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ESTABLISHMENT OF FACILITIES FOR ELECTRICAL EQUIPMENT DEVELOPMENT, DESIGN AND PRODUCTS IN DEVELOPING COUNTRIES 1/

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United Nations Industrial Development Organization

Expert Group Meeting on the Development of Engineering Design Capabilities in Developing Countries

Vienna, 11 - 15 May 1970

ESTABLISHMENT OF FACILITIES FOR ELECTRICAL EQUIPMENT DEVELOPMENT, DESIGN AND PRODUCTION IN DEVELOPING COUNTRIES 1/

Corrigendum

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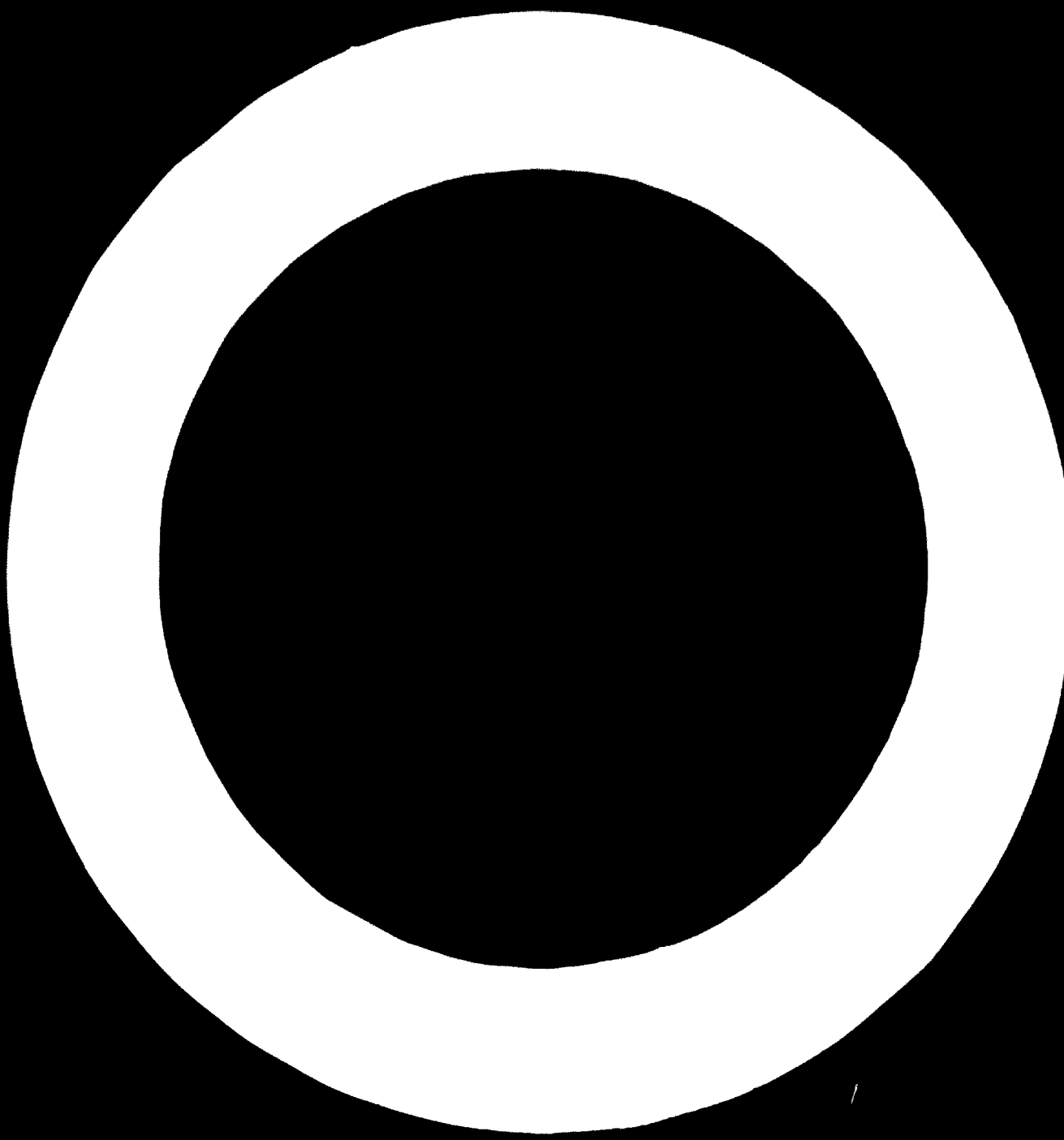

A. Scope of Paper

In considering centrally-located design facilities for developing countries, an analysis must be made of the existing situation in the country, the justification for such a project and the necessary steps to implement the plan expeditiously and efficiently.

1. This paper will cover the identification of industry's needs, the available sources of assistance, the kinds of electrical products to be considered, the procedures and steps to be taken in setting up a design facility, and some of the problems involved.

2. It will not include the use of private facilities for an individual manufacturer.

3. It will, however, include facilities of a general character which might be available to many manufacturers or industries.

4. The paper will exclude such heavy-industry items as large generators and motors, and high-voltage transformers which are special in character and usually are custom built.

5. The information provided, though largely assembled from observation and experience in certain types of products, is generally applicable to the electrical industry, but the individual circumstances may dictate modifications in procedures.

B. Motivation for Providing a Design Center.

1.The Need to Meet Growing Demands.

The non-availability or shortage of a product for which a demand already exists in developing countries provide the greatest motivation and impetus for the establishment of design and development facilities. The product may be available in small quantities, but without the basic engineering knowledge or facilities to obtain the optimum performance characteristics, the best quality, or a suitable cost.

These needs may be from major manufacturing industries which require electrical equipment for their operation and control. But they also exist for individual consumer products since the improved standard in living of developing countries inevitably results in the demand for more electrical equipment for the home.

2.The Establishment of a New Market.

While some businesses develop from popular <u>demand</u> of certain products, some markets are developed from the <u>availability</u> of a product. Entrepreneurs with a vision of the future, and having adequate data on the development of certain markets in other countries, need and justify design support, while taking the risks of such new ventures, their design knowledge and experience on these new products may be inadequate to meet the problems that are certain to arise.

3.For Educational and Technological Advancement.

It is not only specific products for definite markets that require development assistance. To keep abreast of

advances in the more progressive countries, certain general research activities are necessary. This could apply, for example, to the field of electronics where general design information might have application to control, automation, instrumentation, radio and television, as well as in radar and military applications. In such cases, generic research and design may benefit a multiplicity of industries and applications.

Q.Types of Sources for Development Assistance.

The types of sources will vary with the activity in question, but it is useful to consider all of these sources of assistance:

1.Private Industry

a.One of the most common types of assistance is by collaboration contracts with foreign manufacturers. The latter provide designs, prototypes, tools (or tool design) and sometimes some of the components which are most difficult to manufacture. This may be partly altruistic on the part of the foreign manufacturer, but usually there is some profitability in such a venture. It has the effect, however, of diluting the profit in the developing country and often may retard the use of foreign components, but it is one of the simpler approaches to indigenous manufacture.

b.Another means of private assistance to industry is the use of licensing arrangements, permitting the use of patents and designs of another manufacturer, either domestic or for-

sign. This usually involves the payment of patent royalties on the products sold but, generally speaking, provides no direct design aid.

b. Industry Associations sometimes do provide considerable assistance in panel data, in design of machinery, in testing, etc. Good examples of this type of assistance in another field are the Textile Research Associations. Organizations exist in the electrical equipment industry, such as the All India Manufacturers and Dealers Association, but such groups, while assisting with promotional publications, do not usually provide design or testing facilities.

2. Government

Government technical assistance is available at times from government-sponsored centers such as "Service Institutes." These usually specialize in manufacturing assistance to industry, though they may vary somewhat in nature and in the type of expert personnel on their staffs.

3. International Agencies.

Such agencies of world-wide scope have available funds and good facilities for recruiting expert personnel to aid industry in developing countries. Typical of these agencies are:-

a. The Ford Foundation, which has pioneered many such ventures with industry, often laying the groundwork for future projects, and

b. United Nations organizations such as:-

UNIDO-United Nations Industrial Development Organization and UNESCO- " " Educational, Scientific, and Cultural Organization.

These organizations are providing leadership, as well as expert staffs and equipment for the aid of industry in many parts of the world.

4.Combinations of the Above Sponsors.

International agencies co-sponsor development centers and other forms of aid to developing countries with the governments of these countries. At present, this is the most prevalent type of assistance provided. By dividing the cost in approximately equal parts, both co-sponsors assume equal responsability for the progress and success of these development units.

D.Kinds of Electrical Apparatus.

The types of products and equipment for which design and development assistance can be provided will fall into the general categories listed in Paragraph B. The products (in this case electrical equipment) must be those for which adequate development facilities do not exist in the country requesting the assistance. Typical equipment which might be suitable for such assistance would be:-

1.Consumer Products.

This market can be subdivided into the following classes:

a.Household Appliances.

These could include electric irons, vacuum cleaners, re-

frigerators, toasters, and many of the newer appliances used in the preparation of food, etc.

b.Radios

(1) Table types

(2) Portable types

(3) Automobile radios.

These products seem to have a particular appeal in developing countries and often are the first electrical products purchased as prosperity and standards of living increase.

c.Phonographs

(1) Record players-popular types

(2) Hi-Fidelity and stereophonic sets.

The products listed above are not all-inclusive, but are representative of those in which the middle classes of developing countries are interested.

2.Communications

This class of equipment would cover commercial applications, such as:-

a.Commercial radio and broadcasting.

b.Telephone

c.Intercom systems

It has been noted that developing countries usually experience a shortage of telephone equipment as business activities increase, often requiring several months on waiting lists.

3. Electric Motors

These, of course, are produced in many sizes and variations, but the following types would find the greatest use and could benefit most from design assistance:-

a. Fractional Horsepower Motors for Appliances

Every vacuum cleaner, refrigerator, food mixer, etc. would use motors of this type.

b. Motors for Machine Drives

There is a large market here in the machine tool industry.

c. Timing Motors for Clocks, Time Switches, etc.

As industry develops and hand labor is replaced by machines, the use of motors will always rise sharply.

4. Instrumentation

The production of electrical instruments requires design knowledge of a special nature, with special skills and techniques common to no other industry. It is understandable, therefore, that developing countries generally do not have the design information nor the techniques required for efficient manufacture of a high-quality product. The categories of instruments involved are:

a. Small Panel Instruments

b. Switchboard Instruments

c. Portable Instruments

d. Recording, or Curve-Drawing Instruments

e. Process Control Instruments

f. Watthour Meters

In terms of manufacturing quantities, watthour meters for measuring electrical energy consumption in homes, offices, factories, etc., will predominate as they provide the media for the billing of energy use charges. They are manufactured in relatively large quantities, often with foreign collaboration since development and tooling costs are very high.

The indicating and recording instruments normally have production rates in the descending order given above, with small panel instruments leading the field, both in terms of numbers produced and also in the number of manufacturers. These instruments are used widely for radio and communication, transportation (automobiles, locomotives, and aircraft), industrial control, and the like. Besides measuring strictly electrical values, indicating and recording instruments have frequent application in th measurement of non-electrical quantities such as temperature, speed, pressure, etc. by electrical means.

Several countries have excellent standards of definition, test proceedures, and performance, and standards are published also by the I.E.C. (International Electrochemical Commission).

The general activity of instrumentation provides opportunity for assistance to the developing countries by supplying the special skills, as well as the special equipment involved. This is a growing field since the expansion of power consumption, industrial electrification, automation, etc.,

depend very strongly on the use of electrical measuring instruments.

5.Transformers

Here again, the rapid increase in the use of electric power is dependent on the availability of the proper types of transformers. The following standard types might be considered:

a.Distribution Transformers

b.Specialty Transformers (for use with appliances and control devices.)

c.Instrument Transformers (including phase-shifting transformers, for use with instruments and watthour meters on circuits above 600 volts).

d.Radio and Television Transformers.

Transformers are relatively simple to manufacture but the proper materials are not always available. Adequate engineering knowledge and support, as well as proper testing equipment and procedures are essential for successful transformer manufacture.

6.Control Devices

Wherever control of the use of electrical energy or the regulation of the magnitudes of electric current or voltage are involved, control equipment is very essential. Increase in the electrification of industry can be hampered greatly by the lack of the necessary control devices. Some of these are:-

a.General Purpose Control

This would include standard types of control devices

such as switches, contactors, rheostats, etc.

b.Industry Control

Devices for the regulation of voltage and speed, relays, etc. would be included here. To this, we might add the more sophisticated types of electronic control, which are certain to be a factor in future growth.

E.Types of Assistance Needed

1.Training of Personnel

For an indigenous work (and governments of most developing countries like to make these developing industries completely indigenous) there must be a programme of training at all levels. Of course, certain jobs of a clerical nature or mechanical operations of a repetitive character can be performed with a minimum of instruction. More complete training is required for the following personnel:-

a,Designers (Product)

b.Technicians

c.Tool designers

d.Tool Makers

e.Manufacturing Supervisors

These training programmes are necessary to familiarize native personnel with the product itself, its principles of operation, the basic design techniques and proceedures, the techniques of manufacturing and testing, and the development of skills for producing the essential components of the device.

More details of such training programmes will be given

in a later paragraph.

2. Design Assistance

Usually there is insufficient time to train local technical personnel before a project is started. Expertise in electrical design is generally the product of many years of education, training, and experience. It is, therefore, an important type of contributed assistance to start a project of manufacturing electrical equipment in operation, and to deal effectively with the technical problems that arise. So design aid might be directed to either-

a. The Design of New Products, or

b. Improvement in existing Products

3. The Building of Prototypes

Operating samples, or prototypes, constitute an essential step in any new manufacturing enterprise, and particularly so in the electrical equipment field. The products may be either devices originated by the Design Center, or, equipment designed by a manufacturer.

Prototypes provide information on:-

a. The Correctness of Design

b. The Suitability of the Materials Used

c. The Manufacturability of the Product

d. The Performance Characteristics

e. The Ultimate Cost

Obviously, prototypes will cost much more than standard production but they do provide information for estimating the

cost of production quantities on a properly tooled basis.

They are used sometimes for accelerated life tests to determine their stability, long-range performance, and wear characteristics. Such tests often prevent future difficulties and complaints.

4.Providing Laboratory Test Facilities

Adequate testing of new electrical products involves more than routine manufacturing tests. If called upon to meet published Industry Standards, "Type Testing" is usually required. This will determine performance on a large variety of environmental and circuit conditions which may be encountered in practice.

The categories of laboratory test facilities are:-

a.Developmental Testing

This is necessary during the development stage to obtain the desired basic characteristics.

b.Type Testing of New Products

(1.) For basic performance under reference conditions

(2.) Performance under environmental conditions of heat, cold, high humidity, dust, shock, vibration, etc.

(3.) To determine effect of such circuit variations as voltage, frequency, distorted wave forms, etc.

c.Maintenance of Calibration Standards

Tests on all types of electrical equipment require the use of electrical measuring instruments. Such testing instruments must be correct to properly evaluate performance and

meet guarantied values. Thus, normal testing instruments should be backed by standards of greater accuracy and facilities to compare calibrations periodically with national standards.

5.Tooling Facilities

One of the major requisites of successful, uniform,and low-cost production is the availability of proper tooling. This, of course, is dependant somewhat on labor costs in the particular country. Usually labor is cheap in developing countries and many operations can be performed by hand which would justify tooling in other countries. However, many basic tools such as dies and molds are essential for any quantity production, and other tooling is normally required to facilitate uniformity and the proper fit of various components.

The phases of tooling which require aid are as follows:-

a.Tool Design

This requires considerable experience in both the design and manufacture of tools. Proper tool design determines:

(1).Dimensional accuracy of the parts.

(2).The proper fit of mating parts

(3).The effort and skill required for their use

(4).The production quantities capable of being produced.

(5).Product costs

There is a scarcity of good tool designers with adequate experience in most parts of the world, and assistance

in this area would be one of the most valuable contributions of a Design Center.

b.Tool Manufacture

Proper machine tool equipment must be provided and tool makers with sufficient experience to produce molds, dies, jigs, and fixtures necessary for the production of the electrical equipment involved, and will require tools for the Design Center as well as for those having no access to proper tool facilities. Normally, the latter would be provided at cost plus a small surcharge.

Adequate tooling (though not for high-production quantities) must be furnished to build prototypes which are truly representative of the final product.

c.Tool Maintenance

It is not enough to provide facilities for initial tools only. Dies will become dull, other tools will wear, many will be damaged by accident or improper handling. It is important, therefore, that manufacturers be backed by facilities for tool maintenance. This would include emergency equipment to duplicate existing tools which through damage may shut down a production line for an appreciable length of time.

6.Manufacturing Assistance

Each manufacturer, of course, must produce his own salable equipment and a design center should not undertake quantity manufacture which could be competitive and detrimental

to industry. However, the establishment of a new manufacturing facility and the solution of many problems arising in existing plants require expert knowledge and experience which a Design Center might well supply. The types of Manufacturing assistance might be categorized broadly as:-

a.Setting up New Manufacturing Facilities

b.Establishing Manufacturing Methods

c. Assistance in Reducing Manufacturing Cost .

F.Steps to be Taken in Setting up a New Design Center

It is important that these steps be taken in the proper order. The need must be identified and defined, and the plans and agreements well formulated. A group undertaking such a project must truly "See the end from the beginning,"not only in visualizing the end result, but also in properly forecasting the problems that will arise, so that povisions can be made to meet them. Here, then, are the steps to be taken:-

1.Preliminary Survey

a.Purpose

(1).To determine the need and justification for such a Center.

(2).To determine the types of assistance needed and the feasibility of providing them.

(3).To explore the types of sponsorship which might be available.

(4).To evolve a preliminary Plan of Operation.

b.Personnel Requirements for Survey.

(1).A knowledge of the country.

(2).Experience with its manufacturers

(3).Familiarity with the given industry and its problems.

(4).Experience in the types of government and international assistance available.

These people must be selected with great care as their conclusions and reports will be very important in the events which follow.

c.Information Needed in Report

(1).The type of product to be considered

(2).The Nature of Assistance Recommended

(3).The geographical location of the Center.

(4).The size and capacity of the Center.

(5).Sponsors Recommended

d.Decision on Feasibility

When the above facts have been assembled and the report prepared, it should be reviewed with meticulous care by the proposed administrating agencies, and a decision made as to whether or not the plan should be put into operation.

2.The Plan of Operation

a. The nature of the Document

As the name implies, it is a basic plan for the project from start to completion, and should serve as a guide for the entire operation. It will define the purpose of the project and is actually a charter of the scope of its operation. It

will serve also as a contract, or agreement, in the event that it is co-sponsored by two parties, such as the government of the developing country and an international agency like the United Nations Development Programme, outlining the obligations of each party.

The Ideal Plan of Operation should elaborate the work plan, with a budget summary, including a breakdown of the equipment and expertise contributions of each party. Enough detail of the organization must be included to establish salaries, duration of service, etc.

b.Signatures and Agreements

A tentative schedule of operations should be included and the timing and efficiency of the project can be measured against this. It should be signed by the two parties as a binding agreement, and a copy should be placed in the hands of responsible Directors, Managers, Advisers, and Experts to serve as a working guide for the conduct of the Center.

3.Financing the Design Facility

It cannot be expected that the operation of such a design center will be self-supporting, and certainly in its initial stages there will be no source of income other than the support of its sponsors. The following will outline the sources of financing:-

a.The Government of the Developing Country

Since government funds are not plentiful in these countries, it is unlikely that it will assume complete financial

obligation for a Design Center. In event of the usual dual sponsorship, the government normally will provide personnel, services, and equipment available locally. Its contribution usually will include:

(1).Salaries of Director and indigenous officers and other personnel.

(2).Local salaries of fellowship trainees

(3).Land and housing for the Center.

(4).Equipment and supplies produced in the country.

(5).Transportation and handling of imports.

b.An International Agency

Contributions of such agencies as UNIDO and the UNDP Special Fund, usually will be comparable to the government contribution (depending somewhat on the circumstances). Typical of these contributions are:-

(1).Salaries of the Project Manager, or Chief Adviser, and the professional staff of foreign experts.

(2).Machine tools and mechanical equipment not available locally.

(3).Laboratory and electrical equipment of a precision not available locally.

(4).Miscellaneous technical aids, such as-

A Library of books, publications, and technical information

Audio and Visual aids

Calculators, computers, etc.

c.Private Industry

Though not usually involved in the setting up of Design Centers, it can provide assistance in various ways. This type of assistance, by its very nature (to avoid competitive situations) must be in the form of cooperative ventures, and can operate most effectively through Manufacturers' Associations, supported by the contributions or dues of manufacturer members. They can provide:-

(1).Dissemination of technical knowledge.

(2).Assistance in standardization activities.

(3).Common facilities for material testing.

d.Fees from Participants

As a new Design Center increases in sophistication and in service to the manufacturing industry, it can thenreceive some financial remuneration from those who use its services. This would be in the form of fees for:

(1).Consulting service

(2).The use of designs and drawings provided by the Center.

(3).Tool designing.

While this source of revenue may not be large, it has other advantages as by-products:

It tends to discourage some of the irrelevant and"nuisance type" consultations.

The participant manufacturer, by paying proportionately for services rendered, will limit his requests to the

most necessary types of assistance.

4.Approval of Financial Authorizations

Even with prior agreements in the Plan of Operation individual approvals for specific expenditures often involve lengthy delays and require considerable following. Provisions for prior approvals or the expediting of specific approvals should form a part of the original agreement.

5.Type of Organization

Considerable thought must be given to the organizational structure to provide the greatest cooperation and the most efficient operation. In view of the usual dual nature of sponsorship and operation, both of these groups, as well as other organizations vitally interested should participate in some of the following areas:-

a.An Advisory Committee, consisting of-

(1).Representative(s) from Government Ministry

(2). " " International Agency

(3).The Project Manager, or Chief Adviser

(4).The Director

(5).Industry Representative from Local or State Gov't.

(6).Officer of Manufacturers' Association

(7).Representative from Standards Association.

b.Formation of a Corporation or "Society"

This would provide a certain degree of autonomy in providing authorizations and approvals.

c.The Project Manager, or Chief Adviser.

He would be responsible to the International Executing Agency and would provide the initial direction and guidance,

d.The Director

Appointed by the Government and responsible for indigenous operations, facilities, maintenance, etc.

e.Administrative Officer

Responsible to the Director-for servicing the Center on administrative matters, accounting, records, stores, purchasing, payroll, etc.

f.Professional Expert Staff

Directly responsible to the Project Manager and consisting of foreign experts for each of the major fields covered by the project.

g.Counterpart Professional Staff

Consisting of those with some training and experience relevant to the project, working with the foreign experts but responsible to the Director.

h.Management Staff

Local Officers and Managers working under the supervision of the Director And Administrative Officer, to conduct the business and the physical operations of the Center.

6.Selecting the Design Center Site

The following major considerations should determine the location of a project site:-

a. Location with respect to population centers and transportation.

b. Location with respect to concentration of the industries involved.

c. Availability of land and/or buildings.

For the most effective operation, the Design Center must be readily accessible and also nearby a source of skilled or semi-skilled manpower. But it should also be located as centrally as possible with respect to the major groups of industries that it will serve.

To keep initial costs as low as possible, the availability of suitable unused buildings or of undeveloped land, possibly owned by the government, should be given careful thought. Building costs are high, but new buildings of the most suitable type are preferable to the adaptation of existing buildings not suited to the project. However, rather than to delay a new project for the erection of new buildings, temporary housing should be considered. Quarters would then be provided for the responsible personnel who could plan more effectively for the permanent facility.

7. Selecting the Personnel

a. The Professional Expert Staff

It is necessary to select people who by both training and experience are capable of performing the functions of the Design Center. In dealing with this particular problem, education alone is insufficient , and even

experience of a supervisory character may no meet the needs of the Center. The "Expert" must be all that the name implies and there is no substitute for personal experience and involvment in the kind of work to be performed. As the expert may have only limited access to technical or design information or the more sophisticated types of equipment which have been available to him previously, a great amount of resourcefulness is important when starting such a project in a developing country.

The sources of recruitment of such experts are:-

(1).From Industry in the more progressive countries.

(2).From Development or Research Laboratories.

(3).From Universities and other educational institutions.

b.The Locally-Recruited Counterpart Staff

Manpower is usually plentiful in a developing country, but experienced manpower is scarce. The exigencies imposed by time and cost dictate the use of the most experienced personnel available. It is important, therefore, to select:-

(1).Personnel with suitable educational qualifications.

(2).Those having some experience in the same or related fields.

(3).People with native skills who, with minimum training, can perform the necessary tasks or supervision.

The thought must be kept constantly in mind, that these men eventually will completely operate the Design Center after the terms of the foreign experts have expired.

8.Designing the Building.

The design of the Center headquarters is of major importance. A highly competent architect should be selected for this purpose, paticularly one with experience in the developing country. He must know the availability of materials and manpower, and he also must be familiar with the conditions imposed by the climate and the seasons of the year. However, he cannot do this work effectively by himself. Those who will direct the operations of the Design Center are in a far better position to determine the needs of the buildings and should be in touch with the architect constantly during the building design, to furnish him the necessary guidance. The following order is probably the best approach to building design considerations:-

a.Size and Capacity

These are determined by the number of persons employed and the character of the operations involved. They will provide information as to the ground area and the required height of the building.

b.Relative Locations of Working Areas

The position of offices, classrooms, and workshop areas with respect to one another are of vital importance in determining the efficiency of operation-

(1).By establishing the closest locations of those functions requiring the most frequent contact.

(2).By mimimizing interruption to the work of others.

(3).By providing the smoothest flow of materials.

Once the above factors are determined, the general lay-out of the buildings can be followed by more detailed design, which will involve the following determinations:

c.The placement of machines, benches, and permanent equipment;

d. Lighting, ventilation, heating, and air-conditioning needs.

Here the architect can take advantage of sunlight, prevailing wind direction, and similar factors. These may have considerable effect on the directional position of the buildings. In tropical locations, baffles may be built in to eliminate the direct glare of the sun from the windows, and the funneling of prevailing winds through the buildings can add considerably to the comfort of the personnel.

e.Power Requirements

(1).Location and number of lights

(2).Outlets for portable or movable equipment

(3).Machine-tool power requirements

(4).Electrical laboratory circuits.

f.Esthetic Considerations

When the functional design of the Center is completed, then attention should be given to esthetic design and appearance. It must be remembered that these are multi-purpose buildings, serving educational and technical research purposes as well as mechanical operations, and will be visited by many

people. It is not necessary that they resemble factories and artistic appearance can be achieved with little or no cost increase. The grounds also should receive attention and may be made attractive at a minimum of expenditure.

9.Providing Equipment

Receipt of the proper kinds of equipment is necessary before the Design Center can be completely functional. Therefore, it may be a limiting item in becoming fully operative. Equipment is often of a special character and may require many months or even a year to complete. So the placing of orders must be one of the first tasks in establishing a new project. The following is representative of the types of equipment required:-

a.Office Equipment

Some of this equipment is necessary to even start operation. Good quality office furniture is not expensive and may contribute greatly to the efficiency of operation. Metal furniture is suggested as it usually lasts longer and can be obtained readily in most countries. In tropical countries, attention must be given to chair seats, allowing proper ventilation to prevent perspiration and discomfort. Desks should be of optimum height and should have surfaces capable of being polished, with plenty of drawer space. Filing cabinets should be designed for filing with the lowest possible expenditure of time, and should be equipped with locks. Typewriters must be available from the very beginning of the pro-

ject.

b. Design and Drafting Equipment

The major objective here is to avoid spending time on routine or repetitive operations and to increase the efficiency of those tasks which are necessary.

Assuming that there would be insufficient repetitive calculation to justify a computer, some type of calculator, even of the simplest form, can result in considerable time saving.

So-called "drafting machines" with horizontal and vertical movable scales and angular settings will avoid the handling of individual scales, triangles, protractors, etc., with considerable time saving. They are often furnished with drafting boards.

Reproduction facilities are important in any drafting office. These should be flexible in character and rapid in operation.

c. Laboratory Test Equipment

The categories of laboratory test facilities have already been outlined with the purposes they will serve. Here again, procurement time may be long and the equipment should be ordered as early as possible. Important considerations are:

(1). Accuracy and performance characteristics

(2). Reliability

(3). Repair, calibration, or adjustment facilities.

It is important to select manufacturers whose prod-

ucts have had a history of successful performance, and whose facilities and service have inspired confidence. There is also a distinct advantage in having manufacturer's representatives and/or service facilities in the country where the Design Center is being established. Prompt handling of complaints on either damage or malfunction would be facilitated by the close proximity of such a representative.

d. Machine Shop Equipment

Machine tools serve a dual purpose here,-the manufacture of prototypes and the building of tools. In either case precision is necessary and the degree of precision required must be taken into consideration when ordering the equipment. In some cases, machine tools of the general nature required are produced in developing countries. However, they may not have the capabilities or the precision of foreign-made machines. These factors must be weighed carefully, and foreign products of reliable and experienced manufacturers should be chosen where high precision is needed.

Consideration should be given also, to flexibility of operation. Machines of a multi-purpose nature may obviate the need for additional machines which might be used infrequently, and thus provide better utilization of machine time.

Procurement of machine tools may require from three months to a year, and thus must be ordered at the earliest possible moment. However, they usually represent a considerable investment and should not be ordered in too great haste

to evaluate all of the tasks which they are expected to perform. Many machines lie idle in these development projects because they are unsuited to the purpose.

Other points of great importance to be specified on orders are:-

(1).The nature of the service-

Circuit voltages, frequency, and number of phases.

Desired machine speeds

Type of drive or control

Special functions it must perform.

(2).Accessories

Lack of attention to accessories is another hazard in ordering machine tools. These may be inoperative for long periods of time when the proper accessories in suitable quantities are not ordered. Since these are made for particular machines, they are not usually available in the developing country, and re-order will result in additional lost time.

In placing the original machine-tool order, therefore, it is very essential to call for the proper

Chucks	Milling Tools
Collets	Grinding Wheels
Drills	Saw Blades
Cutters	etc.

To these should be added spare parts or replacement items recommended by the manufacturer.

e.Prototype Manufacturing Equipment

In addition to the machine tools for machining operations there are certain general facilities required as well as many types of special purpose equipment which are adapted to the particular type of product involved. It is impossible to be very specific here because of the great variety of electrical devices manufactured, but following are some examples:-

(1).General

Heat treating equipment-for hardening tools and product parts

Electroplating equipment

Painting facilities (spraying booths, spray guns, blowers, etc.)

(2).Specific purpose equipment

Coil Winders

Sand casting equipment

Die casting equipment

Plastic molding presses

Marking presses- for dials, markers, nameplates,etc.

Wood-working facilities

Assembly equipment of various types (depending on the product)

Equipment for incoming test of purchased components.

Routine product test equipment (apart from Laboratory equipment).

These represent just a few of the facilities which may be required even for prototype manufacture, since the prototypes themselves should be representative of the final product in construction, performance, and appearance. One skilled in a particular type of product development or manufacture will visualize readily the type of equipment to be provided.

f.Maintenance

This field should not be overlooked because of the general scarcity of facilities and skills in these developing countries. Provision should be made for several types of maintenance:-

(1).Building Maintenance

(2).Machine Maintenance

(3).Electrical Maintenance.

A section should be provided for this purpose, with knowledgeable people and proper facilities.

g.Inspection

Equipment is necessary to inspect both incoming purchased materials and those parts and assemblies built for prototypes. It is also required to verify the accuracy of tools, dies, and jigs built at the Center. Inspection facilities will be in three major classifications:-

(1).Visual Inspection

This will include microscopes, profile projectors, and other magnifying apparatus.

(2).Dimensional Standards and Measuring Equipment.

Included here will be micrometers, comparators, thickness gages, gage blocks, etc.

(3).Miscellaneous Testing Devices, such as-

Hardness testers

Gear testers

Spring tension testers

Insulation testing equipment, etc.

10.Providing Training Facilities

Since one of the major objectives in establishing Design Centers in developing countries is the training of native personnel, it is important that adequate facilities be provided for this purpose.

a.Class Room Equipment

Blackboards, wall type and portable

Chair with provision for writing.

b.Lecture Hall Equipment

Audio-Visual Aids, including:

Slide projectors

Opaque reflectors

Moving picture projectors (with sound)

Loud speakers

Projection screens

Easels for paper charts.

c.Library

This should provide good text books covering the major subject of the Design Center, basic electrical texts, suit-

able reference handbooks, industry standards, periodicals, reports, etc., as well as quiet, well lighted premises for study.

11.Publicity

It is important that the Design Center be publicised and that related manufacturers, industry associations, technical institutions, and laboratories know its purpose and the scope of its activities. This can be accomplished in several ways:-

a.By mailed announcements

b.By publishing information in trade magazines

c.By personal visits.

These media will assist in establishing rapport with the industry and those whom the Center will serve, and will provide means for obtaining statistics and information on their needs.

12.Setting up Design Specifications

The design of electrical products is a major objective of any type of electrical Design Center. Much time at the beginning will be concentrated on consultation work and training. When the proper equipment and personnel are in place,and sufficient contacts have been made with manufacturers, the following steps may be taken to start the design activity:-

a.Review of the needs of the industry

There are several approaches to this-

(1).Questionnaires sent to all manufacturers

(2).Detailed correspondence with manufacturers

(3).Personal visitation of experts.

While these activities provide necessary background information, it should not be too disappointing if they do not yield a clear mandate from the manufacturers as to the type of design and development [illegible] There will be individual whims which cannot be taken very seriously. Also, there will be individual requirements which may benefit only a single manufacturer. Many manufacturers may not have sufficient knowledge to identify their future needs, and some may express their needs vaguely for lack of necessary information. Design effort to aid industry, therefore, requires careful study of existing manufacture and trends in the industry, both in the developing country and in the more progressive nations. If these trends are basic and are an aid to manufacture, they are certain to find demand in developing countries eventually. Thus, they should form a sound basis for development and design. Certainly, a major effort of this type should be selected to benefit a substatial portion of the industry. The decision, however, must be made by the Design Center, but review with an Advisory Committee is very desirable.

b.Review of Industry Standards

Are there adequate standards in the developing country to define properly the product and its performance? If so, they should be reviewed in detail to determine the type of service or performance required. If there are no local standards, it would be well to review international standards,

when they exist,-otherwise U.S. or European standards can provide very useful guides. In any event, definite goals should be established and performance specifications outlined before active work is started.

c.Product Specifications

Once the basic goals have been defined, and industry standards evaluated, detailed product specifications should be prepared. Since these will provide a working guide in the functions of the Design Center for a period of several months to a year or more, they must be definitive in character. Unless the scope of the activity is limited and defined, it may lead into many branch activities. The content of these specifications, therefore, should be as follows:-

(1).The Nature of the product

(2).The specific design activity planned

(3).The scope of this activity (in terms of sizes,styles, ratings, and ranges of operation).

(4).Performance Specifications

These will vary with the type of product but, in general, should define the characteristics of normal operation, the effects of circuit variations (voltage, frequency, wave form, circuit unbalance, etc.), and the effects of environmental influences (high and low temperatures, humidity, shock, dust, vibration, etc.). With these provisions, a very comprehensive set of specifications can be evolved

and adequate plans laid for the design, prototype manufacture, and a suitable testing program.

G.Problems of Starting New Facilities.

Before entering into a venture of this kind, it is well to face the problems that are certain to arise, with realism and with plans and preparations for overcoming them.

Some of the problems which have been encountered, and appear to be of general or repetitive nature are as follows:-

1.Buildings

It is seldom that completely suitable quarters are immediately available. All buildings are designed for a certain purpose and, since a Design Center is a combination of educational, development, and manufacturing activities it is unlikely that a permanent location can be found immediately. Usually new buildings must be erected and this takes time.So in order to start operations, temporary quarters must be arranged. Some of the problems are:-

a.Adapting existing buildings for use as a design center.

b.Cleaning, repairing, painting, etc.

c.Providing facilities suitable for international experts.

The mode of life in developing countries does not always provide facilities adequate or congenial for foreign personnel. These may includ proper ventilation, air conditioning, proper lighting, toilet facilities, and properly controlled food and water.

The appearance of the temporary quarters must not be

neglected as it can affect greatly the future prestige of the Center.

2.Government Authorizations

Since the governments of developing countries are usually co-sponsors of these activities, they will normally provide housing, local personnel, and some equipment. These all require government authorizations. In countries which are very bureaucratic, these authorizations and approvals may be painfully slow and may hold up progress for weeks, even though they were a part of the original Plan of Operation agreement. A multiplicity of government bureaus from which approval must be obtained, and the common failure to delegate authority during absence, compound these problems. Some suggestions for handling these matters are:-

a.Arrange to have one government official responsible for obtaining approvals and all the necessary signatures.

b.Obtain a written schedule and agreement as to when these approvals will be obtained.

c.Request sanction and recruitment for local personnel well in advance of the arrival of foreign experts.

Strange as it may seem, the governments requesting assistance are often the greatest sources of delay and hold-ups. The officials involved must be visited periodically to keep the project moving.

3.Time Lag In Obtaining Equipment

This is a relatively uncontrollable source which must be

faced. Even with expedited approvals, the following steps are required:-

a.Obtaining Quotations and making selections.

b.Ordering time

(accumulating all data on details and accessories, typing, headquarters' routines, etc.)

c.Manufacturing time

Apart from stock items, which are usually in the minority, most equipment takes several months to complete.

4.Lack of Local Response and Cooperation

It seems somewhat paradoxical that the greatest lack of response is found often among those who have the greatest need for the services of the Center. It is not that they reject these services necessarily, but lack of knowledge and reluctance to confide in a new organization, often make it difficult to start operations. The reasons, then, may be summarized as:-

a.The difficulty in establishing channels of communication

b.The problem of identifying manufacturers' needs

c.The fear of revealing trade secrets and future development plans.

These problems can be aided by a good publicity campaign, the assistance of a trade association, and by personal contacts and consultation which will establish confidence in the capability and integrity of the Design Center. The manufacturers must be made to feel that the personnel of the Center

have a sincere and impartial interest in all of the manufacturers of the particular product, and that their information and services are confidential.

H. Starting Training Operations.

What are the real needs in this area? In the first place, it appears that many are attempting to engage in the manufacture of some electrical equipment whose principles are unknown to them, and their major effort has been to copy some foreign design or to perform certain tasks with a very minimum of training or explanation. It seems then, that the first and basic need is-

1. Preliminary Training in Operation and Design Principles.

Assuming that a manufacturing unit is in operation it would seem wise to instruct manufacturing personnel in the basic principles of operation and some of the design principles which can be used in their daily operations. This would provide the fastest type of practical assistance.

Beyond this, however, there is usually a lack of knowledge of fundamental sciences that may limit the activities of a manufacturing group. So a second step could be-

2. Organized Courses in Basic Subjects.

These should be conducted in suitable classrooms by those knowledgable in the subjects, using good text books and instruction schedules set up by experienced educators. They could include Physics, Mathematics, Electrical Engineering, and many of the more specific subjects.

Once the background of these basic subjects has been established, the logical third step would be-

3.Courses in Design at Greater Depth.

These would combine the basic sciences and electrical theory with practical applications in the relevant field.They would go beyond the ready-made text book formulas and give the student the training for original design calculation in new situations and with new devices.

4.Foreign Travel for Training.

The selection of personnel for training abroad requires a good knowledge of these people, their background, their capability, and their potential. This type of training involves considerable investment and there must be assurance, not only that these people will benefit by the experience, but also that this experience can and will be used for the benefit of the Design Center. Since funds for these training Fellowships are usually provided through the Center, it is important that agreements be signed promising a suitable period of service with the Design Center following their return.

These training Fellowships are not usually of an academic nature although college or university courses might well form a part of training in special fields, such as Audio and Visual Aids. Normally, however, they will relate to the design of a particular type of equipment, or certain aspects of its manufacture or test. The chief value of such training is that it supplements book knowledge with practical experience

on the devices themselves. Foreign manufacturing plants and laboratories provide the most fertile field for such training. Salaries are usually paid by the Center, but may be a part of the government's contribution.

I. Starting Design Activities

Determining of design needs has already been discussed. The course to pursue may be outlined briefly as follows:-

1. Conferences with manufacturers
2. Determination of products to be designed
3. Product specifications
4. Sketches and layout drawings
5. Rough samples and experimental tests
6. Final design and drawings
7. Prototypes

Once the design activity has been defined in terms of a product, and specifications have been derived for this product, ideas can be translated to sketches and layout drawings sufficient to determine the possibilities of the design and to permit the construction of rough working samples for experimental testing. Any attempt to shorten this method of procedure may result in considerable wasted effort and expense, and may require repeating the entire schedule with a consequent loss of time. First class drawings of a final nature should not be attempted until experimental tests have proven the feasibility of the design.

J. Elements of Design Cost

In planning an operation of this kind, it is of great value to know the composition of costs for the major activities. These elements of cost are not always understood by those providing financial budgets. While prototypes may be regarded as part of the design function, it is being separated here for greater clarity.

The basic design items may be classified as follows:-

1. Engineering time-salaries of experts and professional counterparts.
2. Drafting time-drafting salaries for sketches, layouts, and preliminary design.
3. Preliminary working sample-material and labor
4. Laboratory experimentation and performance tests.

A major part of design cost usually consists of the salaries of engineering experts who are responsible for the active design work as well as the planning, drafting, and testing involved in the entire project. It is a common failure to estimate correctly the time to be spent in completing this activity, which usually requires many months, depending greatly on the complexity of the design project.

Drafting time may be a "cut-and-try" proceedure with a certain amount of repetitive activity until a final design is established.

It is essential that theory be reduced to practice by "breadboard" models or other preliminary working samples.

These may not be in the final mechanical form or appearance, but should be electrically and mechanically equivalent. These samples will require considerable hand-work labor in construction and some operations may be "trial-and-error" procedures with repetitive operations involved.

Considerable laboratory experimental work may be involved in trying out the basic idea and is closely allied to the original design work. Testing may prove to be an important part of the programme and determination of the relative methods of procedure are often involved, as well as characteristics and life of components. Once a working sample is produced, performance tests are a very necessary part of the programme.

K. Prototype Costs

As previously indicated, prototypes should be representative of the final product. They may not be produced by the same means and methods, but they should have the final physical and mechanical form and the same electrical components and characteristics. The elements of prototype costs are:-

1. Engineering time- salaries
2. Drafting time- salaries
3. Material costs- raw material and components
4. Hand-work labor
5. Preliminary tooling for some parts
6. Cost of "Type Testing".

Engineering following will be a necessary part of proto-

type cost.

Drafting time will be considerable as drawings must be made in final form, with proper dimensional tolerances, material specifications, etc.

Sample costs will be high, requiring material and components purchased in very small quantities. Parts must be fabricated by casting, machining, welding, and similar processes to avoid the cost of expensive tools. Critical drilling dimensions may require hand layouts.

There are occasions when a few inexpensive tools or fixtures may be less costly than machining from solid stock or drilling by hand layout. Thus it may prove to be economically sound to provide low-cost patterns for casting, simple punching or forming dies, template drill jigs, and the like. the advisability of providing these low-cost tools can be determined only by the economics of the individual situation, depending to a large extent on the number of prototypes to be built.

It is not unusual for prototypes to cost from five to ten times the normal cost of the quantity-manufactured product.

L. Recommendations

From the problems and experiences described in this paper, one may be forewarned of some of the difficulties and delays which may be encountered. Avoiding and correcting these problems are quite another matter. Hence the following recom-

mendations for proceedures which might help to reduce these difficulties:-

1.Selection of well-qualified persons for the preliminary survey. Unless this is conducted by people of adequate knowledge and experience, even the necessity of establishing a Design Center may be seriously in doubt. Basic decisions concerning the Center, its objective and scope, must be based on this survey.

2.Composition of a Clear and Accurate Plan of Operation. This is the basic document, the contract and charter of the project. It must define accurately the objectives of the center, its organization, and the obligations of each sponsor. Agreements should be in force when the project starts and the personnel arrive.

3.Flexibility Allowance for Changes and Modifications.

Regardless of the care taken in the preparation of the Plan of Operation, changes in detailed plans are certain to occur. Conditions may change in the developing country, calling for a modification or increase in its objectives. Costs change, and the availability of equipment within the country may change, requiring revisions in the equipment plan. These possible changes should be recognized, and sufficient flexibility provided in the Plan of Operation to permit rapid response to required changes without revision and re-approval of the document. This could avoid delays.

4.Elimination of Delays by Arrangement of Prior Approvals.

Sanctions and approvals of individual actions and purchases can be very time consuming. They are often redundant when they fall within the provisions of the Plan of Operation. It is prudent, therefore, to include in this Plan sufficient "built-in" prior approvals so that the provisions of the Plan can be carried out without any delay. This has been tried on occasions and proved successful. There must be a clear understanding of these approvals, however, when the Plan is signed.

5. Early Ordering of Equipment.

Since manufacture of equipment such as machine tools requires many months, early ordering will prevent delays in the full operation of the Design Center. The prior agreements mentioned in the previous paragraph will help to facilitate the placing of orders without delay.

6. Adequate Publicity to Advertise the Design Center.

Unless the presence of the Design Center is known, together with its objectives, its personnel, and the types of assistance it can provide, efficient use cannot be made of the facilities of the Center. Complete confidence and cooperation can be obtained only by adequate publicity arrangements as outlined in paragraph F 11.

7. Early Contacts with Manufacturers.

No amount of correspondence can replace effectively personal contact with manufacturers in the developing country. It is during these times that a first-hand appraisal of the manufacturer's operation and needs can be obtained. These

personal contacts also build up friendly cooperation and confidence.

M. Conclusions

A Design Center for Electrical Equipment can be established effectively in most developing countries by cooperation of its government and other organizations such as international agencies. Previous experiences, both good and bad, have combined to provide those interested in new activities with background information, suggestions, and warnings. This paper has attempted to summarize this available information. When properly digested and used effectively, it can help to provide a smoothly operating facility with a minimum of problems and delays, and with maximum benefit to the developing country.

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