OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

FAIR USE POLICY

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

D03623

Distr.
LIMITED

ID/WG.110/7
6 October 1971

ORIGINAL: ENGLISH

United Nations Industrial Development Organization

Workshop on Creation and Transfer
of Metallurgical Know-How

Jamshedpur, India, 6 - 10 December 1971

DESIGN AND ENGINEERING SERVICES ON METALLURGICAL PROJECTS [1]

by

M.N. Dastur
M.N. Dastur & Co. Private Ltd.
Consulting Engineers
Calcutta, India

1/ The views and opinions expressed in this paper are those of the author and do not necessarily reflect the views of the secretariat of UNIDO. This document has been reproduced without formal editing.

I. INTRODUCTION

1. Indigenous design and engineering effort is known to act as the 'prime mover' in a country's industrial development. Most of the developing countries have embarked upon programmes of rapid industrial development and economic growth. Metallurgical industries, particularly the iron and steel industry, enjoy a high priority in these development plans, as they are essential for sustained economic growth. The speedy establishment of metallurgical industries, would in turn require ready availability of local expertise for planning, design and operation of plant installations.

2. Experience has shown that the construction and operation of a number of metallurgical plants have not automatically generated the ability to design and build new metallurgical plants. Most of these plants have been set up with foreign assistance, but in many cases there has been no effective transfer of know-how nor opportunity for the development of local skills and expertise, particularly in the case of turnkey projects. While foreign assistance is both necessary and helpful, many developing countries feel that they cannot continue to depend primarily on imported 'know-how' for the development of their metallurgical industries. The early creation of a nucleus of design and engineering capacity to assume responsibilities for the planned development of metallurgical industries is therefore imperative in those countries where these facilities are not available. Whereas, in the case of those developing countries where such a nucleus already exists, the development and use of local expertise and technical skills should be a continuous exercise and an integral part of the developing

country's deliberate national policy to establish a strong scientific technological base in the country.

3. Independent professional consulting firms continuously build up technical know-how and experience in the country, taking advantage of the technological advances elsewhere, and choosing the most appropriate processes and adapting them to suit the specific requirements of the project and the country. They assist in the development of indigenous materials, machinery and equipment and ensure their maximum utilization in metallurgical and other projects. They also help bring about speedy utilization of indigenous research efforts where available and supplement development efforts. Thus, they also assist in the evolution and development of local standards and codes of practice.

4. India provides a good example of a developing country which has not only established the nuclei of metallurgical know-how, technical consultancy services, research and development etc, but is in a position to share its experience and assist other developing countries in setting up their own design organizations. It is felt, therefore, that Indian experience in this field would be of benefit to other developing countries.

5. This paper is based on the experience of consultancy work in India and abroad during the last 15 years and deals specifically with the provision of design, engineering and procurement services for large integrated steel plants. The services rendered by the consultants for the preparation of feasibility studies have been discussed in another paper.

II. DESIGN AND ENGINEERING SERVICES

Detailed project report

6. The starting point for the provision of design and engineering services on a metallurgical project is the feasibility study. Normally, the consultancy firm which has prepared the feasibility study, is also entrusted with the design and engineering of the project, or 'project engineering', which include diverse services for the successive phases in the implementation of the

metallurgical plant, namely

i) Preparation of the detailed project report giving the overall design of the project including raw materials, product-mix, production processes, and capital and manufacturing costs

ii) Preparation of tender documents for equipment, services and utilities, civil engineering works and other construction work

iii) Analysis and evaluation of bids for equipment and engineering contracts and recommendations

iv) Inspection of equipment manufacture

v) Coordination of all engineering and construction works, equipment manufacture, delivery and erection schedules

vi) Preparation of designs and drawings

vii) Supervision of construction and erection of the plant and equipment

viii) Supervision of start-up and commissioning.

ix) Assistance in preparation of manning schedules, job specification, recruitment and training programmes.

7. The scope of work and the responsibilities of the consultants is normally detailed in the contract document. Based on this, the consultant proceeds to prepare the overall design of the project, for the given product-mix, plant size and location, as determined by the feasibility study and accepted by the client.

8. Planning the general layout of a metallurgical plant is an exercise in rational arrangement of the main production units, the energy networks, and the auxiliary shops, within the limitations of the selected site. The major criteria of a good metallurgical plant layout are

i) it must provide for the uninterrupted receipt and stocking of bulk materials, the rapid movement of in-process materials, and the smooth disposal of finished products and by-products;

ii) the production and auxiliary units together with the utility systems must be so arranged as to assist in economy of capital and operating expenditure not only

for the initial plant but also for subsequent expansion; and

iii) it must provide scope for rational future expansion in order to meet growing requirements and also to take advantage of the economies of scale.

The layout, besides, should not only incorporate proven technological advances in the initial design, but also give thought to techniques which show promise for the future. At the same time the layout must facilitate expeditious construction and commissioning of the units.

9. The layout inevitably undergoes a series of revisions from a mere concept of the designer to the various alternative designs on the drawing board, until the 'final layout' emerges, which would not only meet the immediate requirements, but go beyond it to maintain its logic and flexibility. As layout mistakes are usually permanent and expensive, many man-months of engineering enter into the evolution of most suitable arrangement of facilities. Careful layout planning is very important in developing countries which must make the most effective use of their limited resources, specially foreign exchange, and at the same time provide for much needed expansion - by providing space for new production units or by providing certain in-built facilities which would cut down investment costs of expansion.

Raw material requirements

10. The consultants also reassess the data given in the feasibility study on the available raw materials and the requirements of the project, in the light of new data that may have become available, identify the sources of supply, suggest measures necessary to develop the sources of supply wherever necessary, and indicate alternative sources if feasible. In the case of steel, for instance, the magnitude of the task can be appreciated when it is realised that a modern one million ton steel plant would require per year approximately the following quantities of raw materials:

		Tons/year
Iron ore (64% Fe)	..	1,500,000
Coking coal (16% ash)	..	1,250,000
Limestone (BF, SM grade)	..	550,000
Dolomite	..	150,000
Dolomite for refractories	..	35,000
Refractories	..	56,800
Manganese ore (30% Mn)	..	60,000
Bauxite	..	6,500
Ferro-alloys (FeMn, FeSi)	..	17,000
Scrap	..	240,000

The task is made none the easier by the fact that mining development takes even longer than erecting a steel plant. Where local availability of certain raw materials is uncertain, possibilities of import of these raw materials are investigated so that necessary steps can be initiated early by the project authorities to arrange for their imports on a long-term basis, which would ensure their uninterrupted supplies when the plant goes into stream. The transport of large quantities of bulk materials from source to plant site is a major task and very often the necessary facilities need to be developed.

Choice of technology, production processes and utilities

11. The consultants next review the available technology and based on the availability of raw materials, their characteristics and limitations, and on the local requirements and conditions, select the technology best suited to the project. In view of the large investments involved, only well-established commercially proved processes are selected. For instance, in the case of an integrated steel project, the consultants will have to consider the techno-economic feasibility of the alternative routes of iron and steelmaking, such as

i) the blast furnace (ironmaking) - LD converter (steelmaking) - continuous casting or conventional casting

ii) direct reduction (sponge iron)/electric furnace steelmaking/continuous casting.

They will also have to determine the most suitable feed material required, pellets, sinter or lump ore, or a blend of any of them for iron and steelmaking for each route. The consultants evaluate the alternative routes in terms of available raw materials and product-mix, as well as, considerations of profitability in the case where more than one alternative is technically feasible, and finally select the most appropriate process for the project.

12. Once the technology is determined, the next step is the selection of optimum size production units to derive the maximum benefits of economies of scale. The consultant then studies in detail the engineering requirements of each plant department and their inter-relationship, paying particular attention to the flow of materials, transportation and materials handling facilities, utilities etc, and prepares the detailed layouts and engineering drawings for each plant department.

Assistance in foreign aid negotiations and agreements

13. The consultants have a major role to play where foreign assistance has been sought for the metallurgical project. The experience of some of the developing countries in this respect has shown that foreign aid does not always come as an unmixed blessing. Difficulties often arise mainly due to the mishandling of aid-negotiations and collaboration arrangements by bureaucrats without any technical experience. This emphasizes the need for active association of the consultants with contract negotiations, so that some of the mistakes, either in the choice of technology or in the design and engineering of the project which would impair the economic viability of the project, could be avoided.

14. Contrary to that one hears about 'aid without strings', a good deal of political pressures continues to be exerted in one guise or the other by aid-givers, be they from the capitalist bloc or from the socialist countries. Aid-giving countries have been known to insist that feasibility studies and detailed project reports are carried out by agencies in their own country, even when requisite expertise is available within the recipient country. There is also the inherent danger that the recipient country is likely to be saddled with a 'mixed bag' of technology. Many of the

techniques peculiar to the aid-giving country are transferred wholesale to the developing country, particularly under 'tied-aid' agreements. Due to an exaggerated notion of the technical backwardness of the country, almost complete control of the project during the construction and early operation stages is assumed by the foreign collaborators, who insist on this as a pre-condition for giving technical guarantees.

15. Wrong choice of layout, technology and design mistakes are usually permanent and add to the capital and product costs, which cannot be remedied when the plant operations commence. In the absence of proper technical scrutiny from the developing country's end, the plant may cost twice as much as that of a comparable plant built in an advanced country. The presence of independent consulting engineers at the aid negotiations and collaboration arrangements, would help to safeguard the interests of the recipient country and to ensure that most suited processes and equipment - rather than 'off-the-shelf' processes and equipment more suited to the aid-giving country - are adopted.

III. PREPARATION OF TECHNICAL SPECIFICATIONS AND TENDER DOCUMENTS

16. The preparation of technical specifications and tender documents which serve as the basis of bids of the various equipment suppliers or contractors is a specialised service performed by the consulting engineers requiring a great deal of engineering expertise and experience as well as sound judgement and knowledge of the sources of equipment supply. The legal and financial terms and conditions that govern the relationship between the equipment supplier/contractor and the client are usually specified in the section on general conditions.

17. The technical specifications are generally divided into distinct machinery groups, according to the manufacturing functions and they specify the number of items needed, design, size, output, capacity, construction material, safety features, performance, guarantees and other relevant requirements. Construction standards and tolerances are stipulated and the workmanship is defined according to specific codes of practice and is ultimately subject

to the consultants' inspection and approval. The possibilities of standardisation of various items of equipment is also kept in view, while drawing up the specifications.

18. To ensure fair practice in tendering and supply of equipment, and to obviate favouring one manufacturer over another, technical specifications do not usually refer to equipment by the trade marks or brand names. However, in case the equipment is mentioned by its brand name, it is specifically mentioned that the brand name or its equivalent is intended. It is also customary to append general arrangement drawings, flow diagrams, instrumentation schematics, electrical line diagrams, detailed plans, drawings and blue prints to each set of technical specifications which include many details essential for the clear understanding of the written specification. The choice is also given to the tenderers to submit alternative offers for the equipment outlining their specific advantages.

Evaluation of tender

19. The call for tender may be on the basis of open tenders or on selective tender basis, according to well-established procedures. From the point of view of expediting the equipment supply and the progress on the project as well as ensuring the quality of the supply, selective tendering by registered suppliers whose credentials have been screened, would be preferable. Once the bids are received and opened publicly on the specified date in the presence of the representatives of suppliers, the client and the consultants, the bids are evaluated, taking into account their compliance with specifications, their completeness, the quality of supplies, the price, the competence and capacity of the supplier, the delivery period etc. The main objective is to select the lowest technically acceptable offer, commensurate with delivery requirements and other conditions. This is primarily the function of the consultant who analyses and compares the various functional groupings of equipment and records the preferences and the reasons for the choice and alternatives if any. The salient features of each offer are tabulated and a summary prepared.

20. The recommendations concerning each bid are prepared, submitted to the client, and then discussed with the client. The suppliers whose bids have been recommended are contacted for negotiations and for settling the technical aspects of the bid. The consultants assist the client during the negotiations in draft ng the contract documer .s and in obtainin, the guarantees required. They also participate in the discussions concerning the delivery period and other technical matters.

Preparation of civil engineering specifications and tender documents

21. As in the case of equipment required for the project, the consultant plans for the civil engineering and structural work and prepares the tender documents consisting of general and special conditions of contract, technical specifications, bill of quantities and drawings. The specifications give the basic design data and the description of the dimensions, materials, workmanship, type of construction and finish of each section of the plant.

22. The quality of the various building materials are clearly specified. The functions, dimensions and characteristics of each of the various types of structures such as production shops, administrative buildings, water supply and drainage structures, roads and railway tracks are specified. Water, power and steam lines are indicated explicitly, and their location, the size of the outlets etc are shown on the drawings. The drawings are generally detailed enough to allow the contractor to plan the construction requirements and estimate its magnitude so that he could allocate his resources for the construction and assess the time for completion.

23. The codes of practice, standards or materials used in the specifications should be based on local standards. Foreign standards should be used only in cases where local standards or codes of practice are not available. The participation of local consultancy and engineering services on the project will ensure that local standards and specifications are adhered to in the construction of the project.

24. In view of the magnitude of the construction work, tenders are normally invited from those contractors who have adequate experience and necessary capacity and resources to take up the work. For this purpose, the contractor usually states his qualifications for the work, the engineering personnel and their qualifications, the type of site organization proposed to be set up by him, extent of his facilities and machinery, and experience on similar construction projects. If the job is too large or beyond the capabilities of local contractors, the tender is put up for international biddings and in cases of large projects divided into convenient zones.

25. The evaluation of the bids for construction is carried out by the consultants as in the case of bids for equipment who, after an analysis of the various aspects, make their recommendations to the client. The contractor or contractors are selected on the basis of these recommendations, the details of contract are negotiated and the contract concluded. The selected contractor is provided with necessary design and working drawings by the consultant to enable him to execute the work.

Supervision of equipment manufacture

26. After the placement of equipment orders, the consultants approve, after scrutiny, the general arrangement and other drawings submitted by the tenderers, to enable them to proceed with manufacture. The consultants are also required to carry out periodic inspection of equipment manufacture to ensure materials of the right quality are used and the workmanship conforms to the specific requirements as well as to expedite the manufacture. Performance tests on some types of equipment are carried out by the equipment manufacturer, which are witnessed by the consultant.

27. This service offered by the consultants involves several visits to the manufacturers' plant at various intervals. For this purpose the consultants draw up the inspection procedures in consultation with the equipment manufacturers, outlining the type of tests and stage inspection etc required. The work is

rendered more difficult in the developing countries which depend on foreign supplies for most of the equipment, entailing visits to the manufacturers' country which would be both costly and time-consuming. In such cases it would be advantageous to entrust such inspection and certification to reputed inspection agencies in the country, who will also check the shipment to ensure that the contracts comply with the bills of lading.

Procurement problems

28. The wide variety and large number of equipment required for a metallurgical project like steel plant makes the procurement from different sources, a complex and time-consuming operation. This is particularly so in those developing countries which pursue vigorously import substitution policies to ease their difficult balance of payments position, as in the case of India. Some of the developing countries have already established some machine building capacity in furtherance of their import substitution efforts. Government policies in these countries require that as much equipment and supplies as possible must be procured from indigenous sources. Since some items of equipment are being manufactured for the first time in these countries, inspection assumes greater significance as quality and standards of performance have yet to be established.

29. Action needs to be taken well in advance, right from the project report preparation stage itself to list out major equipment, identify likely indigenous manufacturers, assess their capacity and workload and to encourage them to manufacture the equipment items. Assistance also needs to be given by the project authorities to the indigenous manufacturers to procure critical materials required for equipment manufacture either locally or through imports. Such a procedure would also pinpoint the items which have to be imported either due to non-availability in the country or uncertainty about supplies in time.

Steel and other materials

50. A million ton steel plant requires about 100,000 tons of structural steel and a two million ton plant about 160,000 tons. In developing countries, it is very difficult to procure from indigenous sources such large quantities in time in the required sizes and shapes to suit the construction schedules. Indian experience has shown that the practice of placing orders for steel after the commencement of engineering invariably leads to delay, particularly due to difficulties in procuring plates and matching steel through imports. These delays could be avoided to a large extent by preparing material indent during the DPR stage itself.

51. The consultants should advise the project authorities on the advance action to be taken for the import of steels and sections which cannot be obtained locally. Similarly, in the case of other materials like refractories, ferro-alloys etc, the supplies of which are either locally not available or uncertain, the consultants should recommend to the projects the appropriate action to be taken in these respects.

Coordination services

52. The physical magnitude of construction work involved in the installation of a steel plant is immense. Worst, difficulties arise due to short supply of structural steel and other construction materials. Second, in view of the large quantities of equipment to be procured from various sources, both indigenous and foreign, there is every likelihood of delayed deliveries which has to be safeguarded. Third, a large number of agencies will be engaged in the different aspects of the project construction, whose activities are often inter-related and dove-tailed. Planning and coordination of the various activities is therefore a complex task, which emphasises the need for specialised coordination services by the Consultants.

53. In a complex metallurgical project like a steel plant, in addition to the basic task of dove-tailing of various constructional operations, a number of activities have to be carried out simultaneously to avoid delay and bottlenecks and to

expedite the progress of the project. Further, in order to achieve coordinated work on various items at all stages, the agencies concerned with construction and fabrication, equipment supply and erection etc have to be alerted well ahead of the actual execution of their respective tasks.

34. The monitoring and coordination of the numerous activities is a complex task requiring a detailed analysis and identification of activities through a network analysis. The basic concept of network analysis envisages primarily a logical sequence diagram which outlines the procedure in which the construction should be organised. To make the network truly effective, it is put on a computer as the time of completion changes with alteration in planning and in time estimates. This will necessitate constant computation of the critical path. It is only on the basis of such detailed network, the project can be scheduled, critical areas and bottlenecks identified, resources allocated and corrective measures taken on time. Based on such a detailed study, progress reports are prepared on all aspects of the project which would present a realistic picture on the status of various items of work on the project, the likely bottlenecks and the preventive action required. Such reports would also focus attention on matters requiring decisions by the project authorities and Government agencies.

Project costs reduction and control

35. Experience of steel plant construction in India has shown that the investments are high and the construction periods rather long, which in turn add to the overall cost of the project. Measures discussed above such as detailed project planning, advance action on critical items, effective coordination of construction activities through network monitoring, as well as budgetary control techniques for allocation of resources and phasing of expenditure, would expedite the project and cut down project time and reduce the costs. This process of 'cost-consciousness' should commence right from the planning and design stage, through the engineering and construction of the plant to finally the operating stage. The consultants constantly advise the project

authorities on these and other relevant aspects of project control and assist them in setting up the necessary apparatus and procedures to carry out these tasks smoothly and expeditiously.

Supervision of construction

56. The supervision of construction and erection are important functions of the consultants on the project. For this purpose, the consultants provide a resident staff of engineers, draftsmen and supervisors at plant site to ensure that the engineering plans and specifications are adhered to and that a high level of workmanship is achieved. They also interpret the design drawings and specifications to the contractor and carry out minor alterations in the original designs or installation plans which may become necessary. Occasionally new design drawings may be required, which will be handled by the main office of the consultants. The consultants' engineers at site investigate and request tests to ensure that materials and workmanship comply with the specifications issued to the contractor. The contractor is required to finish the work on schedule as stipulated in the contract, or is penalised except in cases of delays due to circumstances beyond his control. The construction work is measured as it progresses and the authorisation for payment is issued to contractor accordingly.

57. The construction phase of the project is the longest one and requires vast practical experience on the part of the consultants and their engineers at site. The engineering staff at site is constantly faced with administrative and engineering problems which need to be solved effectively, often on the spot. They are backed, of course, by the experience and knowledge of the engineering staff at the main office of the consultants. During this period, the senior staff member who is responsible for the coordination of the project in the main office as well as the key personnel responsible for the design of the various production units and facilities, visit the site to check the progress of work, to iron out difficulties that are beyond the authority of the site engineers, or to take decisions on matters of principle. The consultants' approach should be necessarily

flexible, but in all their decisions, they should bear in mind that their main responsibility is to safeguard the interests of the client.

Supervision of start-up and commissioning

38. The performance guarantees of individual equipment are the responsibility of the equipment suppliers. The consultants, however, supervise the start-up and commissioning after the installation of the production and auxiliary equipment, and the construction of main buildings as well as the connection of the equipment to sources of power, steam, water, compressed air etc and the preparatory tests by the equipment suppliers. Once mechanical adjustments have been made, the actual in-process tests proceed, first individually by each section, then for the plant as a whole, under the supervision of the equipment manufacturers and the control of the consultants. After the condition and performance of the machinery as well as output, quality of the end-product and consumption of utilities are checked and the specified performance levels are met and maintained over a stipulated period of time, a completion document detailing the commissioning of the operations is prepared, which forms the basis of payment to the equipment suppliers.

Recruitment, training and plant management

39. Manpower certainly constitutes one of the most intractable problems in most of the developing countries, because development of skills necessarily takes time. This serves to emphasise the importance of advance action on manpower development, which must start well ahead of the construction of a project. The consultants prepare the manning schedules, job specifications and trade or other tests and proceed to recruit the number and type of people needed at various levels, in consultation with the client. Well-tried recruiting procedures are employed and appropriate training programmes developed. Special attention is paid to the training of technicians and maintenance engineers and normally it would be an advantage to associate the maintenance crew with the erection of the plant. This would necessitate the recruitment and training of the requisite staff sufficiently early in the project construction stage.

40. The consultants may arrange for the training of operatives and technicians at equipment suppliers' establishments within the country. Certain key production personnel may be sent to the equipment manufacturer's plant abroad for specialised training. Where facilities are available, arrangements can also be made for training at other steel plants within the country. The consultants may also recommend the establishment of a steel plant training institute which would ensure a steady supply of trained technicians and skilled operatives to the plant in the future.

41. There is also a real shortage of mature and experienced personnel in developing countries to fill managerial positions in metallurgical projects. The consultants may assist the client in recruiting suitable persons for positions of responsibility and advise on the proper steps and procedures to be taken to pick out the most promising among the new recruits and groom them by additional training to shoulder larger responsibilities in future.

Type and size of consultancy organisation

42. It would be evident that the wide range of consultancy services required for the installation of modern metallurgical plants demand the combined talents of engineers and designers experienced in the design, engineering and construction and operation of metallurgical plants. The personnel would cover the complete range of disciplines - metallurgical, chemical, mechanical, electrical, civil, structural, architectural, as well as experts in economic evaluation, industrial and personnel management as well as project management. The complexity of modern metallurgical plants demands not only engineering knowledge covering various areas of specialisation, but also an inter-disciplinary approach to plant problems and design so that well coordinated integrated services can be made available.

43. The size and type of consultancy organisation would depend primarily on the range of services provided and on the assured volume of work to sustain it. Developing countries which have long-term steel or metallurgical development programme

involving the construction of several new steel plants and/or metallurgical plants can generate adequate amount of consultancy work which could sustain a medium to large-sized consultancy organization. For countries where there is no such assured programme, it would be advantageous to have a smaller consultancy organization with a core group and basic supporting staff, and to recruit additional staff as required on project to project basis. A full-fledged consultancy organization providing the integrated services on metallurgical plants would have a minimum staff of about 300 to 400; whereas a smaller consultancy organization with only the core group may have a strength of about even less than a hundred. Smaller consultancy units may engage external consultants from within the country or abroad, for specific items of work for which they have no facilities within their own organization. For instance, market research, geological investigations, mining development, soil investigations, plant transport requirements, etc may be entrusted to agencies outside the organization. A typical functional organization structure for a medium/large-size consultancy organisation geared to provide integrated services on metallurgical projects is shown in Fig 1. However, in a creative professional activity like consultancy engineering, the calibre and competence of the personnel, their training, experience, capabilities and specific qualifications, more than mere size of the organisation, ensure that a project will be carried out successfully and economically. In fact, these are the very factors that weigh with clients in the choice of consultants for any given project.

44. It should be borne in mind, however, that a consultancy organisation cannot be set up like a factory, with foreign aid. In order to meet the specific needs and conditions, the nucleus of the design force must be created within the country and then given adequate scope and opportunities to develop under competent leadership. While the process of economic development itself is a factor in the growth of strong and competent consultancy organizations in the developing countries, the proper 'climate' for their progress has to be created by the Government as well as

industry in those countries. First, there must be the awareness of the need for independent consultancy services on industrial projects and of the important role and contribution of consultants in industrial development. Second, both Government and industry should have confidence in the ability of their own engineers and consultants. Third, opportunities should be given to local engineers to shoulder responsibilities on industrial projects. Fourth, local engineers should fully participate in projects built with foreign know-how and assistance so as to ensure effective transfer of know-how and building up of consultancy experience in the country. Finally, the developing countries should assess the know-how and skills already available locally, identify the gaps and set about acquiring the know-how required by judicious imports of know-how, while also actively encouraging the development of local expertise and skills. Talented and intelligent young men and women should be encouraged to become engineering and managerial specialists, and provided with adequate training and industrial experience to enable them to practice under conditions that are both professionally and economically satisfying.

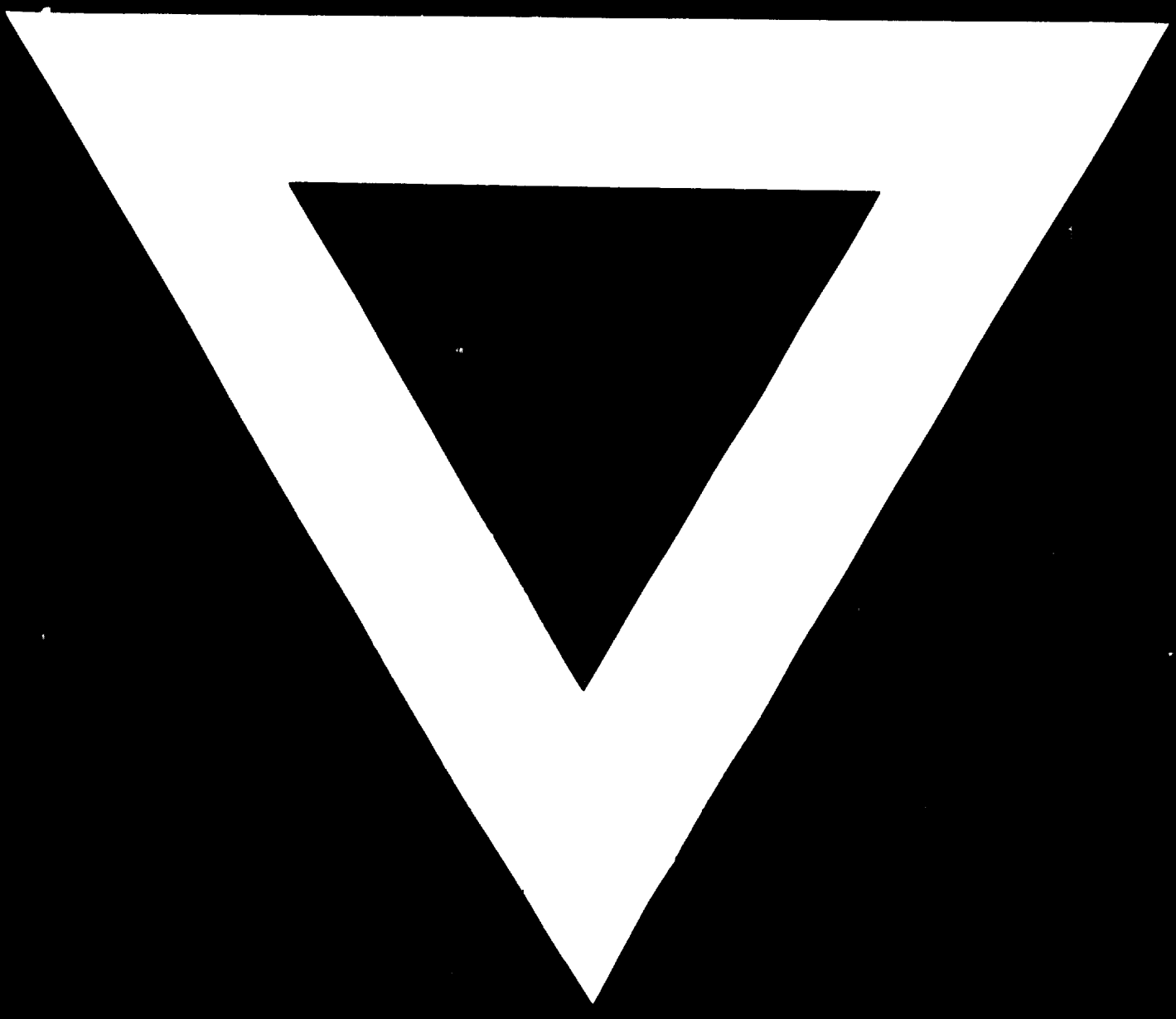
Independent status

45. In this task of setting up a nucleus for design and engineering services for the promotion and development of technology the independence of the consulting organization is a prime consideration. The consultancy organization should have no financial or other commitments whatsoever with manufacturers/suppliers of process or equipment. This independent status should be scrupulously maintained, because a design organization should have objectivity and national perspective to give impartial technical advice on various problems without being influenced by pressures from any source. A captive organization or a firm with business links with equipment manufacturers and contractors, on the other hand, cannot be expected to give independent and unbiased opinion on important technical issues. Their views are likely to be conditioned by their organizational links and loyalties, and other extraneous, non-technical considerations. In view of the huge investments

involved in metallurgical projects, the integrity and objectivity of the independent consultant in technical matters is all the more valuable in the case of a developing country, particularly when there are so many pressures from various sources.

46. The creation and development of local design and engineering organisation will diminish the dependence of the developing countries on outside sources for know-how and reduce the cost of technology transfer through imported technology and services. There need be, however, no conflict between the growth of local consulting profession and foreign consultancy organisations. There are many situations in developing countries where local and foreign consultants can supplement each other's efforts and cooperate on assignments in a particular country or group of countries. This is particularly true of developing countries which do not have well-developed design and consultancy organisations. However, on a long-term basis, it would be to the advantage of the developing country to utilise to the maximum the consultancy and engineering services available in the country and actively encourage their development as a matter of national policy and to import foreign know-how and consultancy services, where absolutely necessary, for the development and progress of the technological and industrial structure of the country.

Fig 1. A TYPICAL FUNCTIONAL ORGANIZATION STRUCTURE FOR A METALLURGICAL CONSULTANCY ORGANIZATION



20.12.73