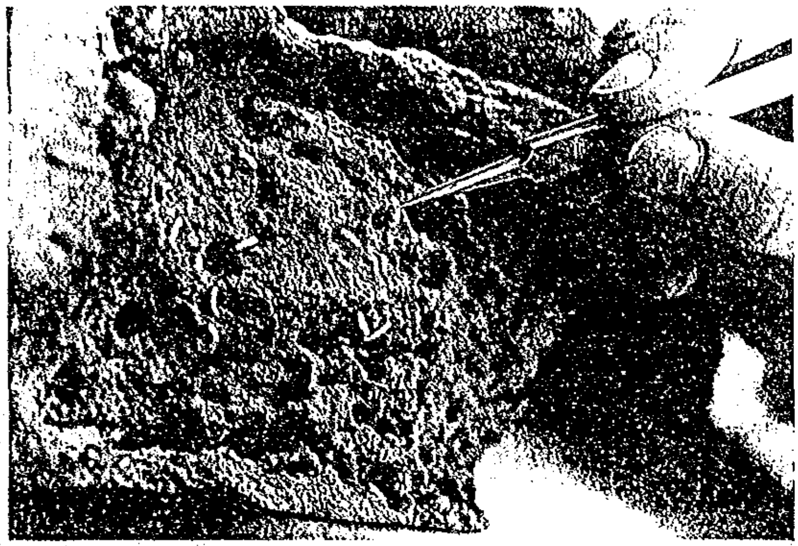
- Pulp Laboratory
- Physical and Chemical Testing Laboratory

Textile Products Group

- Chemical and Physical Testing Laboratory for Textiles - São Paulo (SP)
- Chemical and Physical Testing Laboratory for Textiles - Americana (SP)



Wood Collection with approximately 18,000 commercial samples for macro and microscopic anatomical identification



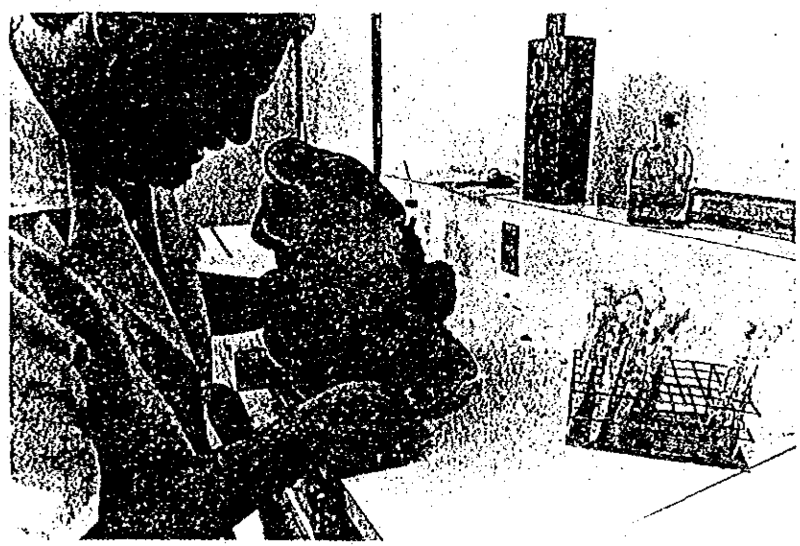
Termite collection in building components for identification and control

Leather and Shoe Technology Group

- Physico-Chemical Laboratory
- Prototype Laboratory

MAIN AREAS OF ACTIVITY

- Anatomy, identification, physical and mechanical properties of wood.
- Development of wood preservation products and identification of deterioration agents.
- Primary and secondary processing and end-product uses of wood.
- Pulping and bleaching of cellulose; paper and conversion.



Botanical identification of rot fungi - Slide mountings for microscopic analysis

· Characterization and identification of textile products and fibers and the development of textile products.
· Characterization and development of raw-materials for shoes and the development of testing equipment for leather and shoes.

MAIN PROJECTS

· Crossarms from reforestation woods.

Intense termite attack in bibliographic material

· Formation of alkaline paper.
· Utilization of residual fibers available in Brazil as possible substitutes for asbestos in asbestos fiber products.
· Conformity testing of tennis shoe.
· Selection of Amazon native woods for the production of

crossties for the Carajas Railway and their quality control.
. Physico-chemical behavior of eucalyptus resin and its implications in the formation of pitch.
. Development of quality control machinery for shoes and components.

MECHANICS AND ELECTRICITY DIVISION

The objective of this division is to contribute to the development of mechanical and electrical engineering, carrying out research and providing specialized technical services for the appropriate industrial sectors.

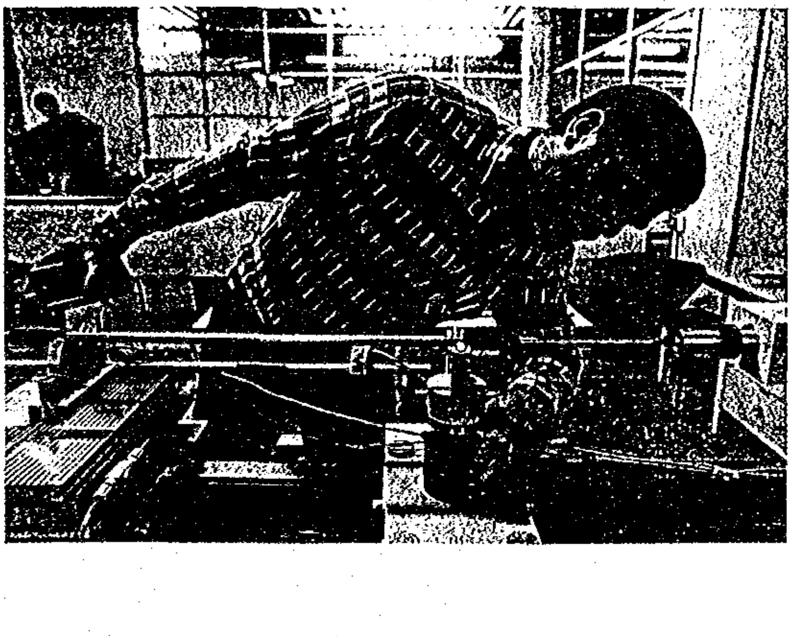
ORGANIZATIONAL STRUCTURE

Technology and Manufacturing Automation Group

- Manufacturing Technology Laboratory
- Projects and Automatized Production Process Section
- Optics and Fine Films Laboratory
- Development of Industrial Equipment Division
- Thermal Plasma Experimental Unit

Metrology and Evaluation of Equipments and Instruments Group

- Metrology Laboratory
- Outflow Measurement and Flow Machine Laboratory
- Mechanical Evaluation of Materials and Components Laboratory
- Dynamic Testing and Vibration Laboratory



Gauging of standard bars for micrometer adjustments in linear measurement machine.

Control Systems Group

- Systems Section
- Digital Electronics Laboratory
- Control Systems Evaluation Laboratory

Thermal Engineering Group

- Combustion and Gasification Laboratory
- Refrigeration Cycles and Air Conditioning Laboratory
- Power Cycles Section
- Thermal Measurement Laboratory

Motors Group

- *Motors Laboratory*
- Motor Combustion Laboratory

Technology of Electrical Equipment Group

- Gauging and Evaluation of Electrical Measurement Instruments Laboratory
- Evaluation of Materials and Electrical Equipment Laboratory
- Electromechanical Actuator Laboratory

MAIN AREAS OF ACTIVITY

• Improvement of Industrial Quality. This line of work involves the *activities of the Metrology and Equipment Evaluation* Group and Instruments and Electrical Equipment Group, and is based on measurement laboratories that constitute the National Calibration Network. Industrial measurements,

Utilization of CAD for plasma torch projects in metallurgical processes evaluation testing and the development of equipment and instruments are carried out in order to judge performance and durability, as well as to certify conformity.

- Manufacturing Automation. This area involves the activities of the Technology and Manufacturing Automation Group and Control systems Group via research and development of project and manufacturing techniques, automatized manufacturing systems and production process planning.
- Process Control. This area involves the Control Systems and Thermal Engineering Groups. Its objective is the development of systems of control for industrial processes.
- Conversion, Conservation and Utilization of Energy. This area involves activities of the Thermal Engineering and Motors Groups. Its objectives are the optimization and development of equipment and systems that involve thermal energy conversion processes, from both conventional and alternative sources, with lower pollution emission levels.

MAIN PROJECTS

- Preparation of energy conversion manuals for the cement, cellulose and paper, ceramic, textile, glass, foundry, fertilizer, metalworking, sugar, and alcohol sectors.
- Construction of a nozzle chamber for fan testing.
- Installation of a Thermal Plasma Experimental Unit.
- Combustion of asphalt emulsion residues in water (RASF).
- Utilization of ethanol and methanol in motors.
- Design and construction of a horizontal broach.
- Elevator control system for up to 64 stories.
- Evaluation and rationalization of energy consumption in air conditioning systems.
- Assessment of operating conditions of GCC combustible compressed gas run motor.
- Development of a measurement sublance for steel convertors.

METALLURGY DIVISION

The present Metallurgy Division is the result of the union of the former Metallurgy and Mineral Ore Treatment Divisions.
Its fundamental objectives are research and development of metallic materials, involving everything from raw materials, basic inputs and processes for obtaining metals to the refinement and elaboration of alloys, product metallurgy, with conformation and detailed technological characterization in every phase.

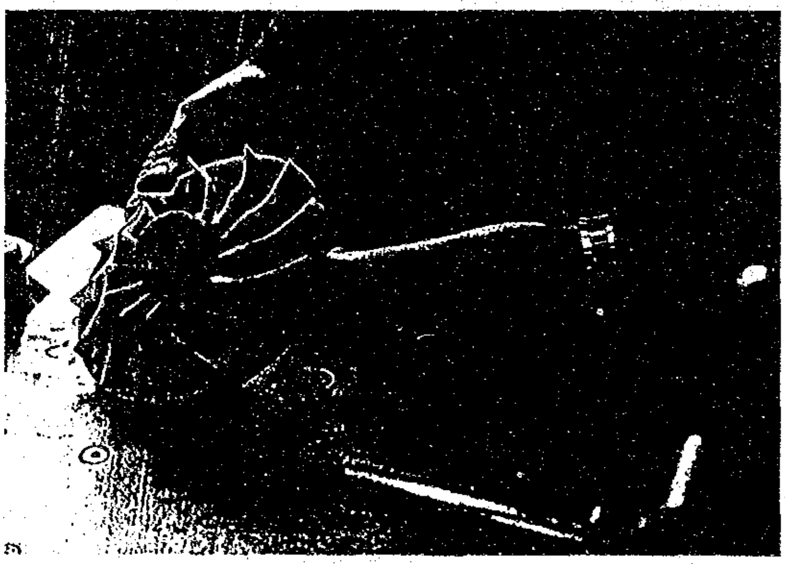
ORGANIZATIONAL STRUCTURE

Characterization of Metallurgical Products Group

- Metallurgy Laboratory
- Welding and Special Tests Laboratory
- Corrosion and Electrodeposition Laboratory

Metal and Alloys Preparation Group

- Dust Metallurgy and Magnetic Materials Laboratory



Wax model for precision casting

- Process Metallurgy Laboratory
- Analytical Support Laboratory

Metal Casting and Mechanical Working Group

- Casting Laboratory
- Mechanical Transformation Laboratory

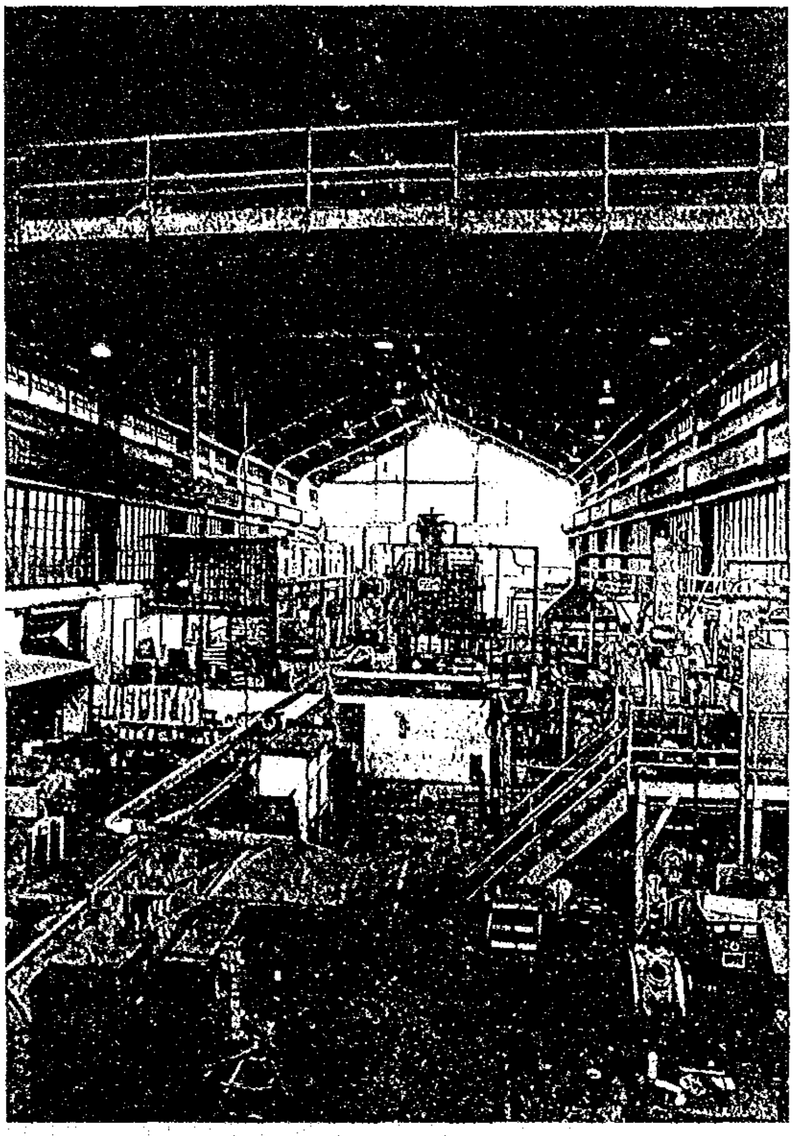
Mineral Ore Treatment Laboratory

- Mineral Ore Enrichment Laboratory
- Metallurgical Raw Materials Laboratory
- Extractive Metallurgy Laboratory

MAIN AREAS OF ACTIVITY

. Characterization of the microstructure, mechanical properties and corrosin resistance of metallic materials and products.
. Prediction and performance evaluation, damage and failure analysis.
. Design or specification of metal alloys to attain predetermined performance standards.
. Development of alloys (product metallurgy) and refinement processes and the elaboration of metals (process metallurgy) executed in a integrated fashion, including the preparation of metallic raw materials and other specific inputs, the alloy elaboration process and its processing, up to obtaining the final metallurgical products, its chemical and physical characterization and the evaluation of its in service performance.

Overall view of the Metals and Alloys Preparation Laboratory (front), and Mechanical Transformation laboratory (rear).



MAIN PROJECTS

- Study of the corrosion of motor components caused by hydrated alcohol.
- Atmospheric corrosion.
- Study of cracks in welded tracks.
- Development of rare earths magnets.
- Purification of metallurgical silicon.
- Sinterized iron-silicon alloy for magnetic applications.
- Development of precision aluminum alloy casting.
- High chrome mill balls of cast white iron.
- Consolidation for extrusion of high resistance aluminum dust.

. Technological characterization and exploratory study of mineral ore concentration in the Itaoca massif in São Paulo: wollastonite and scheelite.

. Magnesium extraction and purification of ammonia chloride from refuse and, asbestos processing.

TRANSPORTATION TECHNOLOGY DIVISION

The objective of the Transportation Technology Division is to support the development of Brazilian roadway, water, and railway system, as well as to promote research and projects applicable to industries, transportation companies and oceanic systems.

ORGANIZATIONAL STRUCTURE

Water Transportation Group

Operation of an extrusion press

Hydrodynamics Group

- Experimental Hydrodynamics Laboratory

Railroad Development Group

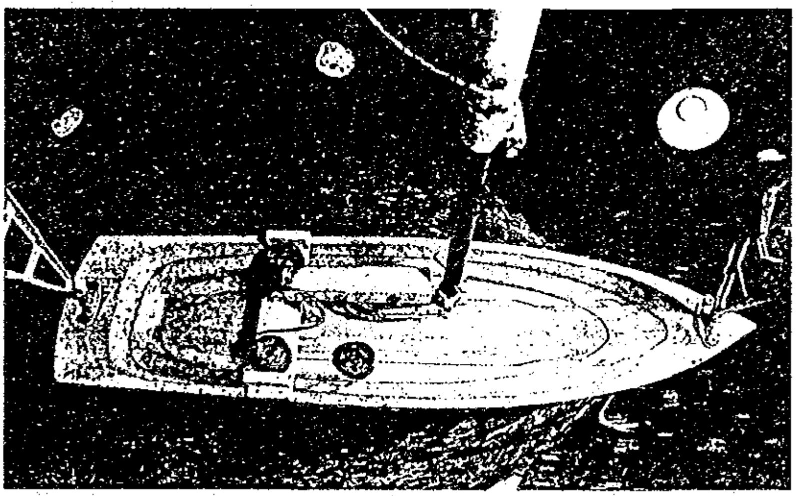
- Dynamic Testing Laboratory for Vehicles and Components

Logistics and Transportation Group

- Packaging and Packing Group

MAIN AREAS OF ACTIVITY

. Development of studies, research and projects related to waterway systems (naval and metallic structural projects in general).
. Economic-operational study of systems of water transportation.
. Basic and contract projects related to ships and port terminals.
. Studies of the dynamic behavior of naval structures.
. Operation of the only testing tank in the Southern Hemisphere as well as a cavitation tunnel to study ship models.
. Theoretical and experimental studies of propulsion resistance and auto-propulsion of ships and floating, semi-submerged, and submerged structures.
. Studies of the dynamic behavior of ships and oceanic systems in calm and rough waters.
. Evaluation of hydrological and oceanic equipment.
. Development of electronic systems to support model testing and measures in full scale.
. Development of research and projects that contribute to increase highway and railway capacities and productivities.
. Evaluation of equipment performance, laboratory tests and development of instrumentation.
. Capacity to evaluate and test the performance of vehicles and trains, as well as to model and mathematically simulate their dynamic behavior.
. Development, evaluation and performance testing of systems, equipment, and railway components.
. Research to optimize the structure and operation of cargo and passenger transportation.
. Development of computational systems for programming and management of transportation systems.
. Development of demand studies and evaluation of systems of cargo transportation.
. Promotion of technological development in the area of packaging and containers.



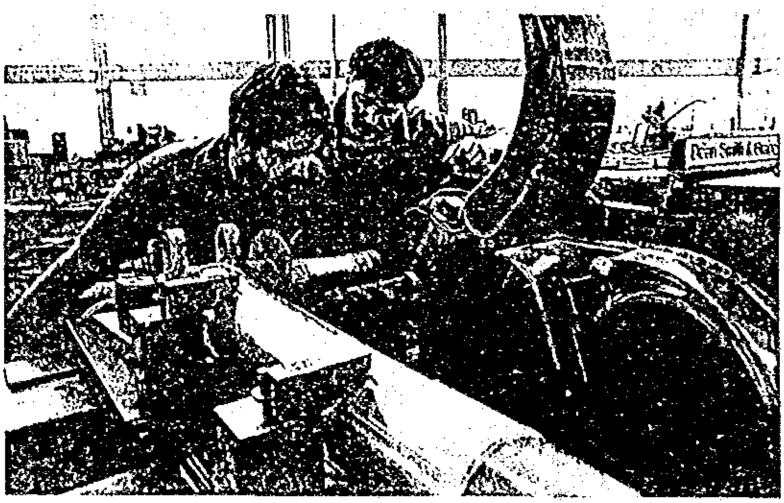
Production of lateral waves with a reduced scale model in movement and during a propulsion resistance test

- Users manual for projects of passenger and cargo ships.
- Project of tugboats and barges to re-equip the shipping service fleet of the La Plata Basin and of the Navigation Company of Amazônia.
- Dimensioning of the port tugboat fleet for the Ponta da Madeira Port in the state of Maranhão.
- Navigability study of the Araguaia river through an experimental convoy.
- Study of the maneuverability of a tanker ship through a reduced scale radio-commanded model, with on-board microcomputer control.
- Study and evaluation of a linear motor with low speed ignition for urban transportation.
- High speed train operation program.
- Cargo system improvement program.
- Viability study of the waterway transportation system in the Tibagi-Paranapanema river basin.
- Technical assistance for municipalities implementing integrated transportation systems (Piracicaba, Sorocaba, Mogi-Guaçu, and Campinas, SP).
- Methodological research for testing packing materials and to formulate projects of norms for packaging.

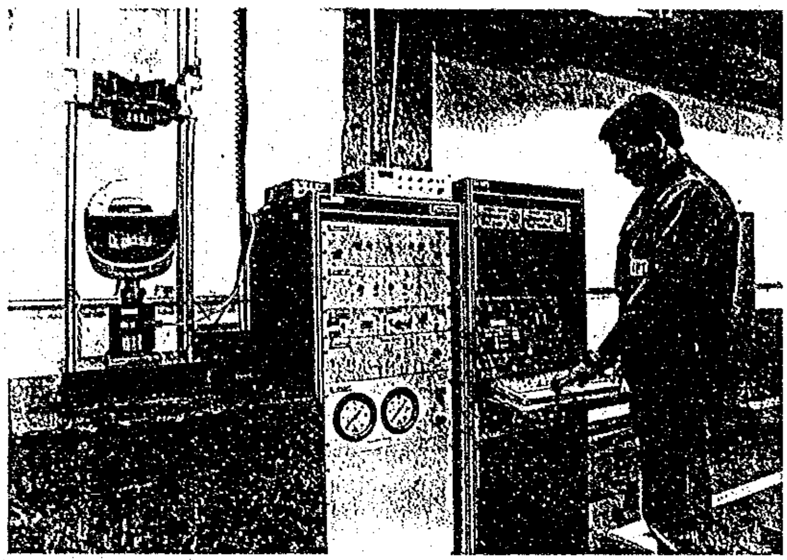
CHEMISTRY DIVISION

The Chemistry Division was constituted in 1934 from laboratories whose principal activity was to execute tests and analyses, as well as consultation and the elaboration of norms and reports for outside clients. The research and development activity started in certain sectors in the beginning of the 1970's.

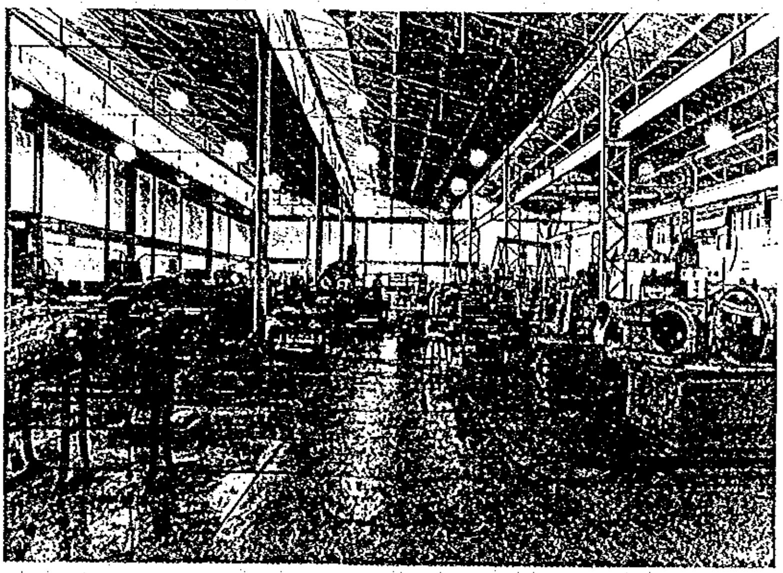
Among the Division's priorities are the development and improvement of chemical and biotechnological processes in order to provide industry and governmental organs with the necessary support for the resolution of



Development of complex milling for special parts



Motorcycle helmet impact test in the packaging laboratory



Partial view of the manufacturing laboratory

technological problems inherent to the sector. The Division also offers support for small, medium, and large companies by carrying out tests and analyses, offering consulting services, and producing certified reference materials.

ORGANIZATIONAL STRUCTURE

Chemical Analyses and Reference Materials Group

- Inorganic Chemical Analyses Laboratory
- Organic Chemical Analyses Laboratory
- Inorganic Reference Materials Laboratory
- Organic Reference Materials Laboratory

Bacteria cultivation for nitrogen fixation to legumes

Biotechnology Group

- Industrial Fermentation Laboratory
- Industrial Microbiology Laboratory
- Residue Biological Treatment Laboratory

Chemical Processes Group

- Process Analysis Laboratory
- Chemical Reaction Laboratory

Inorganic Products Group

- Raw Materials and Inorganic Products Characterization Laboratory
- Catalysis Laboratory
- Ceramics Laboratory
- Fertilizer Laboratory

Organic Products Group

- Lubrication and Combustion Laboratory
- Organic Product Development Laboratory
- Polymeric Materials Laboratory
- Industrial Microbiology Laboratory

MAIN AREAS OF ACTIVITY

. Development of research and studies in biotechnology and ceramic processes.
. Studies and development of processes of industrial interest.
. Characterization and qualification of raw materials and organic and inorganic products such as: paints, rubber, plastics, combustibles, lubricants, catalysts, fertilizers, ceramics

and glass, and others.
- Technological support for industry through tests, analyses, and specialized consulting.
- Development of analytical methodologies.
- Preparation of certified reference materials.
- Coordination of inter-laboratory programs and metrological reliability studies.
- Development of new Products.
- Courses and apprenticeships for technical workers of industries, institutes and universities.

MAIN PROJECTS

- Production of Vitamin C: data gathering for the conversion of sorbitol into sorbose by fermentation.
- Evaluation of used lubricating oils with the objective of reducing consumption and improving preventive maintenance of motors.
- Development of catalysts and catalytic convertors for vehicle emissions.
- Comparative study of the physical characteristics of tempered and laminated glass for use in the automobile industry.
- Nucleus of industrial crystallization processes.
- Preparation of certified reference material (benzoic acid) for the standardization of equipment.
- Study of vehicles for agricultural inoculations.
- Biochemical and microbiological studies of anaerobic digestion of urban waste.
- Development of a tubular reactor for the production of granulated fertilizers.

Partial view of the ceramic oxide pilot plant

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1899 - STRENGTH OF MATERIALS BUREAU FROM THE SÃO PAULO POLYTECHNIC SCHOOL (EP-SP)

1926 - MATERIALS TESTING LABORATORY FROM THE SÃO PAULO POLYTECHNIC SCHOOL (EP-SP)

1934 - INSTITUTE FOR TECHNOLOGICAL RESEARCH (IPT) - ANNEX TO THE UNIVERSITY OF SÃO PAULO (USP)

1944 - INSTITUTE FOR TECHNOLOGICAL RESEARCH (IPT-SP) (INDENPENDENT INSTITUTE)

1976 - INSTITUTE FOR TECHNOLOGICAL RESEARCH (IPT-SP) (NON-PROFIT CORPORATION)

STRATEGIC AND STATUTE MISSIONS

1. INSTRUMENT FOR PUBLIC POLICIES

   SUPPORT IN SOLVING TECHNOLOGICAL CHALLENGES OF GOVERNMENT PLANS, PROGRAMS AND PROJECTS.

2. TECHNOLOGICAL SUPPORT TO INDUSTRY

   OFFER OF TECHNICAL ASSISTANCE TO SOLVE CURRENT PROBLEMS, TECHNOLOGY TRANSFERENCE AND TECHNOLOGY DEVELOPMENT FOR INDUSTRY

3. TECHNOLOGICAL COMPETENCE AND SKILLS

   TECHNOLOGICAL COMPETENCE IN HUMAN AND MATERIAL RESOURCES TO IMPROVE SOCIAL AND ECONOMIC RETURN FROM INVESTMENTS IN SCIENCE AND TECHNOLOGY.

ACTIVITIES

- RESEARCH AND DEVELOPMENT
- TECHNICAL STUDIES
- SPECIALIZED TECHNICAL SERVICES
- EXPERIMENTAL PRODUCTION
- KNOWLEDGE DISSEMINATION
- TRAINING
- ADMINISTRATIVE SUPPORT

OBJECTIVES

- MANAGE R&D ACTIVITIES IN ORDER TO ACCOMPLISH IPT's MISSION, PARTICULARLY TECHNOLOGICAL SUPPORT TO INDUSTRY

- TO TAKE PRIORITY TO TECHNICAL STUDIES FOR INVESTMENTS IN PUBLIC POLICIES AND SUPPORT TO THE PRODUCTIVE SECTOR

- INCREASE AND IMPROVE THE SUPPORT TO THE PRODUCTIVE SECTOR THROUGH SPECIALIZED TECHNICAL SERVICES

- STRENGTHENING OF IPT IN TECHNOLOGICAL ASSESSMENT TO GOVERNMENTAL PROGRAMS AND PROJECTS THROUGH SPECIALIZED TECHNICAL SERVICES

- KNOWLEDGE DISSEMINATION FOR THE PRODUCTIVE SECTOR AND GOVERNMENTAL ORGANIZATIONS

- STRENGTHEN INDUSTRIAL QUALITY THROUGH DISSEMINATION OF SERVICES IN INDUSTRIAL BASIC TECHNOLOGY (METROLOGY, NORMALIZATION AND INSTRUMENTATION)

- TO IMPROVE TECHNOLOGICAL RESOURCES BY MEANS OF A LARGE TRAINING PROGRAM

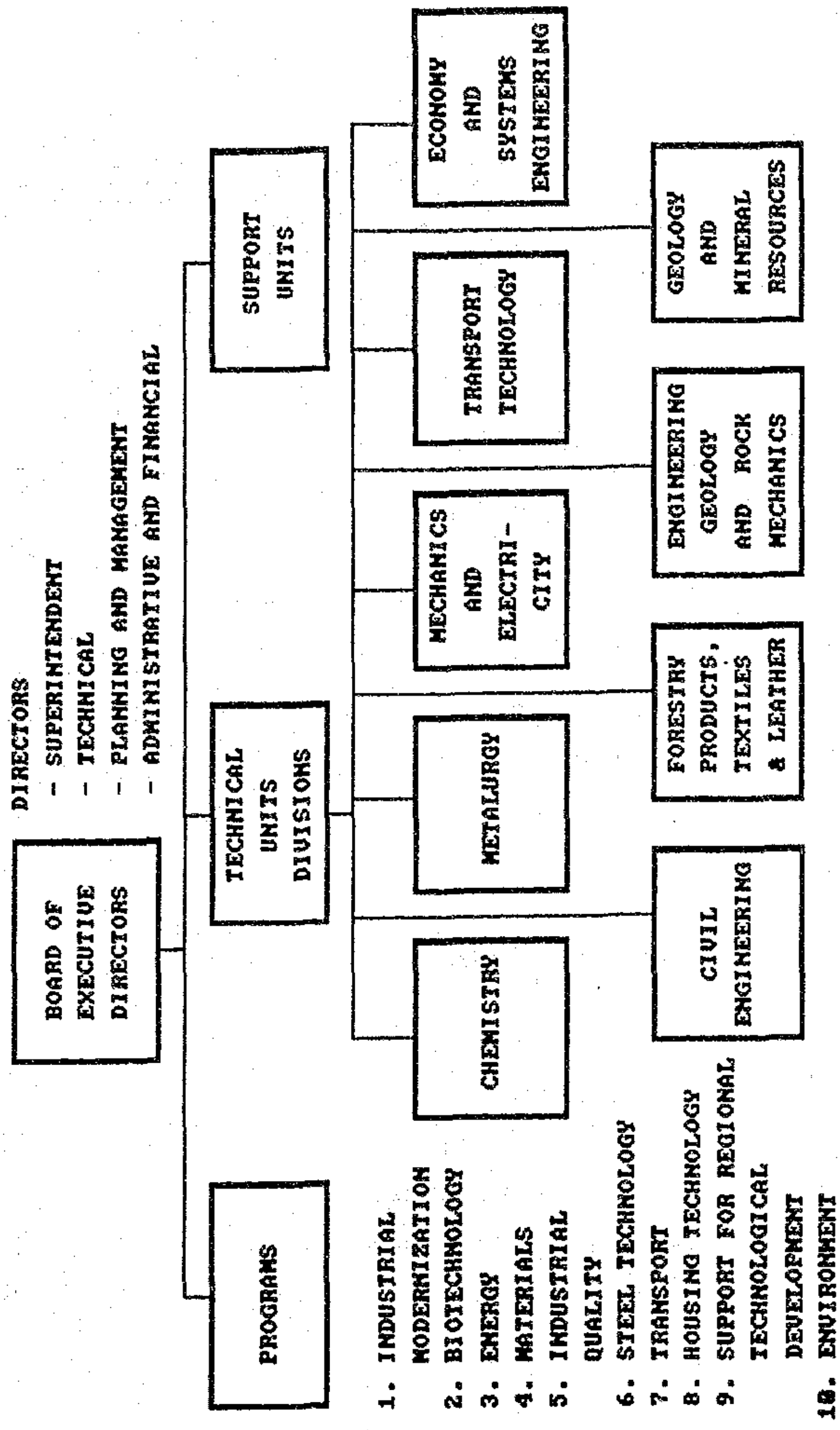
- TO RATIONALIZE SUPPORT AND ADMINISTRATIVE ACTIVITIES IN ORDER TO COMPLY WITH STRATEGIC MISSIONS

1992 GOALS

- INCREASE ANNUAL RESOURCES IN R&D FROM 7,6% TO 10,0%
- REDUCE ANNUAL RESOURCES IN TECHNICAL STUDIES FROM 12,2% TO 10,0%
- REDUCE ANNUAL RESOURCES IN TECHNICAL SPECIALIZED SERVICES FROM 26,4% TO 25%
- REDUCE ANNUAL RESOURCES IN EXPERIMENTAL PRODUCTION FROM 4,7% TO 4,0%
- MAINTAIN RESOURCES APPLIED IN DISSEMINATION IN 6,3%
- INCREASE ANNUAL RESOURCES IN TRAINING FROM 4,8% TO 13,4%
- REDUCE ANNUAL RESOURCES IN ADMINISTRATIVE AND SUPPORT ACTIVITIES FROM 38,0% TO 31,3%
- INCREASE THE RATIO INCOME OPERATIONAL EXPENSES FROM ANNUAL MEDIA OF 16% TO 26%
- INCREASE THE NUMBER OF TRANSFERENCE TECHNOLOGY CONTRACTS FROM 87 TO 93
- INCREASE THE TOTAL NUMBER OF REQUESTS OF PRIVILEGE (INVENTION PATENTS, INDUSTRIAL DESIGN, UTILITY MODELS ETC.) FROM 83 TO 90

1992 GOALS (CONT.)

- INCREASE THE NUMBER OF ENGINEERS WITH QUALITY ENGINEER CERTIFICATE FROM 27 TO 34 UNTIL JULY 1992
- INCREASE THE NUMBER OF TESTS AND ANALYSIS FOR THE PRODUCTIVE SECTOR FROM 8100 TO 9000
- INCREASE THE NUMBER OF SPEEDY TESTS AND ANALYSIS (UP TO 48 HOURS) FROM 120 TO 150
- INCREASE THE RATIO OF POSTGRADUATES RESEARCHERS/TOTAL RESEARCHERS FROM 33,3% TO 36,4%
- INCREASE THE ANNUAL NUMBER OF CONSULTS TO THE NORMS AND STANDARDS CENTER FROM 11.200 TO 14.000
- INCREASE THE NUMBER OF CITIES TO WHOM TECHNICAL SERVICES WERE SERVED FROM 32 TO 60
- TRANSFER TO THE PRIVATE INITIATIVE 9 MINING RIGHTS
- INCREASE THE NUMBER OF STUDIES ANALYSING BRANCHES OF PRODUCTIVE SECTORS FROM 3 TO 6 IN THE INDUSTRIAL TECHNOLOGY UPGRADING PROGRAM
- INCREASE IN 20% THE LABORATORIAL QUALITY INCREASING THE LABORATORIAL QUALITY INDEX FROM 55,7% TO 66,8%
- INCREASE THE NUMBER OF INFORMATIZED LIBRARIES FROM 1 TO 5


BOARD OF EXECUTIVE DIRECTORS
DIRECTORS
- SUPERINTENDENT
- TECHNICAL
- PLANNING AND MANAGEMENT
- ADMINISTRATIVE AND FINANCIAL
PROGRAMS
TECHNICAL UNITS DIVISIONS
SUPPORT UNITS
CHEMISTRY
METALURGY
MECHANICS AND ELECTRI-CITY
TRANSPORT TECHNOLOGY
ECONOMY AND SYSTEMS ENGINEERING
CIVIL ENGINEERING
FORESTRY PRODUCTS, TEXTILES & LEATHER
ENGINEERING GEOLOGY AND ROCK MECHANICS
GEOLOGY AND MINERAL RESOURCES
1. INDUSTRIAL MODERNIZATION
2. BIOTECHNOLOGY
3. ENERGY
4. MATERIALS
5. INDUSTRIAL QUALITY
6. STEEL TECHNOLOGY
7. TRANSPORT
8. HOUSING TECHNOLOGY
9. SUPPORT FOR REGIONAL TECHNOLOGICAL DEVELOPMENT
10. ENVIRONMENT

RELEVANT FIGURES - HUMAN RESOURCES

(DEC - 1991)

PERSONNEL 2.212

PROFESSIONALS 636

	BRASIL	ABROAD	TOTAL
Ph D	29	32	61
M Sc	129	21	150

TECHNICIANS 584

SUPPORT STAFF 311

ADMINISTRATIVE 681

TRAINING PROGRAM

STUDENT TRAINEES 217

PROFESSIONALS ABROAD

LONG TERM 23

SHORT TERM 26

COURSES OFFERED (SHORT TERM) 20

PARTICIPANTS 340

RELEVANT FIGURES - 1992 BUDGET

	IN US$ 1,000.00	
OPERATIONAL BUDGET	57,500	(94,0%)
CAPITAL INVESTMENT	3,700	(6,0%)
TOTAL BUDGET	61,200	

CONTRACT RESEARCH & TECHNOLOGICAL SERVICES	12,500	(20,4%)
STATE FUNDS	33,400	(54,6%)
FUNDS TO NEGOCIATE	15,300	(25,0%)

APPLICATIONS

RESEARCH & DEVELOPMENT	7 - 12%
SPECIALIZED TECHNO-LOGICAL STUDIES	10 - 12%
TESTS, ANALYSIS & TECHNOLOGICAL STUDIES	45 - 60%
EXPERIMENTAL PRODUCTION	7 - 10%
TRAINING PROGRAMS	7 - 10%
OTHERS	qsp 100%

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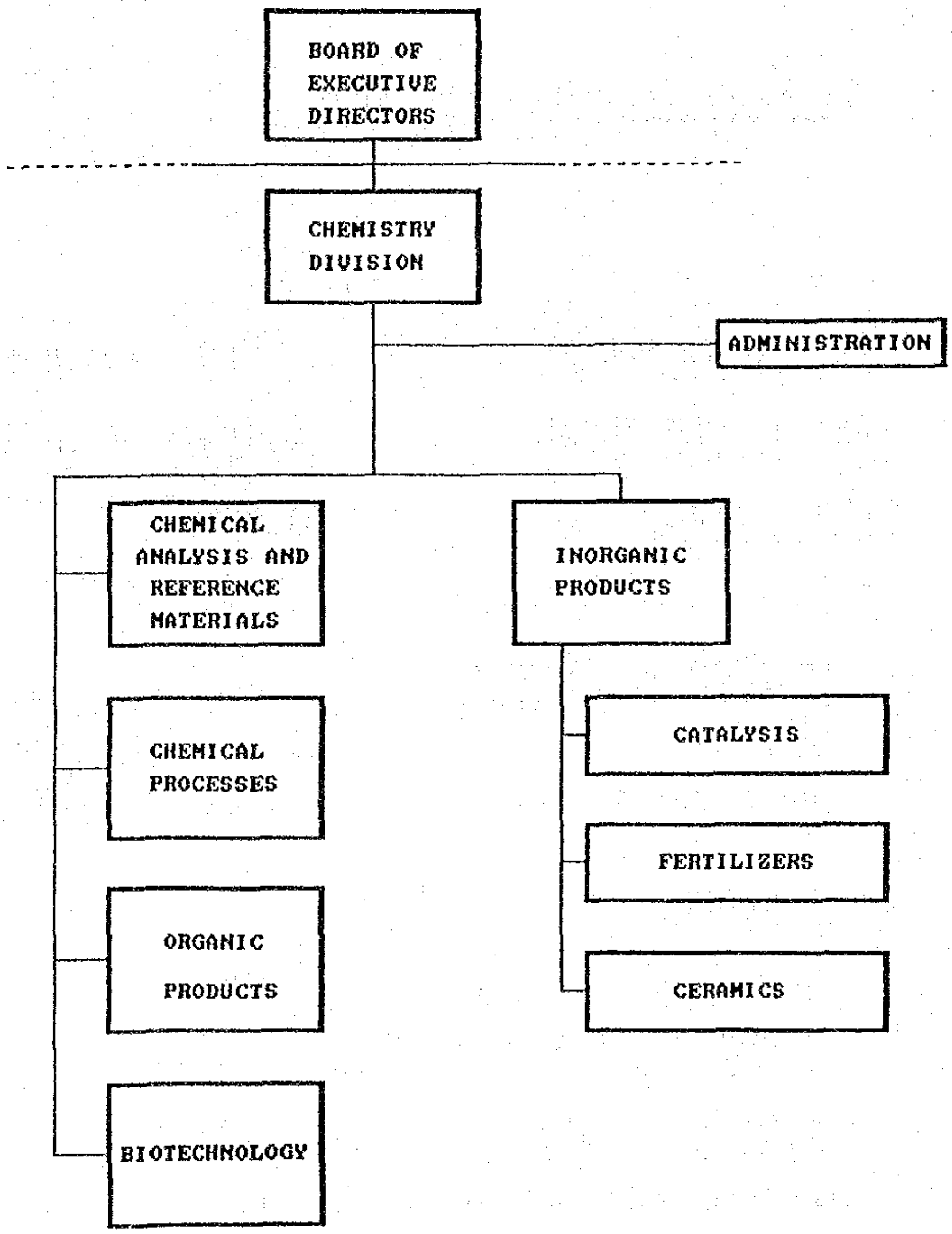
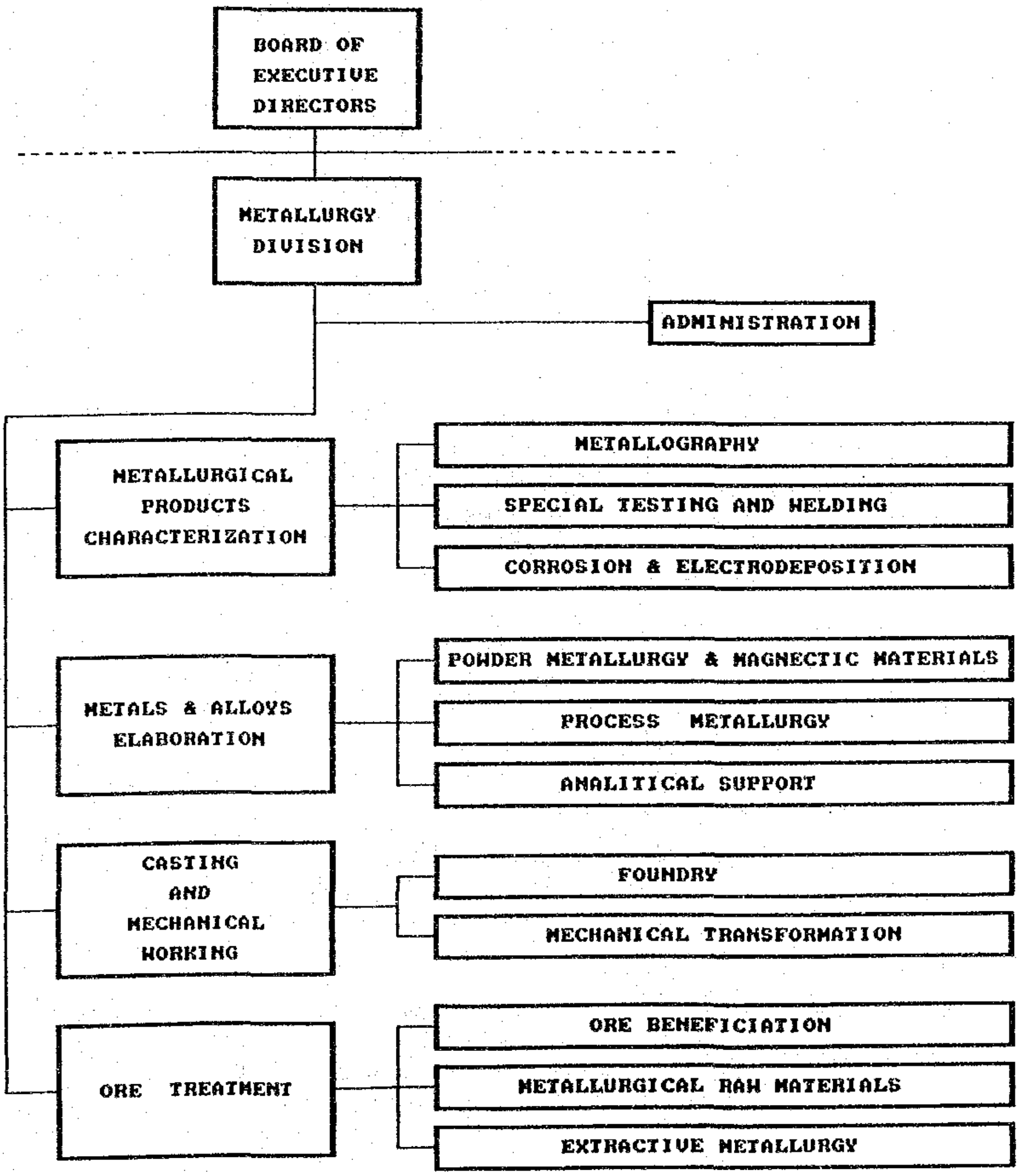
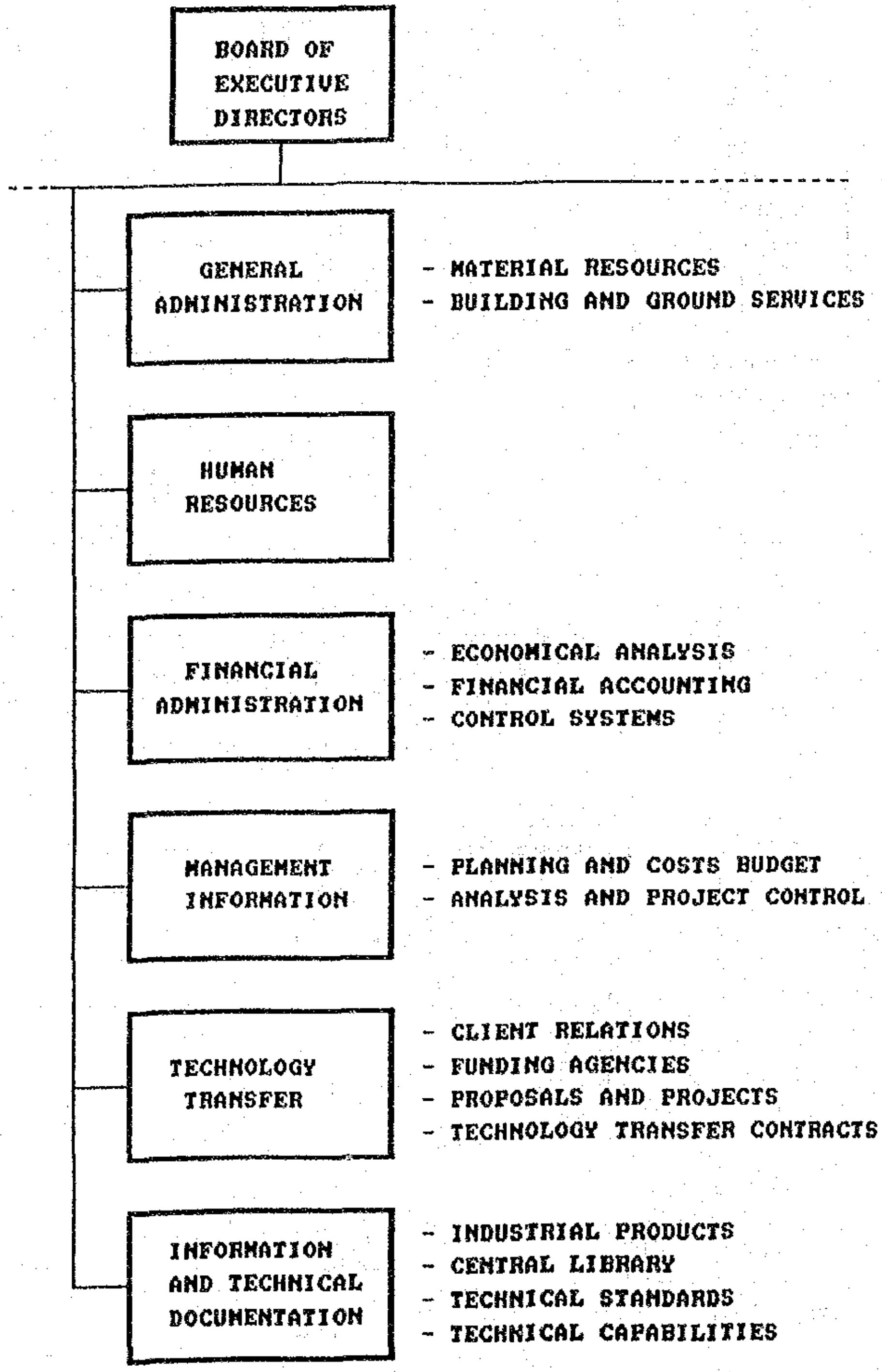



BOARD OF EXECUTIVE DIRECTORS
METALLURGY DIVISION
ADMINISTRATION
METALLURGICAL PRODUCTS CHARACTERIZATION
METALLOGRAPHY
SPECIAL TESTING AND WELDING
CORROSION & ELECTRODEPOSITION
METALS & ALLOYS ELABORATION
POWDER METALLURGY & MAGNECTIC MATERIALS
PROCESS METALLURGY
ANALITICAL SUPPORT
CASTING AND MECHANICAL WORKING
FOUNDRY
MECHANICAL TRANSFORMATION
ORE TREATMENT
ORE BENEFICIATION
METALLURGICAL RAW MATERIALS
EXTRACTIVE METALLURGY


BOARD OF EXECUTIVE DIRECTORS
GENERAL ADMINISTRATION
- MATERIAL RESOURCES
- BUILDING AND GROUND SERVICES
HUMAN RESOURCES
FINANCIAL ADMINISTRATION
- ECONOMICAL ANALYSIS
- FINANCIAL ACCOUNTING
- CONTROL SYSTEMS
MANAGEMENT INFORMATION
- PLANNING AND COSTS BUDGET
- ANALYSIS AND PROJECT CONTROL
TECHNOLOGY TRANSFER
- CLIENT RELATIONS
- FUNDING AGENCIES
- PROPOSALS AND PROJECTS
- TECHNOLOGY TRANSFER CONTRACTS
INFORMATION AND TECHNICAL DOCUMENTATION
- INDUSTRIAL PRODUCTS
- CENTRAL LIBRARY
- TECHNICAL STANDARDS
- TECHNICAL CAPABILITIES

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ACTIVITIES

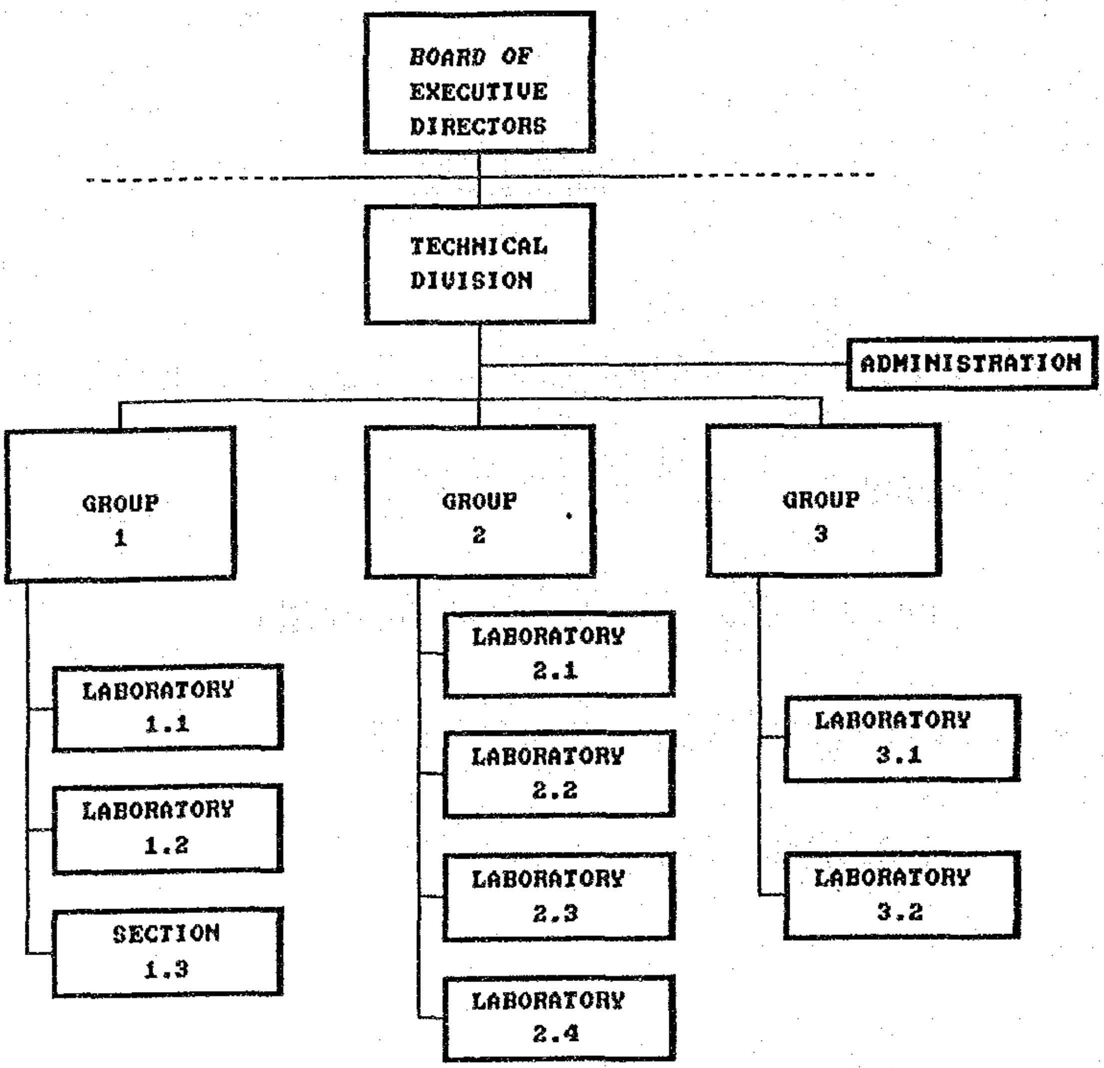
TECHNICAL & ECONOMICAL FEASIBILITY STUDIES

PRODUCT & PROCESS DEVELOPMENT

TARGET RESEARCH & TROUBLE SHOOTING

STANDARDS & QUALITY ASSURANCE

HUMAN RESOURCES DEVELOPMENT


BOARD OF EXECUTIVE DIRECTORS
TECHNICAL DIVISION
ADMINISTRATION
GROUP 1
GROUP 2
GROUP 3
LABORATORY 1.1
LABORATORY 1.2
SECTION 1.3
LABORATORY 2.1
LABORATORY 2.2
LABORATORY 2.3
LABORATORY 2.4
LABORATORY 3.1
LABORATORY 3.2

IPT ②-3
Instituto de Pesquisas Tecnológicas

TECHNICAL COOPERATION

BRAZIL - JAPAN

TECHNOLOGICAL CAPACITATION IN MATERIALS

(RESEARCH PROJECT ON NEW MATERIALS)

SÃO PAULO - BRAZIL
FEBRUARY 1992

IPT
Instituto de Pesquisas Tecnológicas

TECHNICAL COOPERATION
BRAZIL-JAPAN

TECHNOLOGICAL CAPACITATION
IN MATERIALS
(RESEARCH PROJECT ON NEW MATERIALS)

TEXT PREPARED BY:

Marco Antonio Pacheco Jordão ....

Evaristo Pereira Goulart ....

Chen Tsung Jye ....

São Paulo, February 17th 1992.

....
Paulo Affonso Doin
Chemical Division Coordinator

IPT

Instituto de Pesquisas Tecnológicas

PROJECT: TECHNOLOGICAL CAPACITATION IN MATERIALS
(RESEARCH PROJECT ON NEW MATERIALS)

1. OBJECTIVES

The main objective of this project is to acquire competence in new materials, beginning with works on characterization of advanced ceramics through:

- the implementation of laboratories with the necessary facilities for the development of tests and basic technological research on ceramics
- the training of Brazilian technicians in Japan
- the cooperative work of Japanese experts and the Brazilian team.

2. JUSTIFICATION

This Project intends to solve one of the pressing needs of this country, that is, the implementation of Centers for Basic Technological Research on Materials, in order to contribute positively in the upgrading of the present technological level and to give convenient support to the industrial growth in this field.

Despite the Brazilian industrial development in the period between 1950 and 1980, when plants of different industrial sectors have been established in this country (e. g. automotive, chemical, electronic, ceramics, siderurgical branches), at the beginning of the 80's, due to a wrong economical policy, Brazil has been hit by a strong recessive period. At the same time, the different industrial sectors handled the development issue with negligence, leading to technological stagnation and loss of efficiency.

As a consequence of this situation, the progress of the research on advanced ceramics in Brazil has been very slow. However, with the present changes in industrial and economical policies and with the constitution of MERCOSUL, it is expected that the Brazilian technological level will at last begin to rise again.

17/feb/92

As ABIPTI (Brazilian Association of Industrial Technological Research Institutions) points out, in 1988 the Brazilian advanced ceramics market reached up to US$ 250 million, distributed in the following functions (see also Table 1):

Electronic Ceramics	45%
Mechanical Ceramics	19%
Optical Ceramics	17%
Magnetic Ceramics	9%
Nuclear Ceramics	1%
Other Types	9%

Assuming a growth rate of 14% per year, as suggested by ABIPTI, it is estimated that, at the end of this decade, the Brazilian market will reach US$ 1.2 billion. Considering the levering index of 11 to 1 for advanced ceramics products, this market will sum US$ 13 billion. In these estimations, the possibility of Brazil to take part in the world market for advanced ceramics in the next future has not been considered.

The implementation of an advanced ceramics characterization center at IPT is justified by its situation as one of the biggest Institute for Technological Research in Brazil, by its multidisciplinarity, its location near the main Brazilian industries, its 50 years old experience on traditional ceramics, and its excellent relationship with both ceramics producers and consumers.

This advanced ceramics characterization center will greatly strengthen the technological research, promoting both human resources upgrading and technological development, creating therefore conditions for an effective support to Industry. This center will also contribute to a stronger cooperation between IPT and other Brazilian Research Centers and Universities.

The Brazil/Japan Cooperation Program will bring to IPT and to Brazil other advantages, such as:

- the introduction of a working system and methodology for technological research development through a very qualified Japanese Scientists team;
- the setting up of technical standards based on JIS, to be used in this project.

TABLE 1 - BRAZILIAN MARKET OF FINE CERAMIC PRODUCTS - DATA COLLECTED BY THE BRAZILIAN ASSOCIATION OF INDUSTRIAL AND TECHNOLOGICAL RESEARCH INSTITUTES - ABIPTI

CERAMIC AREA	TYPE	1989		1994		Estimated increasing rate per year (%)
		US$$10^6$	%	US$$10^6$	%	
Electric	Insulation	67,6	27,2	90,5	14,5	6
	Ferroelectric	28,0	11,2	58,8	9,4	16
	Semiconductor	17,0	6,8	63,1	10,1	30
	Piezoelectric	*	--	--	--	--
Magnetic	Soft ferrite	7,5	3,0	10,0	1,6	6
	Hard ferrite	15,0	6,0	26,4	4,2	12
Optical	Fiber	25,0	10,0	89,3	14,3	26
	Translucent alumina	8,5	3,4	19,4	3,1	18
	Others **	10,0	4,0	14,7	2,3	8
Mechanical	Cutting tools ***	27,3	11,0	67,9	10,8	20
	Structural	20	8,0	22,1	3,5	2
Nuclear	Fuels	3,5	1,4	15,8	2,5	35
Others	Catalyst substrate	--	--	110,0	17,6	--
	Others ****	20	8,0	38,0	6,1	14
TOTAL		249,4	100,0	626,0	100,0	14,2

* Market not clear due to difficulties in information collection in this wide area
** Components for advanced optical equipments (laser etc.)
*** Not including silicon nitride and sialon market
**** Estimated value (catalyst for chemical industry, sensor etc.)

Furthermore, as a result of this program, knowledge transfer to other Latin-American and African countries, will occur, as it is already occurring with traditional ceramics both through the International Ceramics Training Courses (IPT/JICA - TCTP) and through personal training programmes and specific contracts with Research Centers or Universities in these countries.

3. PROJECT SCHEDULE

3.1 Training program in:

- instrumental techniques for fine ceramics research
- powder and test piece characterization

3.2 Basic technological research in collaboration with Japanese experts (See Annex II).

3.2.1 Research in high purity ceramic powder preparation, such as: Al_2O_3, ZrO_2, Si_3N_4, SiC, AlN, Sialon, PZT, PLZT and HBN.

3.2.2 Materials characterization studies, including:

- test piece preparation (mixing, granulation and forming)
- sintering
- finishing (cutting, grinding, polishing etc.)
- characterization and evaluation for each step from raw material preparation to final test piece finishing:
  - chemical analysis
  - surface chemical analysis, phase analysis and microstructural analysis
  - physical, mechanical, thermal, electrical and optical properties determination.

  Materials selected for research:
  - aluminium oxide
  - zirconium oxide, partially or totally stabilized
  - aluminium oxide mixed with zirconium oxide
  - aluminium oxide mixed with titanium carbide
  - aluminium oxide mixed with silicon carbide whiskers
  - magnesium oxide
  - sialon
  - silicon carbide
  - silicon nitride
  - aluminium nitride
  - lead zirconate-titanate (PZT) and lead zirconate-titanate modified with lanthanum (PLZT)
  - hexagonal boron nitride (HBN)

3.2.3 Characterization of sapphire, ruby and other monocrystals, including raw materials study and production of test piece by fusion and crystallization

3.2.4 Characterization of special glass, such as aluminossilicate glasses dopped with rare earth elements and silica glass.

3.3 Plan for the laboratory inplantation

Based on the previous experience, on information obtained from IPT researchers who visited Japanese Research Centers and on recommendations of Dr. Yasutoshi T. Hasegawa from NIRIM, the requirements for the fine ceramics characterization center has to consider the following laboratories and main equipments, which are further described (Annex II):

3.3.1 Bulk Chemistry Characterization Laboratory (LC)

LC1 Inductively coupled plasma spectroscope or
Spark source mass spectroscope

LC2 Atomic absorption spectrophotometer

LC3 Oxygen/nitrogen analyzer
Carbon analyzer

LC4 UV-VIS spectrophotometer

LC5 Sample preparation (solubilization)

3.3.2 Spatial Chemistry, Phases and Microstructure Characterization Laboratory (LCPM)

LCPM 1 Scanning electron microscope (SEM) or
Electron probe microanalyzer (EPMA) equipped with image analyzer

LCPM 2 Scanning transmission electron microscope (STEM) with EDS, and EELS and image analyzer (room with special anti-vibration floor).

LCPM 3 Optical microscope
Digital microhardness tester
Refractometer
Polariscope
Image analyzer for direct microscopy and scanner for photographs

LCPM 4 Scanning laser acoustic microscope (SLAM)
Photoacoustic microscope (PAM)

LCPM 5 Fourier transforn infrared spectroscope (FT-IR)

LCPM 6 X-Ray diffractometers (XRD) with accessories (phase quantification, texture analysis, phase mapping and small-angle scattering device - SAXS)

LCPM 7 Electronic spectroscope (ESCA)

LCPM 8 Metal deposition system
Ion beam etching system

LCPM 9 Photographic laboratory

3.3.3 Sample Preparation Laboratory (LS)

LS 1 Milling units

LS 2 Automatic surface grinders
Precision multi-cutting and grinding machine
Cylindrical grinder
Precision thin section machine

LS 3 Vacuum-impregnation apparatus (cold mounting)
Hot compression moulding apparatus
Engraver for sample marking

LS 4 Balance
Thermostatic water-bath apparatus
Ultrasonic cleaning apparatus
Oven

3.3.4 Physical Characterization Laboratory (LF)

LF 1 Particle size analyzers (laser, centrifugal and X-ray)
Helium pycnometer
Mercury porosimeter
Specific area measuring equipment (BET)
Permeater

LF 2 Absorption, bulk density and porosity determination
Analytical balance
Electric heater

3.3.5 Mechanical Characterization Laboratory (LM)

LM 1 Universal mechanical testing machine
Erosion wear testing equipment
Dynamic elastic modulus measuring equipment
Surface roughness tester
High temperature mechanical testing machine
Creep testing equipment
Measuring instruments
Oven

3.3.6 Thermal Characterization Laboratory (LT)

LT 1 Thermal property measuring equipments (TGA, DTA, DSC, TMA)
Thermal conductivity meter
Glass thermal dilatometer

3.3.7 Electrical Characterization Laboratory (LE)

LE 1 Volume resistivity
Dielectric constant
Dielectric power factor
Dielectric breakdown strength
Electro-mechanical coupling coefficient
Specific dielectric constant
Piezoelectric constant
Mechanical Q
Frequency constant

3.3.8 Rheological Characterization Laboratory (LR)

LR 1 Zeta potential analyzer
Programmable viscometer model DVIII Brookfield with thermostatic water-bath
Ultrasonic dispersion equipment
Mechanical dispersion equipment
Automatic pipets or burets
pHmeter for suspensions
Balance

3.3.9 Powder Synthesis Laboratory (LPS)

LPS 1 Oxide powders synthesis equipment

LPS 2 Non-oxide powders synthesis equipment

3.3.10 Research Experiments Laboratory (LRE)

LRE 1 Ball mill
Attritor
Jet mill with classifier

LRE 2 Ball mill
Mixer
Spray dryer

LRE 3 Slip casting (ball mill, mixer and oven)

LRE 4 Ball mill
Mixer
Doctor Blade machine

LRE 5 Hot mixer
Granulator
Injection molding machine
Dewaxing furnace
Uniaxial press
Cold isostatic press
Hot press
Controlled atmosphere furnace
Electric furnaces to 1700°C
Sintering furnace for PZT
Sintering furnace for translucent alumina in hydrogen atmosphere

LRE 6 Equipment to produce monocrystal

LRE 7 Glass fusion furnace
Electric furnace for thermal treatment
High temperature viscometer
Glass annealing furnace
Quartz melting furnace

3.3.11 Data Processing System

The needs of data processing equipment, other than that connected with the laboratory equipments, for this project are, initially for: storing of technical and management data, mathematical calculation and simulation, text editing and processing, planning and project control and for communication.

The data processing equipment need to be IBM compatible and with the system of that connected to the laboratory equipments.

The data processing system will include laboratory systems and a multiuser system equipped with IBM compatible equipments such as:

- IBM-286 compatible computer (desktop and laptop)
- IBM-486 compatible computer
- Dot matrix printers
- Laser printer
- Color plotter
- Color printer (inkjet type)
- Color scanner
- Modem
- Facsimile machine

4. TECHNICAL TEAM

For project execution, the technical team will be constituted of at least 22 researchers and 3 technicians. As the field of fine ceramics is wide and complex, the team must be composed of specialists in ceramics, chemistry, physics and even mechanical, electrical and electronical engineers.

The team distribution basically will be:

- Chemical analysis
  1 researcher for studies on oxide materials analytical methods
  1 researcher for studies on covalent materials analytical methods
  1 technician for sample preparation
  support of the group from the chemical analysis center for usual analysis

- Microstructure, surface and phase analysis
  1 researcher for microstructure analysis, microanalysis and phase analysis via transmission electronic microscope.
  1 researcher for microstructure analysis and chemical microanalysis via electronic microprobe
  1 researcher for microstructure analysis and phase analysis through optic and acoustic microscope and microhardness determination
  1 researcher for phase analysis, texture analysis and grain size distribution determination via X-rays diffraction and IR-spectrophotometer
  1 researcher for surface microanalysis through electronic spectroscope (ESCA)
  1 technician for test sample preparation

- Powder preparation
  3 researchers for oxide base powders research
  3 researchers for covalent powders research

- Materials characterization
  - 3 researchers for oxide base materials research
  - 3 researchers for covalent materials research
  - 3 researchers for monocrystal and special glasses research
  - 1 technician for test piece preparation and finishing, and other support works

The study of physical, mechanical, thermal, electrical and rheological properties will be done generally by researchers of the characterization group. As the equipment for chemical analysis and microstructure, surface and phase analysis have a high degree of complexity, the researchers working on them must be more specialized. All the members of these groups are supposed to have an integrated and cooperative work.

5. INSTALLATION

The estimated total area needed for the center is 1900m². For the laboratories approximately 1200m² with the following facilities:

- water purification unit
- air filtration unit
- high and low voltage stabilizer
- electricity generator
- dry air compressor
- special gas installation: acetylene, nitrogen oxide, argon, helium, nitrogen and oxygen
- GLP installation
- air conditioned installation and temperature control for laboratories.

Other facilities are foreseen as offices for researchers, experts and consultants, data processing, administrative support; documentation and library room, meeting room, storing materials room, dressing room and toilets. An available auditorium will be used for special meetings.

ANNEX I

CONSIDERATIONS ON THE PROPOSED RESEARCH PROGRAM

Advanced ceramics raw materials have to present very special features, such as high purity and very fine particle size, that are obtained only by non-conventional methods.

Although Brazil has natural mineral resources that would allow the production of almost all advanced ceramics powders, some structural problems, such as the lack of technology to manufacture high purity powders, or the absence of interest of enterprises in diversifying the production of some powders they already manufacture in order to attend the small advanced ceramics market. Under this point of view, IPT has an important role to play in the development of methods for the production of high-purity powders and in the technological upgrading of small and medium size factories that may be interested in their manufacture.

In a first approach, the following ceramic powders were selected for synthesis in this laboratory: aluminium oxide, zirconium oxide, silicon carbide, silicon nitride, aluminium nitride, sialon, lead titanate-zirconate modified or not by lanthanum and, probably, hexagonal boron nitride. This choice was based on requests received by the Ceramics Laboratory and on the large variety of their uses, even in Brazil.

These powders will be used in the basic technological researches in this Laboratory, in the production of test pieces for the following (industrial) end applications:

- aluminium oxide and aluminium nitride - electronic ceramics as substrates for microelectronic products
- aluminium oxide for optical ceramics - translucent alumina for the production of high pressure sodium vapor lamps
- lead titanate-zirconate modified or not by lanthanum - for piezoelectric ceramics, as parts of microphones, sonars etc.
- aluminium oxide, zirconium oxide, silicon nitride, silicon carbide and sialon, used individually or as composites - for mechanical purposes, such as cutting tools, bearings and rings, engine valves, mechanical seals etc.

Furthermore the following studies are foreseen:

- Growth of sapphire and ruby monocrystals - for use in laboratory and laser equipment
- Development of special aluminossilicate glasses doped with rare-earth elements - for the production of filters, high-strength high-elasticity fibers for composite materials, low-reactivity glasses for chemical process reactors etc.

ANNEX II

CONSIDERATIONS ON THE APPLIED EQUIPMENT

Bulk Chemistry Characterization Laboratory

The Chemistry Division of IPT counts already with a Chemical Analysis Group, that will be responsible for the analytical work to be done on the advanced ceramics raw materials and on the samples produced. However, the equipments listed below are necessary for the updating and adjustment of the analytical methods currently used for the specific needs of the new, very-pure, materials.

- Inductively Coupled Plasma Emission Spectrometer (ICP-AES) - will be used in the analysis of raw materials and products, mainly oxides. This equipment is suited both for the rapid overview qualitative analysis and for the quantitative analysis. For the analysis of carbides, sulfides and nitrides it should be used together with specific analytical apparatuses for the detection of C, S, N. It should be equipped with a laser beam source in order to allow the analysis of solid samples without previous chemical attack, avoiding in this way the contamination of samples by eventually impure reagents.

- Atomic Absorption Spectrophotometer (AAS) - will be used in the analysis of binders and reagents. It can also be used in the analysis of raw materials and products, if the ICP-AES is eventually on maintenance.

- Carbon and Nitrogen-Oxygen Analysis - these apparatuses are needed, as ICP-AES has low sensitivity for these elements. They will be used for the chemical analysis of carbide and nitride products, as well as for detection of incipient oxidation on samples produced from these powders. In the case of oxide powders, as they are often produced from precursors containing C and/or N, the detection of these elements is important for the efficiency evaluation of the powder producing process.

- UV - Visible Spectrophotometer - will be used in the chemical analysis of organic and inorganic materials as well as in the optical characterization of glasses and translucent alumina produced by the research team.

- Sample Preparation Unit - for the chemical attack of the solid materials to be analysed in the previous listed equipment. Mainly microwave ovens and Parr-bombs.

Spatial Chemistry Phases and Microstructure Characterization Laboratory

- Electron probe microanalyzer (EPMA) - used for microstructural and microchemical characterization of powders, green and sintered samples, oxides and non-oxides. As they may detect light elements, such as boron, even boron nitride can be analysed. It must be equipped with EDS, for a quick qualitative surface analysis, and with WDS and standards, for surface quantitative evaluation. As they can also detect secondary electrons, they can efficiently replace the scanning electron microscope. The new models have also an optical polarizing microscope attached, making the equipment very versatile.

- Transmission Electron Microscope (TEM) with accessories for microanalysis (EDS, EELS) and image analyses (IA) - for the microstructural, microchemical and phases characterization of powders and solid samples (oxides and non-oxides), allowing the identification, via microanalysis and microdiffraction, of impurities and inclusions, and the action of sintering additives on the sintering process.

- Optical Microscope (OM) - for the microstructural and phases analysis of powders and samples under low magnification, as the first step of the microstructural analysis.

- Hardness Tester - for the measurement of the sample surface hardness. If used on the surface of the sample it permits the evaluation of its homogeneity.

- Refractometer and Polariscope - will be used as aids in the microstructural analysis of ceramic and glass bodies. The polariscope is mainly used in the analysis of tensions in a glass piece.

- Scanning Laser Acoustic Microscope (SLAM) and Photoacoustic Microscope (PAM) - these apparatuses will be used mainly in the evaluation of green and sintered pieces, prior to their further characterization, as they permit the non-destructive detection of flows and unhomogeneous pores distribution in the sample.

- Fourier Transform Infrared Spectrophotometer (FT-IR) - will be used for the identification of the molecular structure of organic and inorganic materials (binders, additives and raw materials), ceramic and glass samples. As this method is sensitive to variations in the molecular weight, it can be useful to evaluate the action of sintering additives. The Fourier transform version allows rapid obtention of the absorbance/transmittance spectrum (+/-1 sec), making it possible to gather statistically valid data.

- X-Ray Diffractometer (XRD) - equipment used mainly in the analysis of crystalline material. Usually gives the phases composition of the whole sample but, if equipped with an accessory for the phases mapping of solid samples, it detects the phases surface distribution. It must have other two accessories, one for the textural analysis of solid samples, allowing the detection of the degree of orientation of the grains in the piece, and another for grain-size analysis (SAXS).

- Electron Spectrometer for Chemical Analysis (ESCA) or Auger Electron Scanning Microprobe (AES) - for the surface chemical analysis of solid samples, allows also in depth chemical profiling (sheet after sheet) through a module of ionic corrosion. Ideal for the analysis of materials with a sheet structure, fine fibers, electronic ceramics etc.

- Ion Beam Etching and Metal Vaporization System - for the analytical preparation of the samples for electron microscopy.

- Photographic Laboratory (black-and-white) - as most electron microscope analysis produce black-and-white negatives, it is helpful to have a photographic laboratory for the simplification of the work to be done.

Physical Characterization Laboratory

- Particle Size Analyzers - the determination of particle size distribution is of fundamental importance for a good process design and the production of pieces of good performance. As there are several types of equipment, based on different measuring principles (laser or X-rays, centrifugal field) and the particles present irregular forms (leading to distortions of the results), it is important for this Laboratory to have the three kinds of equipment, in order to produce comparative data and to adequate to each process the best suited measuring method.

- Equipment for the determination of the Specific Surface (BET) - this equipment is based on the method of N_2 adsorption. The data obtained are valuable for the determination of the powder reactivity, complementing the information obtained through the particle size analysis.

- Helium Pycnometer - used in the density determination of the raw materials, in a very precise and rapid way. It allows also the determination of density of green and sintered pieces. And is also essential for the particle size distribution calculation.

- Mercury Porosimeter - used for the measurement of the pore size distribution of green and sintered pieces. The pore size distribution has a great influence on the final properties of the pieces.

- Permeameter - used for the determination of the permeability of the green and sintered pieces, as a complement to the pore size distribution.

- Analytical Balance, Electric Heater, Oven - equipment for many applications, but that are also used in the determination of apparent density, apparent porosity and water absorption, of great importance in the quality control of the products.

Mechanical Characterization Laboratory

This laboratory includes all the equipment necessary for the determination of the mechanical behavior of the products, including tenacity measurements.

- Universal Mechanical Testing Machine - accomplishes compression and flexural strength (3 or 4 points) determination of samples.

- Erosion Wear Testing Equipment

- Dynamic Elastic Modulus Equipment

- Surface Roughness Tester - measures the surface roughness of pieces, information of great importance for the development of microelectronical substrates.

- High Temperature Mechanical Testing Machine - used in the determination of the flexural strength of the samples at high temperatures.

- Creep Testing Equipment - used to determine the flow behavior of the pieces at high temperature and long periods of time.

- Measuring Instruments of high precision, as, for instance, calipers, for determination of pieces and samples dimensions.

Thermal Characterization Laboratory

- Thermogravimetric Analyzer (TGA) - measures mass variations of a sample during the heating process (evaporation, sublimation, decomposition, oxidation, reduction, gas adsorption), giving important information for the development of ceramic powders and for the research on the behavior of organic additives in ceramic masses.

- Differential Thermal Analyzer (DTA) - permits the detection of phases transformations and/or reactions occurring in a powder sample during the thermal treatment. These data are important in the behavior forecast of raw materials and masses.

- Differential Scanning Calorimeter (DSC) - detects the difference in the heat flux in the sample and in the reference material during the heating or cooling process under energetic and atmospheric controlled conditions, allowing the measurement of temperatures of fusion, phase transition/cristallization, oxidation, as well as the enthalpy of these reactions.

- Thermal Mechanical Analyses (TMA) - determines the mechanical behavior of a solid sample under compression or tension and thermally controlled conditions; the applied force can be static or dynamic and the deformation of the sample along the tensioned axis is measured. This test is basic for the development, production and quality control of advanced ceramics.

- Thermal Conductivitymeter - determines the global thermal conductivity coefficient of pieces.

- Electric Furnace - will be used, among others, in the thermal shock test.

- Oven - used to dry samples of pieces and powders to be analysed.

Electric Characterization Laboratory

This Laboratory will have some equipment used in the determination of the most important electric properties of ceramic materials such as:

- Volume resistivity
- Dielectric constant
- Dielectric power factor
- Dielectric breakdown strength

It must be also equipped with instruments to measure specific properties of piezoelectric materials, such as:

- Electron-mechanical coupling coefficient
- Specific dielectric constant
- Piezoelectric constant
- Mechanical Q
- Curie point

Rheological Characterization Laboratory

- Zeta Potential Analyzer - allows the determination of the stability of suspension in relation to ionic concentration. This information is important for the design of processes that involve dispersion of solids, in a fluid medium, and their floculation or coagulation, for instance in the spray drying of suspensions, in the forming of pieces by slip casting (in plaster moulds).

- Programmable Viscometer, Model DV-III Brookfield - used in the study of the rheological behaviour of suspension through the determination of such curves as RPM vs Torque, RPM vs Viscosity, Shear Rate vs Viscosity, Shear Rate vs Shear Stress.

- Support Equipment - for the perfect working conditions, this laboratory must have also other apparatuses such as:

  . Ultrasonic stirrer
  . Mechanical stirrer
  . pH meters
  . Balance.

Research Experiments Laboratory

In this laboratory there will be all equipment necessary for materials processing, including raw materials and mass preparation, forming of pieces by different methods, pieces sintering and their finishing operations. Here are also included the machines needed to the crystallization of nonocrystals and production of glasses. The necessary equipment is listed under item 3.3 of the main text. The most significant apparatuses are:

- Jet mill and Attritor for the milling of raw materials

- Spray dryer for the granulation of suspensions and masses in a laboratory scale.

- Doctor Blade machine for the development of substrata for microelectronics.

- Hot-mixer, granulator, injection molding press and furnace for the vaporization of organic binders in the injection molding process.

- Cold isostatic press for the forming of special pieces, such as the ones constituted by translucent alumina.

- Hot isostatic press used mainly in the development of pieces made up by covalent powders (carbides, nitrides) for several applications, such as machining tools.

- Controlled atmosphere furnace, for the sintering of covalent materials.

- Furnace for sintering piezoelectric materials.

- Equipment for polishing of piezoelectric pieces.

- 1700°C electric furnace for various sintering researches.

- Furnace for translucent alumina sintering.

- Equipment for the development of monocrystals.

- Fusion furnace for special glasses.

- High temperature viscometers.

"FINE CERAMICS" INDUSTRIES
(INTERNATIONAL COMPANIES)

- THOMSON CSF COMPONENTS DO BRASIL LTDA.
  CAPACITORS

- RHOM INDÚSTRIA ELETRÔNICA LTDA.
  CAPACITORS AND RESISTORS

- PHILIPS - DIVISÃO CONSTANTA
  RESISTORS AND FERRITES

- COORS CERÂMICA TÉCNICA DO BRASIL LTDA.
  WEAR RESISTANT MATERIALS OF ALUMINA, ZIRCONIA AND SILICON CARBIDE - SILICON NITRIDE

- CERÂMICA E VELAS DE IGNIÇÃO NGK DO BRASIL S.A.
  IC CIRCUIT SUBSTRATE, ALUMINA WEAR RESISTANT MATERIALS AND SPARK PLUGS

- CARBORUNDUM S.A.
  WEAR RESISTANT MATERIALS OF SILICON CARBIDE - SILICON NITRIDE

- PIRELLI
  OPTICAL FIBER

"FINE CERAMICS" INDUSTRIES
(BRAZILIAN COMPANIES)

- VC VARISTORES CERÂMICOS
  VARISTORS

- PORCELANA INDUSTRIAL PARANÁ S.A.
  VARISTORS

- THORNTON ELETRÔNICA LTDA.
  PIEZOELECTRIC CERAMICS

- SUPERGAUSS LTDA.
  FERRITES

- CERÂMICA INDUSTRIAL LTDA.
  THREAD GUIDES

- CERTEC - INDÚSTRIA DE GUIAS FIOS E PEÇAS CERÂMICAS LTDA.
  THREAD GUIDES

- PULSAR TECNOLOGIA INDÚSTRIA E COMÉRCIO LTDA.
  SPRAY NOZZLES AND DISKS AND OTHER ALUMINA RESISTANT MATERIALS

"FINE CERAMICS" INDUSTRIES (CONT.)

(BRAZILIAN COMPANIES)

- CETEBRA - CERÂMICA TÉCNICA BRASILEIRA LTDA.
  CERAMIC PROTECTING TUBE FOR THERMOCOUPLES, TUBE FOR GAS KILNS BURNER, CAPILLARY TUBE, CATALYST CARRIERS, CRUCIBLE AND OTHERS, ALL ALUMINA BASE

- ENGECER PROJETOS E PRODUTOS CERÂMICOS S.A.
  POWDERS (ZIRCONIA, ALUMINA, CERIA), WEAR RESISTANT MATERIALS AND OXYGEN SENSOR

- KERAMUS CERAMICAS ESPECIAIS LTDA.
  PARTS FOR MINING, CHEMICAL INDUSTRY AND OTHERS, SUCH AS MECHANICAL SEALS, THREAD GUIDE, SPRAY NOZZLE ETC.

- MITTEC MATERIAIS E COMPONENTES LTDA.
  HUMIDITY SENSOR AND OTHERS

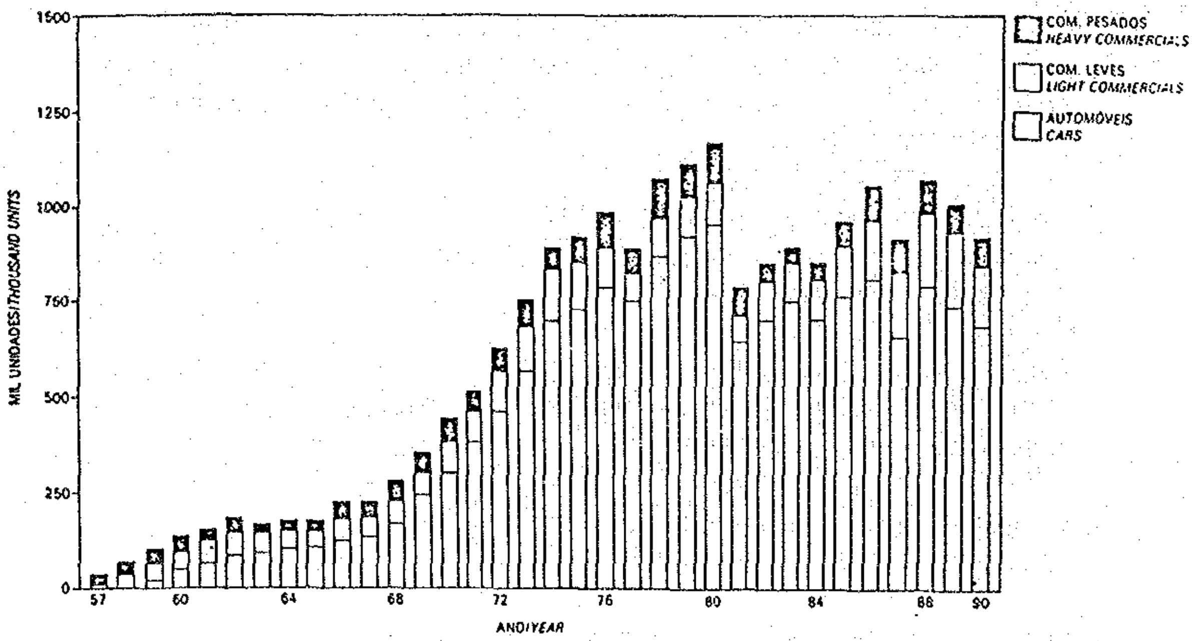
- PROCER PRODUTOS DE CERÂMICA TÉCNICA LTDA.
  ALUMINA PARTS FOR THERMOCOUPLES

- ABC X-TAL
  OPTICAL FIBER

Evolução da Produção de Autoveiculos — 1957/1990

Automotive vehicle production evolution — 1957/1990

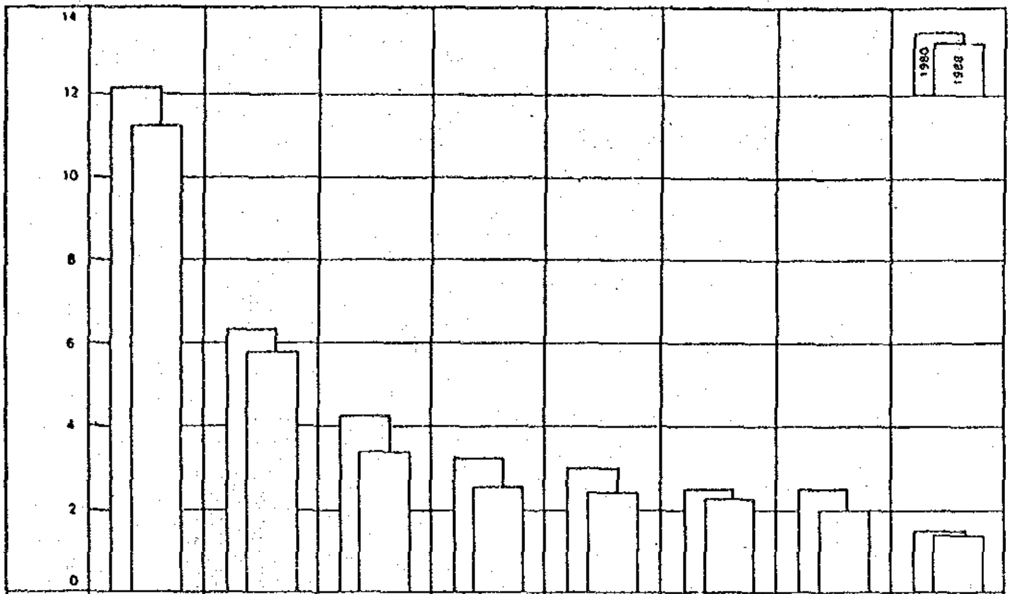
Grafico Chart nº 13



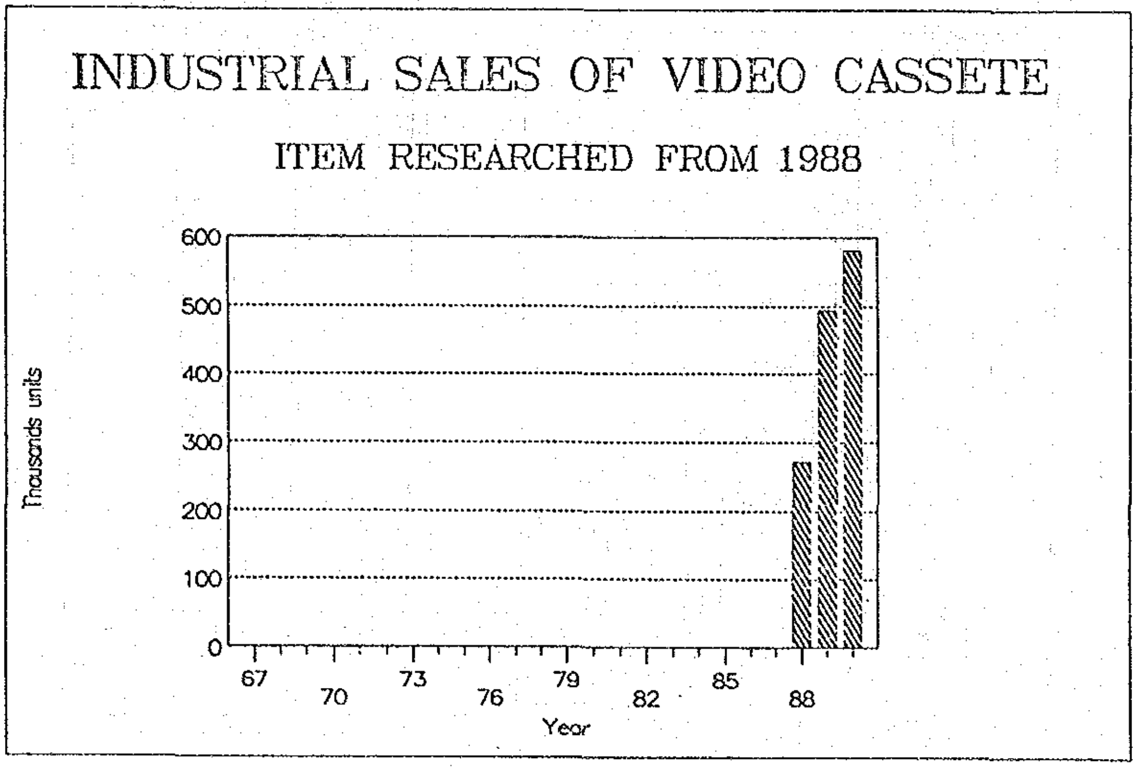
Habitantes por veículo em alguns países — 1980/1988

Inhabitants per vehicle in selected countries — 1980/1988

Gráfico/Chart nº 2



PAÍS *COUNTRY*	BRASIL *BRAZIL*	ARGENTINA *ARGENTINA*	ESPANHA *SPAIN*	JAPÃO *JAPAN*	ITÁLIA *ITALY*	FRANÇA *FRANCE*	ALEM. OCID. *W. GERMANY*	E.U.A. *U.S.A.*
1980	12,1	6,3	4,2	3,1	3,0	2,5	2,5	1,4
1988	11,4	5,7	3,4	2,5	2,3	2,2	1,9	1,3


INDUSTRIAL SALES OF VIDEO CASSETE
ITEM RESEARCHED FROM 1988
Thousands units
600
500
400
300
200
100
0
67
70
73
76
79
82
85
88
Year