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PLANNING AND DESIGN OF THE NATIONAL METROLOGY CENTER IN BRAZIL [1/]

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C O N T E N T S

INTRODUCTION

The purpose of this paper is to set forth in summary form our experience as coordinators of SERVIÇOS DE PLANEJAMENTO S.A. - SPL in the planning and design of the Brazilian Metrology Center. We believe that these services, which were carried out in behalf of the National Institute of Weights and Measures of the Ministry of Industry and Commerce, are especially significant for having been accomplished in a developing country like Brazil.

The general description of this experience, and the more technical information which is contained in the annexes, will be supplemented by oral presentations of the authors.

We appreciate the thoughtful invitation of the United Nations Industrial Development Organization to present this paper and are pleased to try to be able to contribute to UNIDO's high objectives.

I - The National Institute of Weights and Measurements (INPM), Ministry of Industry and Commerce - Rio de Janeiro - Brazil

Metrology is one among a variety of essential tools needed by any country striving to reach its full development potential. One such country is Brazil, which continues to enjoy one of the highest development rates in the world, with annual growth in its GNP of 9.3%, 9%, 9.5%, 11.3%, 10.4% and 11.4%, respectively, for the years 1968 through 1973.

A marked increase in the demand for science and technology distinguish this phase of Brazilian development. It is logical, therefore, that under these circumstances, Brazil views with some urgency the creation of an adequate metrological capacity to normalize standards and measures, assure compliance with legal calibration requirements, undergird scientific research and enlarge the area of technological influence. This requires continuous and effective action and vigilance, if full advantage is to be taken of opportunities to contribute to the development of science, technology, industry and commerce.

Metrology is implicit in all human activities. It is not limited to the control of weights and measures, but extendes to matters related to the market, to development and to the quality of products. Metrology is closely interwoven with NORMALIZATION, QUALITY CONTROL and CERTIFICATION, forming a continuum. It is in this context that the INPM, appraising the present stage of Brazilian development which has assumed a dynamism characteristic of developed nations, decided to expand and modernize its former facilities and laboratories and to make provision for the acquisition of qualified staff to meets its new responsibilities in the area of normalization and quality of industrial products.

Serviços de Planejamento S.A., a Brazilian firm with headquarters in Rio de Janeiro, was awarded the contract, in accordance with Brazilian legislation governing public bidding procedures, to make the studies and prepare the project to create a new NATIONAL METROLOGY CENTER. A tract of land measuring some 1.8 million square meters, located twenty-three kilometers from Rio de Janeiro, was made available for this purpose.

In only one year, the studies and the design of the project were accomplished, as well as the preparation of a draft law creating a public Agency (autarquia). This law, whose text is enclosed as Annex I to this paper, was approved by the Congress, providing financial autonomy and administrative flexibility.

As generally happens in developing countries, the actual establishment of a Metrology Center is a challenge to the Government. The challenge stems not only from the fact that the Center will operate on a national scale, but mainly from the scope of the undertaking which, since it should include all specialities, requires central and regional laboratories well equipped in terms of technical and scientific facilities and staffed with highly qualified personnel, whose education and training represent a high level of investment. Return on capital is a long term proposition and operational and maintence costs are high, with no compensating surplus in income which sould permit amortization of investments within conventional time periods. A good share of return on capital invested is indirect and difficult to identify. Another important fact to be considered is that, in these countries undergoing rapid technological change, industrial activities increase daily and, as a consequence, the rythm of growth required of the laboratories to keep pace with the rapid sequence of innovations necessitates a constant rate os expansiona incompatible with the profit orientation of undertakings of this nature in the private sector. Finally, and this important feature is well worth emphasis, a Metrology Center as conceived in Brazil goes far beyond the traditional role of legal metrology, and concentrates on research and development and on the coordination of normalization and industrial quality. These activities are carried out not only in connection with products for the domestic market, but also for products intended for the highly competitive international markets.

II - Planning

The planning of a National Metrology Center is a challange in developing countries, not only because of the multiplicity of aspects to be considered, some of which are entirely new, but also because of the necessity for the absorption and evaluation of all technical-scientific progress. The same types of difficulties arise relative to architectural problems and the preparation of layouts for the variety of options and approaches which present themselves as a consequence of the diversity of laboratory services and functions, when an effort is made to achieve for the whole complex a unity of style and an esthetic homogeneity, without prejudice to the operational individuality of the parts.

The best planning will inevitably be out-dated as new conditions, brought about by scientific, technical, economic, social and political progress, require changes and adaptations. Planning should be based on the present, while anticipating probable changes in the near future. And it should be characterized by flexibility which will permit it to meet the requirements of the constant evolution of human conquests. For these reasons, it would be as improper to create a Metrology Center patterned after those of the most completely developed countries as it would be to consider the most rudimentary Center as satisfactory.

The fundamental factors underlying the development of the country must be taken into account in the planning process in order for the solutions to be compatible with the stage of its economy and culture and to permit the planning process to accompany its expansion.

The assumption exists on the part of some that by simply observing the functioning of metrology centers in the most advanced nations, sufficient data can be gathered to prepare a project adapted to the conditions of another country. This, however, has not been our experience in the Brazilian project.

In the metrological world, there are no uniform criteria for the metrology centers. In most instances, the most modern centers possess advanced features in some respects and conventional or even outdated features in others. Normally, these institutions were organized as consequence of the industrial development and of the strong support of highly skilled professionals in certain sectors.

This situation which creates problems in the planning phase, becomes advantageous for countries whose laboratoris are not up to the desired standards for it permits the widest choices. The very absence of entrenched traditions facilitates the immediate implementation of the most advances solutions.

Once a complete knowledge of all alternative has been obtained, planning must proceed to a final solution which faces the totality of problems identified. This approach will produce as a final product, the economic viability of each of the units and of the Center as a while, since all technical requirements to meet the objectives of the National Metrology Center will be satisfied with respect to its necessary and dynamic role in the development of the country.

III - Methodology

Brazilian experience indicates that in preparing for planning a National Metrology Center it is advisable that all aspects to be studied be grouped in three distinct sectors, each of these operating under the control of a senior professional. These professionals, in turn, work under a general coordinator responsible for carrying out the project, and they are:

Sector C1 - Legal, institutional and financial-economic aspects
Sector C2 - Scientific and technological aspects
Sector C3 - Engineering and architectural aspects.

This structure permits parallel action and, consequently, reducing to the minimum the dependency of each sector on the inputs of the others. These inputs are channelled through the general coordinator who is responsible for the overall supervision. In meetings with the contractor, the Project Manager should be accompanied, whenever necessary, by members of the team which are studying the matters to be discussed.

Thus, the global integration of the studies is achieved by sucessive approximations and additions, until they reach, step by step, the final phases of synthesis and proposals.

Another basic and simultaneous procedure consists of presenting partial reports of the sectors in the form of detached documents, as each of these is concluded, to shorten its processing time and facilitate its examination by the contractor.

The methodology for the execution of the project is distinguished initially by the studies made by each sector. When those of group C2 reach the conclusive stage, the elements needed for preliminary engineering and architectural plans can be furnished by sector C3. The preliminary urbanization plans and the first architectural outlines are analysed and criticized jointly, by the three sectors, enabling thereafter the execution of the projects with their accompanying norms and budgets. (*)

SECTOR C1

The essential objective of this sector is to maximize the functional capacity of the National Metrology Center so that it can meet the technical demands deriving from the development of the country. This objective requires, in the first instance, an analyses of all relative legislation, including its constitutional basis and the legal and regulatory consequences stemming therefrom. Simultaneously, the conduct of research on national requirements for metrological services makes it possibie to sketch out the potential demand which, considered in conjunction with the studies of sector C2, indicate the future delineation of the laboratory units, provided that, in addition to the type of demand, the data permit an evaluation of its volume.

In the event it is found appropriate to restructure and modernize the metrological organ, if one exists, or, if none exists, to create a new organ, it is the responsibility of sector C1 to propose the directives stablishing a national metrological policy. The inclusion of questions relative to

(*) - The list of technicians belonging to these sectors is included in Appendix VI of Annex III.

normalization, certification and quality control in this study is of greatest importance.

Sector C1 concludes its work with studies of the establishment of Special Centers: Data Processing, Human Resources and Metrological Information, as well as formulating the financial-economic programming process.

In Brazil, the studies resulted in supporting data which contributed to Government approval of the creation of a new institution, the National Institute of Metrology, Normalization and Industrial Quality (INMETRO), a federal agency, and the creation of the National Council of Metrology, Normalization and Industrial Quality (CONMETRO), within the Ministry of Industry and Commerce. A description of CONMETRO may be found in Annex I.

SECTOR C2

Normally, in other countries,metrology centers have been formed by addition of successive segments and not as in Brazil, were was essential the integral planning of a national center in its entirety, in a very short period.

One of the central objectives of the project was to select and provide specifications for the laboratories, and further, to dimension them in the short, medium and long term, proportionally to the rythm of national scientific, technological and insdustrial development. It must also be recognized that the very existence of a modern and efficient metrological center will stimulate by its presence a greater demand for services essential to the scientific-technical development of the country.

It was assumed, implicitly, that the several options or viable solutions constituted a list that could not be reduced to a single basic choice. This, however, contradicted the initial idea. The example of metrological laboratories abroad is clear and informative in this respect. Even though the maximum degree of perfection cannot be attributed to any of them, it can be affirmed with confidence that they all function well, although possessing different structures. This experience was of undeniable value in the selection and choice of the types of laboratories most adequate for Brazil, where the very absence of strong traditions facilitated the immediate implementation of advanced solutions.

Considering the inadequacy of most of the foreign models for the structuring of the National Metrology Center and, at the same time, the suitability of their scientific and technical aspects, the process of selection of the units was based, on one hand, on the clear and precise definition of a series of guiding scientific criteria, and on the other hand, on the evaluation of the short, medium and long term problable demand for metrological services, considerering not only the readily apparent needs, but also repressed and potential requirements.

As no obligation existed to follow any rigid scheme in the development of the project, and starting from the premise of a global planning process which would meet the requirements of Brazilian regional diversification, it was possible to adopt general and flexible criteria for the organization of the laboratories in sectors, grouped homogeneously according to the technique utilized or to the predominant type of scientific knowledge required.

Another very important criterion was that of establishing the relationship of one laboratory to another, that is, which laboratories have interests in common, as for example, like equipment. This was done in an effort to reduce initial capital investments, as well as to determine which laboratories should be separate from the other, for technical reasons.

Sector C2 was also responsible for establishing the objectives, functions and services, physical areas, environmental control, personnel estimates and all other pre requisites for the operation of each laboratory, including methods of measurement, their techniques and specialized equipment. Examples of the functions of sector C2 are described in Annex 3.

SECTOR C3

The engineering group of Sector C3 was responsible for the studies and solution of physical location, demarkation of areas, survey of geological and climatic conditions, water supply, drainage, sewerage system, etc. which make up another area of investigations.

In the study of urbanization, groups of activities which by their characteristics presented specific location and space requirements, were preliminarly identified, consideration being given to the Access Sector, Support Sector and Laboratories Sector, with Miscelaneous Services being distributed in separate points.

An effort was made, through landscape planning, to give the whole space the atmosphere and quality of a campus environment, to enhance work output and the well being of the personnel who will man the Center.

The application of the concept of modularity in the architectural design of the Center provided the laboratories with the best operational conditions and resulted in a reduction in final capital investments, with the adoption of two standard modules, one for the electricity and temperature laboratories and the other for mechanics and optics, in addition to the special case of acoustics.

The work schedule of Sector C3 was as follows:

a) Reconnaissance of the locale where the Center was to be established;
b) Collection of data for engineering studies (topography, soils, water, drainage, sewerage system, electric energy, noises and vibration);

c) Complementation of existing soundings;
d) Visits to and technical observation of national and foreign laboratories in operation or under construction;
e) First analysis of studies and conclusions of Sectors C1 and C2;
f) Preparation of the basic program for urbanization and construction;
g) Preparation of the first draft of the urbanization project;
h) Initial outlines of the architectural projects for laboratory units;
i) Preparation of a revised draft of the urbanization project;
j) Critique of Sector C2 partial reports;
k) Consulation with national experts in areas of specialined engineering (climatization, communications, fire prevention, lighting, etc.)
l) Preparation of final preliminary architectural designs for buildings, to house center support activities;
m) Preparation of final preliminary urbanization and landscaping plans;
n) Preparation of final preliminary architectural designs for the laboratory units;
o) Estimations of cost;
p) Preparation of specifications and technical norms for project execution;
q) Engineering, architectural and urbanization projects;
r) Budgets.

Annex 2 contains the fluxogram which served as the basis of the over all planning of the National Metrology Center.

IV - Use of foreign know-how in the National Metrology Center Project

The National Institute of Weights and Measures decided to open the selection of consultants to public bidding, permitting the participation of foreign firms in consortium with national firms. The purpose of this approach was to bring foreign experience to bear on the problem, in recognition of the difficulty in carrying out the project with only the resources of INPM itself, or of any national firm, due to lack at that time of specific experience in this field, Serviços de Planejamento S.A. - SPL, a Brazilian Consulting Firm, decided to submit a proposal in response to the public invitation to bid and, after a preliminary study of the terms of reference, established an initial working hypothesis on which the structure of the whole project was based. The principal point concerned the most suitable form of arranging for specialized know-how from abroad. The hypothesis os establishing a consortium with foreigh firms presented one serious disadvantage. Brazilian conditions were unsuitable for the transfer of methods and solutions customarily used by these firms in their home countries. Further, Brazil possesses advanced know-how in engineering and architecture, which should be used as the basis of the entire project.

The solution to this problem was the invitation, made by SPL, to divers specialized foreign scientists and technicians, who had experience in metrological activities. Instead of becoming associated with foreign firms, SPL brought well known scientists and technicians to Brazil. These foreign specialist, working in conjunction with a counterpart national team, produced a plan for the laboratories, with all adaptations required to meet Brazilian needs, and without the drawbacks (from both, the technological and economic points of view) of a pure and simple incorporation of foreign experience.

Projects must be compatible with the characteristics of each country, with thoughtful consideration of its social realities, stage of economic and cultural development, level of scientific specialization and technological progress. The contribution of case-studies, therefore, becomes important.

International experience, the undeniable competence of foreign consultants, the active participation of national technicians, the supporting date represented by the study of available information on nationel and foreign laboratories and the rich bibliography, consulted, constituted a guarantee of the objectivity of the overall epproach to the problem, and enabled a generel evaluetion of all elements which came to compose the proposed plan.

The main foreign consultants on this project who led their own groups os specialists, who they, themselves, selected, are listed below:

1. H. L. Daneman (USA)

Foreign Consultant on Electrical and Heat Laboratories and Environmental Controls. He was responsible for functional and technical reports as follows:

Functional	Technical
Area and Relationship of Labs	AC Facility
Calibration Procedures	Calorimetry
Consultants	Cryogenics
Distribution of Calibration Services	Current/Low Resistance
Economic Information on Services	Electrical Laboratories - General
Environmental Control - Concepts and Recommendations	Humidity
Foreign Laboratories	Magnetic Testing
Functions and Organization	Microwave Measurements
Inventory Procedure and Format	Pyrometry

Functional	Technical
Library and Bibliography	Resistance
Questionnaire Design and Use	Temperature Laboratories - General
	Voltage - High Range
	Wattmeter Calibration

Each technical report defined:

Functions of Laboratory - basic and advanced
Design Requirements - including special facilities
Apparatus Lists - for basic and advanced work
Technicians and scientists of personnel requirements
Area needed for laboratories and related facilities
References and documentation most appropriate to needs.

Mr. Daneman made complete arrangements for a demonstration tour of major U.S. Metrology Laboratories and guided the brazilian group on this tour.

His colaboration was also valuable as he offered many suggestions and made comments on architectural and engineering designs. Examples are the introduction of modularity, the arrangement of rooms with respect to environmental protection and related usage, layouts within laboratories and outlines of services and utilities.

2. Prof. E. J. C. Engelhard (Germany)

Foreign Consultant on Mechanical and Optics Laboratories. Basically, he was responsible for the same type of reports described above, for his group of laboratories.

3. Prof. P. V. Brüel (Dannemark)

Foreign Consultant on Acoustical and Vibration Laboratory, Within his field he was also responsible for the same type of reports described above.

V - Rationale for a human resources center

Among the fundamental points which merit mention in the implementation of a National Metrologic Center in a developing country are recruitment, education and training of human resources.

In 1972, in order to create an efficient human resources reserve, the National Institute of Weights and Measures (INPM) launched the Project Krypton. This measure was necessary due to the small number of experts available at the time. The main reason for this shortage of personnel was the low salary levels in effect in the Public Service, which frustrated all efforts to improve the human resources area. Project Krypton consisted of a course in metrology with a duration of 12 months, after which the students had an equal period of practical professional training in a metrological laboratory abroad. INPM was offered scholarships for this purpose by Germany, France and UNIDO.

Upon the creation of a federal Agency the Institute of Metrology, Normalization and Industrial Quality, (INMETRO), to substitute INPM, the salary problem should no longuer constitute the obstacle which for so many years made it difficult to attract qualified personnel or manpower capable of receiving education and training in this specific area.

Programming of the Human Resources Center should offer education to professionals in the following levels:

a) high-level personnel (master and doctorate degrees);
b) university-level personnel, with specialization courses in Metrology, for students of Engineering, Physics, Chemistry, etc.;
c) middle-level professional personnel, for the divers tasks to be carried out in the fields of legal and applied metrology;
d) assistant metrologists and calibrators, principally for the plants.

Recruitment and selection were carried out among recent university graduates for the high level course and among high school students and in the labor market, for middle level courses. We should also mention the inclusion of candidates from companies interested in the training and upgrading of their technical personnel.

A formal agreement was entered into with a University Center, the Coordination of Engineering Post-Graduate Programs, (COPPE) of the Federal University of Rio de Janeiro (UFRJ), to obtain a legally recognized academic certificate for holders of scholarships who conclude specialization courses.

Training of technical administrative and clerical-administrave personnel is now being added to the above mentioned courses to enable them to better perform their functions within INMETRO.

Thus, the objectives of the Human Resources Center will be selection, education and training of personnel of other organs of the public or private organs or business in the divers professional levels and in the various fields of Metrology. These objectives are closely related to the current Brazilian policy of scientific technological development, and are characterized by the close associations between the formal courses in Metrology and the specific needs of the profession, specially those needs relative to the high scientific precision required of the instruments.

In line with the practice of scientific interchange, it is planned to promote the collaboration of foreign specialists and international institutions to establish periodic contacts, either in connection with laboratory research and teaching activities or to send Brazilian specialists to foreign countries to work as trainees or to collaborate in programs equivalent to those carried out in Brazil.

In the future, the Human Resources Center should become a School of Metrology, where technicians prepared for industry would be able to contribute to defend industrial quality standards.

VI - Market study of Applied Metrology Services

It is incontestable that the most dynamic element in the diagnosis of metrology problems in Brazil is the volume of demand for metrologic services on the part of those industries using high level technology. In the past, indifference or even opposition to innovations involving costs and controls on the part of businessmen could be considered resistance to industrial modernization. Therefore, it would be advisable to identify the attitude of the more representative group of entrepreneurs (firms under state control, private firms with predominant foreign capital and national private firms), vis-a-vis the new phase into which the system of weights and measurements has entered.

To a certain extent, the steadfastness of the implementation of Fundamental Metrology (to which capital investments currently being applied at the Center at km 23 are linked) should be related to and complemented by the flow of concrete demand for high level calibrations, and not only to elementary calibration practices of a fiscal nature.

Based on this approach, a field survey was conceived and carried out, designed to determine the preliminary reactions of hundreds of entrepreneurs and technologists to the idea of a systematic provision of services in this sector.

These marketing studies had also the following purposes:

I - definition of the sectorial structures of the industrial and related demand;

II - delineation of the qualitative extent of services to be offered, through the specification of the divers kinds os services and the varied types of equipment susceptible to calibration:

III - collection of technical and economic data on client firms to enable a correlation of these data with the metrological demand;

IV - estimation, to the extent possible, of demand in each industrial sector, for each group of services which may justify the selection and dimensioning of the technical scientifical laboratories which will compose the CNM.

Simultaneously with this field survey, which involved approximately 600 industrial firms, informal contacts were made with scores of scientists, professors and public civil officials involved in work related to technological areas, all of whom expressed their opinions and presented suggestions on the implementation of a technological development policy in the areas of metrology, industrial quality and normalization.

The results of this work have confirmed the validity of the initial course of action.

Because of the embryonic nature of the official initiative, and in spite of the lack of contact between sources of supply and demand it was possible to detect the main types of services demanded the frequency of calibration (resulting in a great number of cases from the technology itself) and the deep interest of the "potentials clients" in the formalization of the new market. Additionally many cases were discovered in which the plants maintain costly facilities for instrument calibration or, still more serious, are forced to pay for calibration services in the countries where the equipment was produced.

The main result of this survey, however, was the technical registration of the elements which generate demand, that is, the instruments themselves, which are subject to periodic calibration norms.

This registry sould be continuously updated, through direct systematic contacts with each of the selected industrial firms.

VII - Capital investment operating costs and economic projections

In whole numbers and as a provisional forecast, the Brazilian project may be summarised as follows:

1.	Total area	1,000,000 m²
2.	Area to be urbanized	700,000 m²
3.	Area of construction	42,000 m²
4.	Laboratory areas	15,000 m²
5.	Programmed investment	(in US$1,000.00)
	Construction work	16,000
	Equipment and instruments	10,000
	Other items	1,000
		US$27,000,000.00
6.	Personnel working in the 1st phase	1,000
	Technicians and scientists	150
	Other categories	850
7.	Division of activities into sectors:	
	I - Fundamental Metrology (or scientific)	

II - Legal Metrology
III - Applied Metrology (or industrial)
IV - Industrial Quality Certification
V - Normalization

Business Structure

A measure considered to be essential, within the course of action selected, was the adoption of an economic business model for the new Brazilian entity, responsible for the national metrological system, normalization and industrial quality certification. The basis for this decision was the need to assure direct and indirect "returns" to the resources invested in this sector, along with the effective evaluation of the legal and administrative structure (see Law nº 5966 annexed) adopted, is considered suitable to avoid the burocratic distortions which are so harmful to scientific and technical organization, throughout the world.

Productions and Sales Concept

The five sectors listed above correspond to very different types of activity and to special procedures used for listing and meeting demand (if one can consider as demand the simple definition of a need or institutional requirement). Through analogy, it is not difficult to specify either those directly responsible for, or those who directly benefit from decisions which imply options as to the use of human and material resources of the technical office.

So, we have:

I - Fundamental Metrology

- Approval of programs and forecast of funds required are the responsability of the Government.
- Costs in this sector should be financed from the public budget.
- The "client" is the Government.

II - Legal Metrology

- Although is the form of compulsory demand "the clients will be the hundreds of thousands of business which submit their equipment or products to calibration and control, paying the price of these services.
- This sector is expected to earn an appreciable profit.

III - Applied Metrology

- The demand, whether voluntary or spontaneous, for this type of metrological services, will be encouraged by incentive policies promoting technological development.

- A significant part of the services will be carried out by other authorized laboratories.

IV - Industrial Quality Certification

- Although of small significance as an element of cost, normalization has a relevant role, as it will meet the demand of hundreds of areas in the industrial economy, presently lacking the necessary normative support.

Within the operational scheme of the institution, it is important to point out the need to register and control the costs of each activity or project in each sector, with the periodic determination of the business income and expense budget, which show the internal transfers of balances to cover deficits. A source of funds, in the form of public resources or through the application of finantial surpluses resulting from other activities, will be always available to cover a given item of cost, thus escaping the concept according to which, no task should be performed without the payment of the costs involved.

ANNEX 1 - Law Nº 5966, December 11, 1973

Establishment of a National System of Metrology, Normalization and Industrial Quality and Creation of the National Council of Metrology, Normalization and Industrial Quality (CONMETRO) and of the National Institute of Metrology, Normalization and Industrial Quality (INMETRO).

"Establishes the National System of Metrology, Normalization and Industrial Quality and makes other provisions."

Art. 1 - The National System of Metrology, Normalization and Industrial Quality is hereby established for the purposes of formulation and execution of the Brazilian policy on metrology, industrial normalization and certification of industrial quality.

Sole paragraph - The system will be composed of public and private entities which carry out activities related to metrology, normalization and certification of industrial quality.

Art. 2 - The National Council of Metrology, Normalization and Industrial Quality (CONMETRO) is hereby created with the nature of normative organ of the System of Metrology, Normalization and Industrial Quality.

Sole paragraph - The composition and functioning of CONMETRO will be defined by Executive order.

Art. 3 - It is the responsibility of CONMETRO to:

a) formulate, coordinate and supervise the Brazilian policy on metrology, industrial normalization and certification of quality of industrial products, harmonizing the interests of Government and industry and the consumer;

b) assure uniformity and rationality in the application of units of measurement used throughout the country;

c) promote voluntary normalization activities in the country;

d) establish norms governing industrial materials and products;

e) establish criteria and procedures for certification of quality of industrial materials and products;

f) establish criteria for the application of penalties in the event of infractions of the legislative provisions governing metrology, industrial normalization, certification of industrial quality or against the normative regulations relative thereto;

g) coordinate Brazilian participation in international events in the fields of Metrology, Industrial Normalization and Certification of Industrial Quality.

Art. 4 - The National Institute of Metrology, Normalization and Industrial Quality (INMETRO) is hereby created as a federal agency related to the Ministry of Industry and Commerce, with the nature of a public entity capable of exercising legal rights, contracting and fulfilling obligations and possessing its own assets.

Par. 1 - The headquarters of INMETRO will be located in Brasília;

Par. 2 - The legal dispositions concerning the organization and functioning of INMETRO will be laid donw by executive order.

Par. 3 - The head of INMETRO shall be appointed by the President of the Republic.

Art. 5 - INMETRO is the central executive organ of the system defined in Art. 1 of this Law and may, as authorized by CONMETRO, accredit public or private entities to act in its onw fields of competence with the exception of that of legal metrology.

Art. 6 - The assets of INMETRO will be formed in the following manner:

a) through incorporation:

I - of all assets of the Federal Government which are at present directly or indirectly under the care, management and responsibility of the National Institute of Weights and Measures(INPM);

II - of assets acquired with resources derived from metrological services and from the Metrology Fund (FUMET);

III - of the financial resources of FUMET as determined at the date of its extinction.

b) through the opening of a special grant in the Federal Budget for 1973 in the amount of Cr$10.000.000 (ten million cruzeiros);

Sole paragraph - The Minister of Industry and Commerce will appoint a Commission, with the participation of a representative of the Federal Assets Service, in order to inventory the assets referred to in Items I and II-a of this article.

Art. 7 - The resources of INMETRO will be composed of:

a) such budgetary grants and supplemental credits as may be provided it, by law;

b) income received for services rendered in accordance with this Law;

c) revenues derived from the imposing of penalties;

d) funds received from agreements entered into with public and private entities for the purposes defined in this law;

e) others.

Art. 8 - INMETRO will be staffed with its own personnel in numbers and specification to be established in accordance with the law.

Par. 1 - At the discretion of the Executive Branch, those personnel who, on the date of publication of this law are on the cadres of the National Institute of Weights and Measures, may have their functions transferred to INMETRO with no change in the legal status of their employment.

Par. 2 - When the cadres of INMETRO are established, those personnel referred to in the preceding paragraph will be placed there in, subject to the applicable regulations and procedures.

Art. 9 - Infraction of the provisions of this law and of the norms laid down by CONMETRO will carry the following penalties, to be imposed separatedly or cumulatively:

a) warning;

b) fine, up to a maximum of seventy times the minimum monthly wage in effect in the Federal District, to be doubled in the case of repetition;

c) proscription;

d) seizure of merchandise;

e) destruction of merchandise.

Sole paragraph - In the application of these penalties, as well as in the exercise of all its responsibilities, INMETRO will be invested with the privileges and preferences of government action.

Art. 10 - The National Institute of Weights and Measures (INPM) and the Metrology Fund will be estinguished by Executive Order.

Art. 11 - The accounts of INMETRO will be submitted to the Minister of Industry and Commerce who will forward such accounts to the General Accounting Office by the 30th of June of the following fiscal year, accompanied of his statement and by the documents referred to in Decree-Law nº 199, of February 25, 1967.

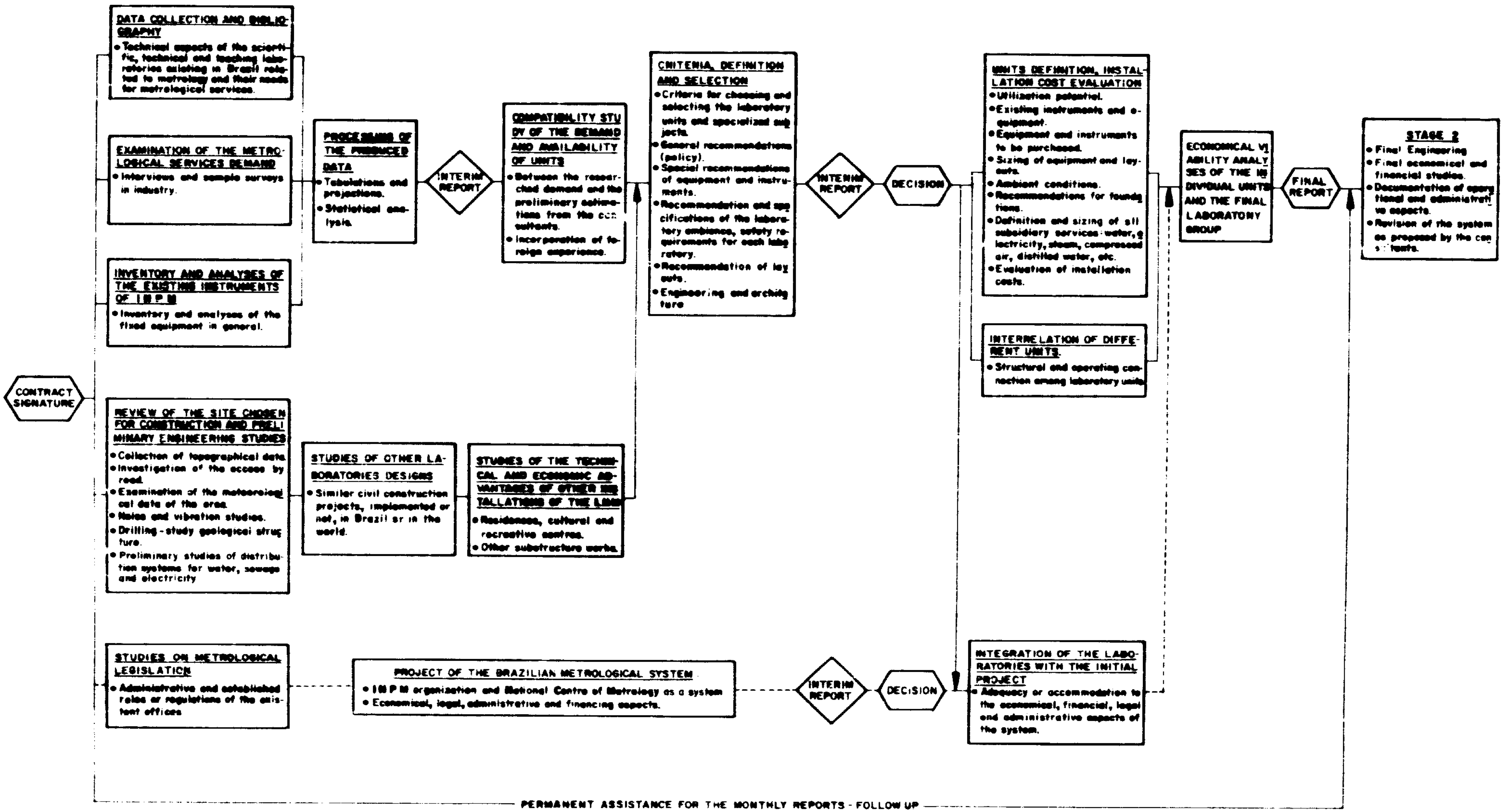
Art. 12 - The provisions of Decree-Law nº 240, of February 28, 1967 as well as the legislation and the normative directives deriving terefrom will remain in effect until the extinction of the National Institute of Weights and Measures and of the Metrology Fund.

Art. 13 - This law enters into effect as of the date of its publication, all provisions contrary thereto being hereby revoked.

Brasilia, December 11, 1973.

ANNEX II

IMPLEMENTATION OF THE NATIONAL CENTRE OF METROLOGY
- FLOW DIAGRAM -



ANNEX III - Technical Scientific Concept

Previous to the issuance of invitations to bid, and between the submission of the bid proposals and the signing of the contract, the Consulting firm made several studies and contacts abroad, intended to shorten as much as possible the period of time necessary to carry out the project. Through these contacts and on the basis of the tentative definition of functions and services for each laboratory, as described in the proposal, the first work phase was started, that is the study and research to be undertaken by the consultants and their staff to identify the more outstanding foreign institutions in each field of activity.

After several months of work, through contacts with various specialists and accredited laboratories, the consultants were able to make a selection, in an effort to bring to Brazil the most up to date concepts, techniques and work methods.

The process of selecting the units which constituted the CNM was based on both the definition of a series of guiding criteria and on the availability of the results of preliminary studies designed to evaluate demand. This evaluation included the short, medium and long term demand for metrological services, taking into consideration not only the readily apparent needs but also the repressed and potential demands, as well as the present capacity for meeting demand in the sectors of scientific metrology, industrial calibration and legal metrology.

After the description of this phase of the work, under the title "Preliminary Notes", the Consultants started to work on the basic concept of each laboratory unit included in the CNM. These notes, based on a study of the best laboratories in the world, made by foreign experts, represent the optimization of the alternative solutions found by these specialists, adapted to Brazilian conditions by Brazilian technicians employed by the Consulting firm.

In the final analysis, the purpose intended was the dimensioning of laboratories in all their aspects. The description of each laboratory was made according to the following logical sequence:

- General considerations
- Concept of the laboratory
- Proposed functions and services
- Recommendations relative to laboratory areas and environment
- Estimation of personnel
- Indication of equipment and instrument lists for each laboratory
- Special recommendations
- Indication of essential bibliographic references

Several general concepts were previously established in the preparation and final study of the Preliminary Notes, such as the full understanding of the fact that, from a formal viewpoint, the Preliminary Notes represented a method of progressive and effective inter-relationship between the Consultants technical staff and the INPM's technical personnel. The objectives of such a method was the gradual and joint (Consultants + Client) evaluation of the basic features of all units and the indispensable and essential participation of all the client's technical staff in the formulation of possible decisions, throughout the various phases of the project. These integrated efforts thus resulted in the participation of all members of both staffs in the final decisions.

The preliminary Notes represent the absorption of foreign know-how into the current Brazilian technology, rather than a simple transfer of a foreign laboratory to the country. They constitute the technical scientific nucleus of the project and contain the inputs necessary for the engineering, architectural and other teams. Some examples of how these Preliminary Notes were presented are provided below:

1. Appendix I shows the definitive list of laboratories, summarizing final result of the project, adopted by INPM as Phase I of its implementation.

2. Appendix II shows a table indicating the number of modules and special rooms in each laboratory, including all sectors.

3. Appendix III shows a table containing an estimate of laboratory personnel and the respective number of modules, planned for their facilities.
   Scientists and technicians referred to in the table are respectively, university level and high school level personnel.

4. Appendix IV presents an example of the way the Preliminary Notes establish the functions and services proposed for each laboratory. This appendix presents a list of the laboratories in the Mechanics Sector, indicating, in each instance and in summary form, the functions and services for each unit.

5. The indication and selection of instruments for each laboratory were carried out according to a specific methodology. A table was prepared for each module, containing a list of instruments for each laboratory, specific equipment, type of measurement to be made, equipment uses, field of measurement, measurement method utilized and accuracy in the measurement intended.

6. A representative list of specialized bibliography and references in shown in Appendix V, selected from the references utilized by the consultants as a basis of their work on High Temperature Laboratory (T-2).

7. Appendix VI indicates all technicians that participated on each Sectros C1, C2 and C3 of this Planning work.

APPENDIX I - List of Laboratories of the National Metrology Center Stage I

ELECTRICAL MEASUREMENTS (E)	
E-1	Voltage and AC current
E-2	Resistance
E-3	Measurements in AC - AC/DC transfer
E-4	Capacitance and Inductance
E-5	Electric Power and Energy
E-6	Current - Transformers tests
E-8	Magnetism
E-9	Time and Frequency
TEMPERATURE (T)	
T-1	General Temperature
T-2	High Temperature
T-4	Calorimetry
T-5	Humidity
ACOUSTICS (A)	
A-1	Acoustics
MECHANICS (M)	
M-1	Line measures
M-2	End measures
M-3	Industrial metrology
M-4	Force, Acceleration and Hardness
M-5	Pressure
M-6	Volume, Density and Aerometry
M-7	Viscosity and Superficial Tension
M-8	Mass
M-9	Flow measurements
OPTICS (O)	
O-1	Photometry, Radiation and Colorimetry
O-2	Interpherometry and Polarimetry
O-3	Geometric Optics
AUXILIARIES (Q)	
Q-1	General Chemistry
Q-2	Photography

APPENDIX II - Table indicating the nº of modules and special rooms for each laboratory

Laboratories	Sector	Modules		
		Type A	Type B	Special Rooms
E1	E	4	4	-
E2		4	4	-
E3		2	2	1 (external)
E4		1	1	-
E5		3	3	-
E6		-	-	1 (external) (triple)
E7		2	2	1 (future)
E8		2	2	+1 (shielded room)
E9		2	2	-
A1	A	-	-	Special Modules
T1	T	3	3	-
T2		2	2	-
T3		(2)	(2)	1 Double (external)
T4		2	2	-
T5		1	1	-
M1	M	1 + 1R	1 + 1R	(a) + 4 assistants
M2		2 + 1R	2 + 1R	-
M3		3 + 2R	3 + 2R	-
M4		1 + 1R	1 + 1R	1 (e) (external)
M5		2 + 1R	2 + 1R	-
M6		1 + 1R	1 + 1R	-
M7		1	1	-
M8		1 + 1R	1 + 1R	-
O1	O	2	2 + 2R	(b)
O2		2	2 + 1R	-
O3		1 + 1R	1 + 1R	(c)
Q1	Q	1	1	-
Q2		1	1	double

APPENDIX III - Table indicating the technical personnel and offices for each laboratory

Laboratories	Sector	Scientists (S)	Technicians (T)	Nº of Offices Modules
E1	(E)	2	2	3
E2		2	2	3
E3		1	1	2
E4		2	2	2
E5		1	2	2
E6		1	1	2
E8		1	1	1
E9		1	1	1
Sub-total		11	12	16
T1	(T)	2	3	2
T2		2	3	2
T4		1	1	1
T5		1	1	1
Sub-total		6	8	6
A1	(A)	1	3 + 4A	2
Sub-total		1	7	2
M1	(M)	2	2	3
M2		2	2	3
M3		4	4	6
M4		2	4	4
M5		2	2	3
M6		1	2	1
M7		1	1	1
M8		2	3	2
M9		2	2	2
Sub-total		18	22	25
O1	(O)	3	6	6
O2		2	2	3
O3		2	2	3
Sub-total		7	10	12
Q1	(Q)	1	1	2
Q2		1	2	2
Sub-total		2	3	4
T O T A L S		45	62	65

APPENDIX IV - Functions and Services of the Mechanical Laboratories (*)

M1 - Line Measures

Calibration of graduated scales, meter bars up to 4m, measuring tapes and geodetic wires up to 50m. Graduation of particular scales. Determination of the linear thermal expansion of line measures.

M1(a) - Length Measurement Techniques

Development of methods, design of apparatus for particular length measurement problems in industry, geodesy and research. Control of length measurement equipment. Automatic length control by use of laser interferometers, gratings or other suitable means. Research on length measurement problems.

M2 - End Measures

Calibration of block gauges and end measures of any kind up to 1m by comparison measurement or optical interferometry. Representation of the primary wavelength standard of length. Thickness measurements of thin films. Determination of the linear thermal expansion of end measures. Measurement of wavelength standards.

M3 - Industrial Metrology

Linear, angular, geometrical measurement and in-process control of size and form. Measurement of mechanical gauges. External and internal diameter measurements.

Surface Microstructure

Measurement of the surface characteristics, surface profile,surface finish, roughness, friction and gloss.

Industrial Production Measurement Techniques

Measurement of machine tools. In-process control of production parts. Automatic machine control. Automatic control of machines Control of grinding and lapping. Investigations on gauging and inspection. Research on production techniques.

M4 - Measurement of straightness, planeness, roundness and concentricity. Alinement. Angle measurements. Measurement of gears, worms and screw threads.

(*) Definition established as first work hypothesis

Mechanical Material Testing

Measurement of hardness, resistance, elasticity and plasticity. Calibration of apparatus measuring these characteristics. Fatigue, creep and flow tests.

M4 (e) - Force

Managing of compressive or tensive forces up to appr. 100 tons. Calibration of testing machines and compression or tension gauges. Measurement of torsional forces. Calibration of torque indicators.

M5 - Pressure

Establishment of the fundamental pressure scale. High pressure measurements. Measurement of the compressibility of materials. Calibration of manometers. Research on the properties of solids, liquids and gases at high pressures.

M6 - Measurement of Liquids

Calibration of volumetric equipment for liquids. Calibration of water and mineral oil meters. Investigation on flow meters for liquids.

Density, Areometry

Density measurements of solid, liquid and gaseous substances.

M7 - Viscosimetry

Measurement of the viscosity of liquids and gases, particularly of mineral oils. Pressure and temperature dependance of the viscosity. Calibration of viscosimeters. Research on viscosity.

Superficial Tension

M8 - Precision Weighing

Measurement of the prototype kilogram. Calibration of weights. Testing of precision balances.

Legal Metrology Weighing

Testing of balances subject to the regulations of the legal metrology service, particularily testing of balances for trade and building materials, load leverage balances, automatic balances with electronic parts. Certification of such balances. Measurement of humidity in air, gases, liquids, solids and grains. Calibration of hygrometers. Air humidity control.

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APPENDIX VI - List of Technicians

The technical group from SPL which collaborated in the various sectors of the National Metrological Center project, was composed of three different teams, divided into sectors C1, C2 and C3. These teams were constituted as follows:

General Coordinator

0.1 - Prof. A. M. Siqueira Cavalcanti

1. Team I - Institutionalization and economy (C1)

1.1 - Coordinator Prof. J. Zacarias Sá Carvalho
1.2 - Administrative Technician Newton F. Campos
1.3 - Lawyer Luiz Eduardo G. Gabarra
1.4 - Economist José Graça Filho
1.5 - Computer Scientist Eng. Luiz Carlos de Sá Carvalho
1.6 - Economist Leonardo de Almeida Rodrigues
1.7 - Eng. Paschoal Davidovich
1.8 - Professor Osmar Fávero (training)
1.9 - Eng. Helcio Antunes (marketing)
1.10 - Eng. Eolo Luz
1.11 - Economist Sergio Augusto Coimbra de Mello
1.12 - Eng. Leonel Duarte

2. Team II - Science and Technology (C2)

2.1 - Coordinator - Industrial Chemist Fábio Becker
2.2 - Eng. H. L. Daneman
2.3 - Prof. Per Vilheln Bruel
2.4 - Prof. Johann Georg Ernst Engelhard
2.5 - Prof. Antonio Seabra Moggi
2.6 - Electronic Eng. A. Carlos Didier B. Vianna
2.7 - Prof. Jacques A. Danon
2.8 - Prof. David Goldstein
2.9 - Prof. Arthur Schechtman
2.10 - Eng. Teodoro Oniga
2.11 - Eng. Tácito Ayres
2.12 - Eng. Bernardino Silva Maia
2.13 - Eng. José Wilson Barberini

3. Team Engineering and Architecture (C3)

3.1 - Coordinator - Eng. J. Marcello P. da Cunha
3.2 - Arch. L. Eduardo Indio da Costa - Physical and architectural planning
3.3 - Eng. Orlando Pilo da Silva Duarte - subcoordinator
3.4 - Arch. Ary Celso France
3.5 - Arch. J. C. Faria Boltshauser
3.6 - Arch. Maria Tereza Megale Franchischini

3.7 - Arch. Salomão Tandeta
3.8 - Arch. J. Luciano Ribeiro Fernandes
3.9 - Prof. Artur Eugenio Jerman
3.10 - Eng. Kurt
3.11 - Eng. Osvaldo Leonardo Pereira
3.12 - Arch. Livio Edmundo Levi
3.13 - Arch. Almir Lima Machado
3.14 - Arch. P. Roberto Martins de Souza

ANNEX IV - Notes on the physical planning and architecture of the National Metrological Center.

a) Physical Planning

Taking into consideration the information and recommendations of teams C1 and C2, the physical planning strove to distribute the various sectors and buildings in a rational manner, while respecting functional interdependences, by designing the complex along the lines of a university campus with the building separated from each other. This preliminary concept enabled the adoption of an approach that offers an enormous capacity for adjustment and flexibility, when the need arises for future expansion of the National Metrology Center.

The zoning proposed for this area took into account institutional, administrative and economic aspects and was based on the following physical characteristics:

- Encircling road system
- Topography
- Hydrography
- Geology
- Solar orientation
- Predominant winds
- Pluviometry

- Relative humidity and its variations
- Temperature and its varistions
- Vibrations, their sources and transmission
- Vegetation
- Existing physical elements such as the INPM's headquarters building.

For the purpose of overall zoning, three sectors were identified: the Access Sector, the Support Sector and the Scientific Sector. Considering that all the laboratories would be located in the Scientific Sector, this Sector was allocated the most favorable area, from the points of view of topography (for construction) and isolation (for control of noises and vibrations).

The site of the Scientific Sector is naturally protected as it is located in a valley surrounded by hills and with two rivers forming natural boundaries.

The project took advantage of these natural conditions, transforming part of the rivers in channels and pools, thus eliminating the need for ostensive and disagreable security barriers.

In order to protect this sector from external interference, the acess of vehicles to the Scientific Sector of the National Metrology Center will be restricted to a minimum number of authorized users, and circulation of vehicles will be made through the peripheral area, thus diminishing the transmission of vibration from vehicles to buildings and avoiding pedestrian crossings.

In addition to the administrative buildings (Headquarters, etc.) and those intended for general services (garages, workshops, etc.),the Support Sector will contain the buildings intended for educational activities (Human Resources Center) and social facilities (sport areas, club, lodgings, hotel, etc.).

The complexity of the project made it necessary to make a study leading to a unified orientation system, using a color codification and symbols. This system will be utilized as a complementary but important element in determining the characteristics of the architectural style.

This codified system of orientation and information facilitates the rigid control to be adopted in the several access areas. Furthermore, it contributes for the better division of parking areas, according to their specific uses: visitors, personnel and cargo.

With respect to the movement of people within the National Metrology Center, its area is divided into free access and restricted access areas,and the movement is indicated through codified colors. The color of a sector indicates the area to which it refers. When the color red is added (inscribed "prohibited") it means that movement is controlled in the area.

The diagrams annexed to these Notes follow the basic codification adopted, namely:

Laboratory .... Dark blue
Studies .... Royal Blue
Administration .... Brown
Social Facilities .... Yellow

The use of these colors will be closely related to the architectural elements (doors,panels, etc.). For orientation purposes these colors will be complemented by red signs (prohibitions), italics and/or explanatory textes.

b) Architecture

Except for the building intended for the administration of the National Metrological Center, it is planned that the other buildings in the Scientific Sector will be laboratories. With regard to their architectural style, they may be classified as Typical Buildings (Nº 2, 3, 4, 5 and 6), Special Buildings and External Rooms (annexed to the Typical Buildings (for specific uses).

In view of the area availability, the circulation and utilization facilities and an economic factor related to the construction methods, the typical buildings were designed as single story structures.

The lay-out was developed as a closed form, surrounded by isolating and protecting sloping banks.

The nucleus of this basic form is a open-air rectangular courtyard. Administrative and study-rooms (see schematic zoning of the building lay-out) open to the central courtyard, encircling it.

The best protected internal areas of the buildings between an isolating peripheral corridor and ducts, encircled by the external slopes and the internal hallways and vestibules, were reserved for the modules (laboratories).

The architectural solution for the laboratories module was to design an arrangement under which each would function as though it were within a box that itself was within another box, in a system of progressive insulation, principally from temperatures, noises and vibrations, starting from the exterior of the building.

An independent structural system in each laboratory module further increases its vibratory insulation to areas outside the building as well as with contiguous internal areas.

The cover slab, protected by crushed rock and insulated with poliuretan foam, the peripheral grassy slopes, the reduced number of openings leading to the outside and the progressively insulating anterooms make for excellent architectural conditions to provide good environmental control. Physical and psychic comfort are achieved through an effectively zoned layout, using suitable finishing materials and the codified colors in architectural elements, such as doors. The external gardened courtyard provides a final humanizing touch.

The scheme of internal facilities (see appendix) contains a passageway for ducts (a corridor of insulating ducts) which supplies the laboratories with all basic utilities, including water, sewerage, electricity, power, gas, vacuum and oxygen. Each passageway can be easily reached for modifications to or maintenance of the system.

Structurally insulated rooms were reserved for the air conditioning equipment which functions as an integrated center for all sectors and from which the outflow and return ducts part, forming two rings over the shielding slab of the external passageway, which branches out to each sector or laboratory, individualizing it.

The air conditioning return system starts through a plenum in the dividing walls of the laboratories, through a scheme of triple panels.

The construction method was adjusted to the regional technology of reinforced concrete, which leads to a modulation of 1.25m x 1.25m and to finishing materials suitable for each specific case.

The possibility of the future enlargement of individual buildings was considered uneconomical and unviable in view of the interference which would be caused by the work during the construction period, in addition to being counterindicated for administrative reasons. Therefore, the design of the complex set aside expansion areas for new buildings when they should become needed.

Distinguished among the special buildings is the Acoustics Laboratory (Building 1) which, being intended among other things for the measurements of sound in the open air (on the roof), had its positioning determined by the requirement that it be constructed non-parallel with the other buildings. Further, this prohibition against parallelism between the surfaces of the Acoustics Laboratory itself, led to the adoption of a pyramidal form.

In furtherance of these requirements and in special consideration of the need to avoid the reflection of sound in the Scientific Sector of the National Metrology Center, the other external rooms annexed to the Typical Buildings had their form tending toward inclined pyramidal planes. These rooms are connected to the Typical Buildings, with which they have functional interdependence, by closed air conditioned walkways. Their location is a consequence of their special functional characteristics, such as the possibility of modulation, necessity for the room height to be greater, placement of noise producing equipment, etc.

APPENDIX 1 - Special facilities of the National Metrology Center laboratories. A brief description

Firefighting System

The following approach was adopted for protection against fire in the facilities and buildings of the National Metrology Center:

All the laboratories modules will,because of the nature of their equipment, have their areas protected by a mixed detector system, which will be activated by either heat or smoke. The sprinkler system was abandonned because, in case of a small fire, the water sprayed over the equipment would cause greater damage than the fire itself. The other areas of the buildings, including offices, corridors, and administration rooms, will be protected by a system of automatic sprinklers.

Illumination

General consideration which take into account the various elements involved, from climatic conditions to architectonic aspects, led us to adopt fluorescent lighting, exclusively, in all laboratories of the Center. The level of illumination chosen was 300 lux.

A system was decided upon, to furnish power to the lamps which should avoid, to the maximum extent possible, a total blackout of the laboratories, in the event of a partial electrical failure. At the same time, an effort was made to find a way to eliminate the stroboscopic effect of this type of illumination and to vary, at will, the luminous intensity at 1/3 or 2/3 of its total, while maintaining acceptable lighting. Special precautions were taken to eliminate the interference of electric noise in the laboratory equipment. Another precaution was to make the illumination circuits independent of the other circuits providing electric power to the laboratories.

Clock System

Since INPM already had, in its entry building, a quartz master clock which dominated the existing installation, it will be used for the emission of inpulses throughout the area of the Center.

Inter-communications

The inter-communication system design for the Center assures a rapid and efficient means of internal and external communication, covering all its sectors and areas. There will be an automatic central telephone switchboard of the PABX type, with an initial capacity of 30 trunk lines and 300 internal extensions.

Emergency Lighting

The emergency lighting system is intended to facilitate the flow of personnel from inside the buildings without panic or trampling in case of accidents. An emergency electric power supply system to permit continuity of work throughout the Center in the event of a general power failure was not believed feasible. The additional electrical output of the emergency generators would make them excessively large and expensive. They would also become a source of noise, vibrations, atmospheric pollution and other similar problems.

Under these circumstances, independent emergency lighting units will be installed, consisting of two small swivel spot lights (60 w each), batteries, automatic chargers and an automatic control system for the spot lights, in case of external energy failure.

Identical spot lights will be installed in the other areas. These, however, will be connected to a single automatic command unit, installed in the Central Command Post of each building. The alkaline batteries, automatic chargers and the entire control system for these lights will also be located in the Central Command Post.

Normal Supply and Distribution of Electricity (117V - 220V - 60Hz)

The electrical power supply of the laboratories is, for technical purposes, made independent of any other use. The power supply will run through duct passageways, constructed in the rear of the laboratories. The electric power ducts run along steel supports, which keep them in position. Connections will be made on the electric power lines, next to each laboratory and always near a dividing wall.

Entrance to the laboratory will be through a closable aperture, planned exclusively for this purpose. After the installation of the electrical and other ducts, this aperture will be hermetically sealed, to avoid disturbances to the environmental control system.

As this sealing will be solid, thus facilitating the transmission of vibrations passing by chance through any tube within the duct, these tubes will be provided with a stretch of flexible tube, in the connection of the main duct, capable of absorbing vibrations.

All the ducts, boxes, blocks, etc., installed within the modules will be external and readily accessible.

Electric Power Supply - 400 Hz

Only the building Nº 2 - Electricity - will be provided with a special network of electric power distribution of 117 Volts 400Hz. The generator of 400 Hz, to supply the modules of electricity laboratories, will be installed in the room of the Central Command Post, from where the ducts necessary for the distribution to laboratories will originate. Installation, entrance into laboratories, etc., will follow the same criteria adopted for "normal electric supply".

Ground System

All the laboratory modules will be provided with an independent ground protection, either from other laboratories or from the grounded neutral of the electric installation.

This ground bar will be formed by an electrolytic copper bar,of rectangular shaps, fixed in the wall, at a variable height, according to the specific laboratory, by means of porcelam insulators. The bar should have special holes for the insertion of "jack type" terminals.

Electric Power Supply - DC-28V

The DC-28V electric power distribution will be made observing ths same precautions processes mentioned in the previous items.

The convsrter will be installed in the Central Comand Post, together with its respsctive control equipment.

Vacuum Cleaning

Each module will be provided with, at least, one vacuum cleaning outlet, with automatic cover and hermetic lock. The external rooms will have more than one outlet. The normal equipment of each module will include a special vacuum hose, equiped with a special tip and with sufficient length to enable the cleaning of equipment anywhere within the module.

The building cleaning equipment will include a type of hose adèquate to clean floors and workbenches.

The Vacuum Facility will be installed in the Utility Center. To avoid vibrations and noise, a type of rotary vacuum pump was selected, equiped with high capacity filters and silencers, with a noise level under 20 decibels, when working.

Compressed Air

Each module will have a compressed air outlet. The external rooms should be provided with a large number of compressed air outlets, due to the type of work they are intended to perform.

The Air Compression Facility will be installed in the Utility Center, including the main air receiver, air-coolers, filters, purgers, etc.

The compressors should be of the rotating type (screw) with filters and high yield mufflers to reduce the noise to a level less than twenty decibels.

Potable Water

The water supply for the Center comes from deep wells, since there is no municipal water network nearby. The water will be suitably treated to maintain the highest degree of potability. The treatment system adopted consists of automated equipment which incorporates decantation, filtration and chlorination.

Pressurized Water

Although almost all the modules that need pressurized water are in the 20 m.w.c. level, some, for example room M4e, require water at 40 m.w.c. In these instances, the criteria of local installation of a direct control pressure system for this purpose was adopted. As an example, the outside room M4e will have equipment for the production of pressurized water in the area planned for air conditioning equipment. As the utilization of this system is not permanent, a control push button to activate the system will be installed close to each water outlet.

Lightning Rods (Atmospheric Electric Discharges)

As the only elevated structure will be the tower of the water reservoir and even this is insufficient to use a wide radius radioactive captor the utilization of public illumination poles appeared to be a satisfactory solution. In the case of the Center, a small number of highly elevated units suffices, if high power metallic vapor lamps are used. This solution, with poles fifteen meters high, permitted us to select a group of them, strategically located, to form a perfect covering shield with medium power radio-active units.

Sound System

The sound system adopted is intended, basically, to transmit messages and to locate people, with intervals filled with music. The system includes an Information Center to be installed in the present Administration building of the INPM. In the future, it is planned to be installed in the administration building of the Center. Cables will be laid from this central point to the reception balconies of all buildings, where microphones and amplifiers will be installed. The central control will also lay cables for small amplifiers and loudspeakers installed outside, in rest and recreation areas.

Within the buildings, each area will have at least one acoustics box equipped with a potentiometer. This potentiometer, however, will be calibrated for a minimum level, which will not permit the total disconnection of the unit.

The control of the level of sound in common areas near the reception balcony will be accomplished by the employee incharge of reception activities, who will also transmit messages and page personnel, when requested.

Shielding

The primary objective of the National Metrology Center makes it absolutely obligatory to eliminate any element alien to the calibrations, comparisons, measurements and like activities which will be carried out in its facilities.

The iron rods of the reinforced concrete will themselves be used to provide general protection. They will be soldered together to function as a cage. Further, care will be taken to properly ground the rods of each main pillar of the roofing structure.

To provide specific protection, the required external rooms will be envelopped with a plate of copper, appropriately fixed in place and welded together in continuous sheets. Special care will be taken with the envelopment of the doors and the contact of each door with the copper shielding of the room.

All lamps will be shielded by means of copper wire screens. Openings for the insufflation and return of air in the air conditioning system, will be protected in the same manner.

The shielding will be properly grounded, independent of the laboratory where located and of contiguous laboratories.

Utilities Center

The following principal services will be permanently installed in this building:

a) District cooling facility

b) Emergency generators and substation

c) Air compressors

d) Vacuum facility

e) Communications center

a) District cooling facility

This facility was designed to meet initially the needs of the four planned buildings plus the external rooms (1st stage). Equipment will be installed in it for the production of cold water equivalent to 2,000 tons. R. Construction of the facility is designed to be carried out in stages, an adjacent area having been set aside to accomodate future expansion.

b) Emergency generators and substation

An emergency substation, equipped with high speed, automatic generators was designed essentially to meet the needs of the National Metrology Center air conditioning system.

c) Air compressors

An area has been reserved to meet the requirements of the first stage. The installation of two groups is planned initially, with an area set aside for two more groups, in the future.

d) Vacuum Facility

As in the case of Item c), above, two vacuum machines will be installed initially to meet the requirements of the first stage, with area reserved for future expansion.

e) Communications Center

An area was carefully selected for the provisional installation of the Telephonic and Communications Center, and plans were drawn for appropriate acoustic, antithermic and anti-vibratory treatment to provide for the well-being of the operators and conservation of the delicate equipment to be installed there.

Observation: All machines and equipment facilities in this building will have their foundations carefully designed and executed in order to avoid transmitting any vibrations whatsoever to the land which supports them. Similarly, precautions will be taken to reduce noises comming from the operation of these machines, as well as to avoid any possible atmospheric pollution.

Sewerage

The final design of the sewerage network, including the main collector and treatment station, was based on the forecast of a population of 1,000 inhabitants, counting both permanent, residents and transients, in the final stage.

The treatment system will be composed of compact units, adopting the technique of activated sludge. The units will be constructed above ground to enable discharge of the digested sludge and clarified liquid by gravity.

All possibly contaminated waste matter, coming from the laboratories, will be appropriately neutralized before entering the general network. In a like manner, waste material from the garages and mechanical workshops will be gathered in a suitable tank, and only after removal of existing sand and oil, will be released into the general network. The designed system will be capable of a final reduction of 85% of BOD/5 and 90% of suspended solids.

APPENDIX 2 - Techniques for laboratory environment control

1. Introduction

The purpose of this part is to describe the methodology utilized to control environmental conditions within the laboratories (Temperature and Relative Humidity). These conditions are in keeping with the precision required by the service standards of the laboratories, as shown in the table indicative of module temperature and relative humidity, at the end of this chapter.

2. General Concepts

In terms of the precision required of a standard laboratory, the problem of temperature control and reletive humidity obliged us to undertake an in-depth study of the area planned for the laboratories. Meteorological surveys were carried out, involving statistic data of minimum and maximum average temperature in the last 40 years. These data were furnished by the National Meteorological Service. Utilizing appropriate techniques, meteorology experts defined the micro-area climate. Information on soil, vegetation, dominant winds, pluviometric date, etc., were collected, providing the team of architects and engineers with the essential information needed to solve the basic problem, namely, the environment control of the metrology laboratories.

From its initial pheses, the architectural project took into eccount the climatic peculiarities of the region where the Metrology Center is located. These basic premises oriented the specialists in the preparation of preliminary recommendations, which were tested and evaluated during the development of the project.

3. Air Conditioning Generel Scheme

To obtain e precise and stable control within the modules, the air should first undergo e primary conditioning in the air conditioning rooms of the various buildings (detailed description presented below). The air should be furnished to the modules at constant volume, with relative humidity previously controlled and at a uniform temperature, approximating that of the controlled laboratory temperature. This temperature must be stabilized at 1ºC below the module temperature. The final heeting of the air is accomplished upon its entrance in each module, being controlled by a independent system which will be described below.

4. Control Scheme Adopted for the Modules

The final control of laboratory environment is intended to assure:

a) That average temperature is kept within the pre-established limits.

b) A uniform temperature distribution within the modules, thus avoiding, as much as possible, the existence of areas with different temperatures.

For that purpose, approximately $30m^2$ of the laboratory areas were planned to function as control zones (CZ), to be independently controlled. In this manner, some of the small modules will be linked to a single Control Zone, while others will be linked to two or more.

5. Scheme of Primary Air Control

The primary air will be controlled in the Air Conditioning Rooms, being furnished to the buildings with relative humidity within the proper limits and temperature 1ºC below the temperature of the modules for which it is intended.

6. Temperature Control

As the external air may be above or below the control temperature, heating and refrigeration systems were planned, each of them operating in accordance with the external air conditions. Therefore, two independent temperature control mechanisms were chosen with triple function (Proportional, Integral and Derivative), in order to obtain an uniform and stable control of primary air temperature. These control mechanism will act upon the heating and refrigeration systems.

7. Relative Humidity Control

Air humidity in the buildings must be kept between 45% and 55% and dehumidifying will be carried out by means of the same elements of the heating system.

8. Recording and Alarm Systems

The installation of a Graphic Recording Instrument was planned in order to keep a permanent record of temperature, uniformity and relative humidity conditions in the modules.

The scanning system will constantly verify the alarm condition of the controls, at the rate of 10 points a second. When an alarm occurs, this will be printed, with the respective identification and hour. At the same time, the system will light a lamp in the laboratory, which will remain lit until it is turned off manually. Thus, even if the alarm occurs when there is no one present in the laboratory, the evidence will remain for later verification and there will be an historical record of the occurrences in the control room.

9. Instrumentation for Control of the Modules

After investigations it was decided that the temperature sensors should be resistance bulbs, due to the precision and stability of these sensors.

Table of temperature and relative humidity of the modules

Laboratory Modules	Temperature	Relative Humidity
E1-A1	25ºC ± 0,5ºC	50% ± 5%
E1-A2	25ºC ± 0,5ºC	50% ± 5%
E1-A3	25ºC ± 0,5ºC	50% ± 5%
E1-A4	25ºC ± 0,5ºC	50% ± 5%
E2-A1	25ºC ± 0,5ºC	50% ± 5%
E2-A2	25ºC ± 0,5ºC	50% ± 5%
E2-A3	25ºC ± 0,5ºC	50% ± 5%
E2-A4	25ºC ± 0,5ºC	50% ± 5%
E3-A1	25ºC ± 0,5ºC	50% ± 5%
E3-A2	25ºC ± 0,5ºC	50% ± 5%
E4-A1	25ºC ± 0,5ºC	50% ± 5%
E4-A2	25ºC ± 0,5ºC	50% ± 5%
E5-A1	25ºC ± 0,5ºC	50% ± 5%
E5-A2/A3	25ºC ± 0,5ºC	50% ± 5%
E6(external)	25ºC ± 0,5ºC	50% ± 5%
E8-A1	25ºC ± 0,5ºC	50% ± 5%
E9-A1	25ºC ± 0,5ºC	50% ± 5%
A-Reverberation I	-	-
A-Reverberation II	-	-
A-Testing Room	25ºC ± 0,5ºC	50% ± 5%
A-Anechoic Chamber (ext.)	-	-
A-Anechoic Chamber	-	-
A-General Laboratory	25ºC ± 0,5ºC	50% ± 5%
A-Vibration Laboratory	25ºC ± 0,5ºC	50% ± 5%
M1-A1	20ºC ± 0,5ºC	60% + 5% - 10%
M1-(a)	20ºC ± 0,5ºC	60% + 5% - 10%
M2-A1-B1	20ºC ± 0,5ºC	60% + 5% - 10%
M2-A2-B2	20ºC ± 0,5ºC	60% + 5% - 10%
M3-A1-B1	20ºC ± 0,5ºC	60% + 5% - 10%
M3-A2-B2	20ºC ± 0,5ºC	60% + 5% - 10%
M3-A3-B3	20ºC ± 0,5ºC	60% + 5% - 10%
M-0	25ºC ± 1ºC	60% + 5% - 10%
M-01	25ºC ± 1ºC	60% + 5% - 10%
M-02	25ºC ± 1ºC	60% + 5% - 10%
M-03	25ºC ± 1ºC	60% + 5% - 10%
M-04	25ºC ± 1ºC	60% + 5% - 10%
M-05	25ºC ± 1ºC	60% + 5% - 10%
M4-(e)	20ºC ± 1ºC	60% + 5% - 10%

Laboratory Modules	Temperature	Relative Humidity
M4-A1-B1	20ºC ± 0,5ºC	60% + 5% - 10%
M5-A1-B1	20ºC ± 0,5ºC	60% + 5% - 10%
M5-A2-B2	20ºC ± 0,5ºC	60% + 5% - 10%
M6-A1-B1	20ºC ± 0,5ºC	60% + 5% - 10%
M6-A2-B2	20ºC ± 0,5ºC	60% + 5% - 10%
M7-A1-B1	20ºC ± 0,5ºC	60% + 5% - 10%
M7-A2-B2	20ºC ± 0,5ºC	60% + 5% - 10%
M8-A1-B1	20ºC ± 0,5ºC	60% + 5% - 10%
M8-A2-B2	20ºC ± 0,5ºC	60% + 5% - 10%
01-A1	25ºC ± 0,5ºC	60% + 5% - 10%
01-A2	25ºC ± 0,5ºC	60% + 5% - 10%
01 (b)	25ºC ± 0,5ºC	60% + 5% - 10%
02-A1-B1	25ºC ± 0,5ºC	60% + 5% - 10%
02-A2	25ºC ± 0,5ºC	60% + 5% - 10%
03-A1-B1	25ºC ± 0,5ºC	60% + 5% - 10%
03 (c)	25ºC ± 0,5ºC	60% + 5% - 10%
0-01	25ºC ± 1ºC	60% + 5% - 10%
0-02	25ºC ± 1ºC	60% + 5% - 10%
0-04	25ºC ± 1ºC	60% + 5% - 10%
0-05	25ºC ± 1ºC	60% + 5% - 10%
T1-A1-B1	25ºC ± 0,5ºC	50% ± 5%
T1-A2-B2	25ºC ± 0,5ºC	50% ± 5%
T1-A3-B3	25ºC ± 0,5ºC	50% ± 5%
T2-A1-B1	25ºC ± 0,5ºC	50% ± 5%
T2-A2-B2	25ºC ± 0,5ºC	50% ± 5%
T4-A1-B1	25ºC ± 0,5ºC	50% ± 5%
T5-A1-B1	25ºC ± 0,5ºC	50% ± 5%
Q1-A1-B1	25ºC ± 0,5ºC	50% ± 5%
Q2-A1-B1	25ºC ± 0,5ºC	50% ± 5%

<u>ANNEX V</u> - The selection of equipment and instruments for the National Metrology Center.

The task of sorting and selecting equipment and instruments for the National Metrology Center evidenced the need to consider a series of orienting criteria that could be used as guidelines, to define this equipment. In a developing country, lacking a modern fully evolved instrument industry, where technical assistance from representatives of foreign firms is not always available, it is evident that the criteria utilized cannot be those adopted in more developed countries, that is, instruments cannot be selected by their characteristics or specifications alone.

Initially, an examination was carried out of operations in the more developed Metrology Centers, and extremely valuable references were obtained as to the more accredited plants in the metrological world. It became clear that a large number of the more well-known metrological laboratories utilize instruments, the major part of which were created and designed by scientists or technicians working in these centers or were developed through years of research, reflecting their know-how in the art of measurement.

However, with the evolution in the industry of measurement equipment, a line of commercial instruments gradually appeared in the instrument market, presenting a design and precision level adequate for most types of metrology work. In order to gain time and to close the technological gap, it was adopted the criterion of utilizing this type of instruments wherever possible, thus saving the INPM years of investigation and work.

Another important fact was the verification that the instrument industry is presently going through a period of significant changes, absorbing the most recent technical advances. The speed of these changes is such that, within a period of one year, plants modify their models, change their characteristics and instruments recently launched in the market become obsolete.

Simultaneously, it has been observed that certain types of instruments or equipment produced by specialized manufacturers are, in practice, universally accepted, as adequate for this or that purpose. Consequently, it is necessary that the buying entity establish special relationships with these specialized manufacturers which very often do not have branches or official representatives in developing countries.

In the list of equipment estimated as being necessary for each laboratory, importance was given to an item that is common to all of them namely accessories and spare parts. Every laboratory has a real need to have at their disposition a diversified range of small gauges, secondary parts, connections, small tools of various types, replacement parts, etc., whose detailed specification is very important during the laboratory construction phase, providing greater flexibility and following suitable technical procedures. In the case of the INPM, the options were made according to the equipment and instruments budget for each units, at 15% of the total estimated value. In instrument selection, a significant factor is the existence or not of manufacturer's representatives for equipment which requires larger investments in accessories and spare parts.

After in-depth studies, it was concluded that in addition to requiring that delivery of the equipment to be made accordingly to indicated specifications, the purchaser must require from the vendor the training of laboratory personel in the handling and maintenance of the equipment, with a view to the optimization of the investment.

Finally, attention should be called to the difficulty a metrology center of a developing country encounters in contacting divers specialized manufacturers located in different parts of Europe, United States and Japan.

Difficulties in communication, slowness in receiving replies, and lack of experience, even on the part of technical personnel who use the equipment, suggest that the institution create a technical department specialized in market research and procurement of needed equipment.

In the case of INPM, a detailed list of all instruments and equipment necessary for each module was drawn up. Contacts were made with more than a hundred and twenty manufacturers from whom descriptive catalogs of the equipment, preliminary prices and estimated delivery periods were obtained, as well as other information concerning special requirements for the installation and operation of this equipment. This experience was most useful, providing an enormous amount of information, which enabled our technologists to furnish to the engineering and architectural group precise and essential information on the preparation of lay-outs, fixed facilities, protective facilities, security and similar elements.

Another guiding criterion is the selection of equipment for the National Metrology Center project made on a preliminary basis, leaving for the procurement phase the final definition of the desired items, with due attention to market conditions and like considerations.

In summary, the selection of equipment for the project under study was not a simple task for a procurement department, but is most certainly and unequivocally an undertaking for a group of technical personnel composed of divers specialists appropriately advised by administrators with commercial experience and personnel knowledgeable in the legislative requirements for importing equipment into developing countries, which are usually quite complex.

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