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08190

Distr.
LIMITED
ID/WG.279/8
26 June 1978
ENGLISH

United Nations Industrial Development Organization

Second Consultative Group on
Appropriate Industrial Technology
Vienna, Austria, 26 - 30 June 1978

ON THE ESTABLISHMENT OF AN INDUSTRIAL TECHNOLOGY DEVELOPMENT POLICY *

by

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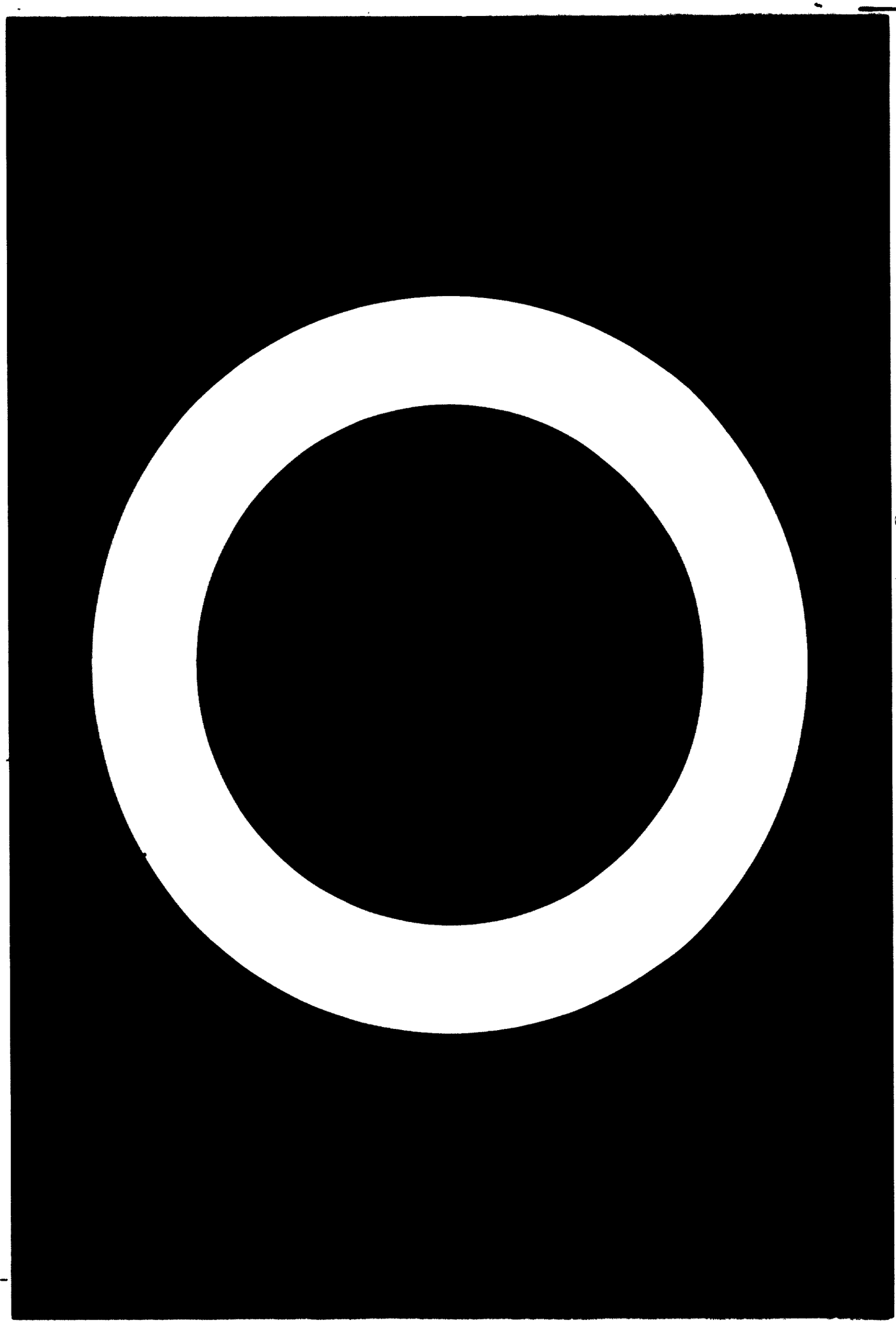
id.78-3931

CONTENTS

I. INTRODUCTION

1. Within the context of national economies in the developing countries the strengthening of basic production capabilities and providing in the requirements of the larger rural communities of these countries constitute major objectives. These objectives are major focus areas for government policies aiming at the strengthening of national technological capabilities. It is in this connection recognized, that technology has an innovative, creative and dynamic nature, which would provide to the development process, at micro as well as macro economic levels, a specific intrinsic strength. With respect to basic production capabilities, it would entail the establishment, sustainment and further development of technology-systems by which, for instance, natural resources can be utilized in an optimal manner, or by which on the basis of imported supplies "downstream-processes" could be strengthened. Meeting the requirements of rural communities which constitute the major part of populations need a variety of technological abilities. Partly this relates to a modernization of existing traditional skills, such as implement production, home-spinning and -weaving, and other crafts. In addition, new forms of technology, e.g. communication-electronics, need introduction, and new forms of organizaing the productive and distributive activities. This process is of a continuous nature, and in its evolution also a continuing interchange is recognizable between human skill development and the incorporation of technological functions in machines and equipment. At a more aggregate level, this interaction also takes place between technology and society, creating the need for development of suitable institutional and infrastructural facilities.



II. EVOLVING TOWARDS A FRAMEWORK FOR APPROPRIATE TECHNOLOGY DEVELOPMENT.

2. As indicated above, a broad range of technologies is needed which in the early stages of development are introduced through transfer of technology. Such a transfer may include know-how development through training, the import of machinery, the on-the-job sharing of experiences in jointly operated industrial enterprises with experienced foreign personnel and through information exchanges in an institutional manner. Simultaneously national educational efforts are to be directed towards a parallel stream of developing technological capabilities. On short term this would include vocational, technical and mangerial training and on the longer term the establishment and evolution of a technological and scientific system, capable of absorbing and improving imported know-how and of generating original technological contributions. The ability to improve continuously on the existing technological base should also be an intrinsic asset of those directly engaged in the industrial activities and would, in fact, have to become a part of their way of life; causing as a consequence a fundamental social change. In turn, society also exerts its influence on individual capabilities and performances. This interaction requires nurturing through a unified conceptual approach, rather than a dualistic or pluralistic one. Such a unified concept should encompass all elements, so that it can comprehensively conduct the stream of changes into an evolutionary process modernizing the entire nation. This guidance process requires for its execution also a set of policy measures to direct an evolutionary maturing of the institutional structure, as arising from the interchange between technological and social development.

3. The technological and institutional aspects integrate with the economic development process in a variety of ways. In terms of policy measures, the following stages may be distinguished :

(a) an early stage during which imported know-how predominates and policy measures are required which facilitate the

implantation of this know-how into the national socio-economic setting;

(b) a subsequent stage during which a more selective approach is desirable, generally recognizing a sector-wise differentiation; i.e. permitting for certain sectors liberal inflow of imported knowhow and simultaneously evolving for other branchespolicy measures aimed at stimulation the application of indigenous innovations;

(c) a more advanced stage where indigenous innovative capability has adequately developed and requires specific policy support for maturing; it is at this stage that institutional co-operation in the field of technology development may often bear its greatest impact;

(d) a maturing stage where the international co-operation evolves into a two-way exchange.

Experience has indicated that the overall duration for these four stages may well extend over several generations. In Japan, for instance, the inflow of modern industrial technology commenced around 1860, a century after its start in Western Europe. The development of some japanese industrial innovations emerged two generations later and came only in the last two decades to full maturity. From the 1960's onwards a growing trend in the receipts of exported knowhow is noticeable. However, Japan's expenditures for the imports of technological know-how are currently still of a higher order *). A closing of this gap is anticipated, when the substantial outlays for research and development will generate cumulatively higher yields beyond the gains already made in external trade.

4. The evolution in the first two of abovementioned stages, and the transition towards the third stage, is to a certain extent reflected in the increase in the contribution, which the manufacturing sector makes to the gross domestic product (GDP). Availability of adequately trained personnel is a major prerequisite

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*) Ref. Science and Technology Planning Agency, Tokyo, Japan

for such a development. This interrelationship is illustrated in attached exhibit. The first of abovementioned stages would roughly correspond with the level upto a 10 to 12 % contribution of manufacturing industry to G.D.P. The second stage would extend upto a share of 18 to 20 %. In this stage a strong focus of development policies to broaden the number of adequately trained technical, engineering and scientific personnel is needed. Subsequently, during the gradual transition towards the third stage, the industrial manpower base requires a strengthening in depth.

5. Aspects of a purely qualitative nature exert a continuous interplay with abovedescribed development process. It is in this connection recognized, that, compared with the traditional structure, an entirely different profile of capabilities is needed. In establishing a strategy for its development, the affinity with traditional assets can, however, be of great importance. A highly developed tradition in arts is, for instance, often an indication for a potential in creative talents, and a high traditional in mathematical sciences a possible indication for the type of analytical capabilities, which are indispensable to the process of fostering and controlling technological developments. Also an ethical outlook positively valueing work as a major and basic element in man's life, is inducive to the nurturing of production-oriented industrial capabilities. The fostering of national technological capabilities should, as implied earlier, be broadly oriented, i.e. geared to the population in its totality. This approach should however not preclude à priori unique contributions by exceptionally gifted persons. The introduction in american industry of the presently widely used systems of production is an instance of such singular efforts. Improvements on an original introduction are naturally at all times needed. However, assessing it in terms of its contemporary contribution, it was a major cornerstone on which american industry developed, and could gain supremacy in many technological fields. In the process of absorbing and subsequently generating own industrial technology, the accelerating effect of rare human achievements deserve therefore appropriate incorporation as a possibility. Nevertheless, widespread availability of industrial talents and skills is needed, and should constitute the main guidepost for the policies fostering the development of national technological capabilities.

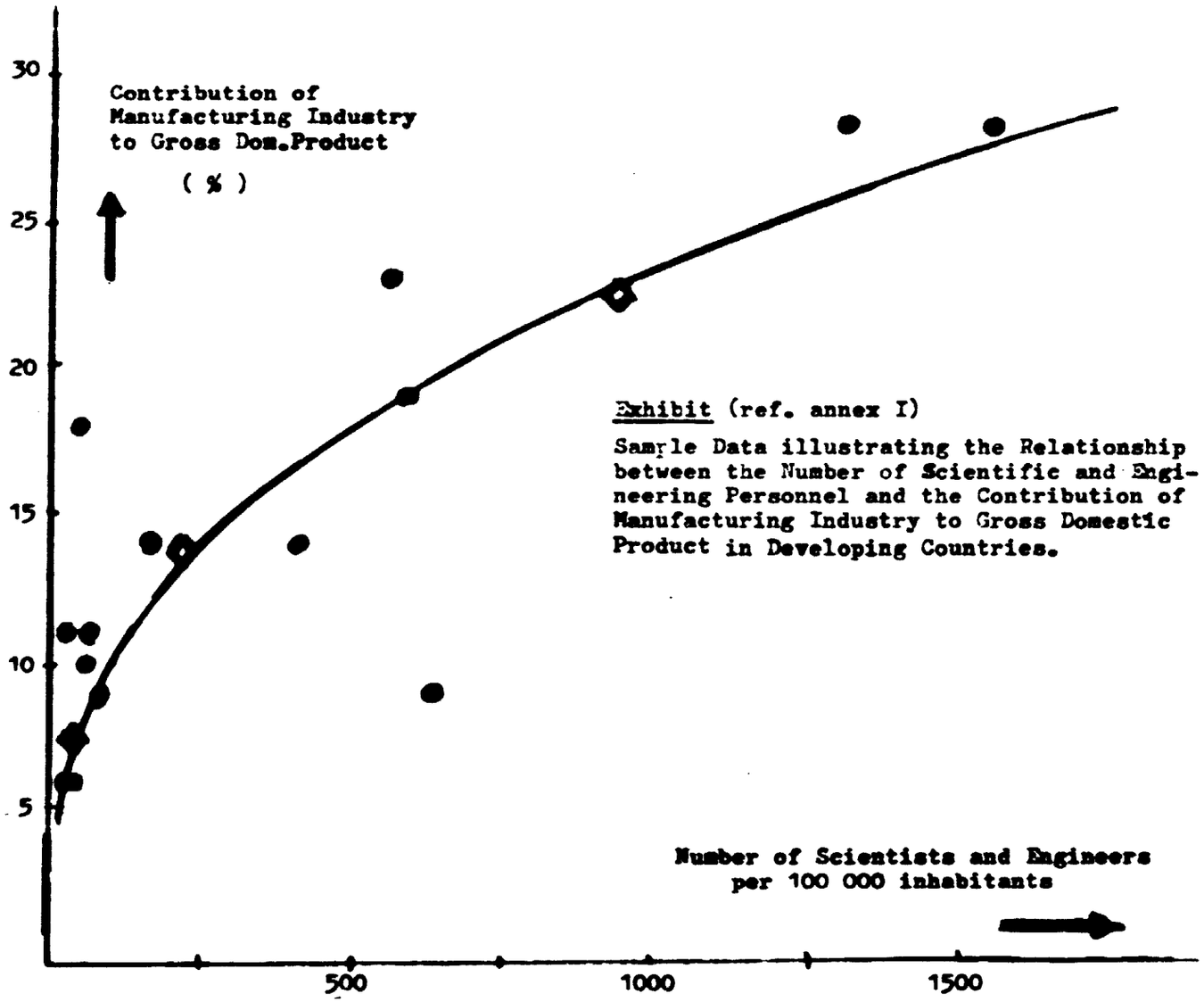

Exhibit (ref. annex I)

Sample Data illustrating the Relationship between the Number of Scientific and Engineering Personnel and the Contribution of Manufacturing Industry to Gross Domestic Product in Developing Countries.

III. TECHNOLOGY APPROACHES IN HEAVY AND LIGHT INDUSTRY DEVELOPMENT

6. Balancing of heavy and light industry development is a major subissue within the context of an industry and technology development framework. In this balance the strategy is to be expressed for evolving technological capabilities in pursuit of the industrialization aims. Within the heavy industry sector, i.e. industries with a relatively capital-intensive nature, industries supplying industrial materials for other industries, and the machine-tool industry producing the means for machinery development in other industries perform special structural functions and are usually referred to as basic industries. Their direct interlinkage with other industries necessitate a special set of policy measures ensuring their continuous function in support of the industry and economy as a whole. Often enactment by law is done. In contrast, light industries provide a variety of functions and embody a flexible technological spectrum adaptable to many different situations for generating industrial activity and integrating technology with the human structure. In the modernization process, light industries perform an invaluable, irreplaceable role and warrant for its development also a policy framework with similar institutional strength.

7. The choice of technology for the heavy industry sector needs, as already mentioned, to be made with a view on longer term requirements. Such longer term aspects should, however, not preclude short term economic viability, but rather should incorporate these short term considerations as a prerequisite for timing the introduction of the technology concerned. Other issues involved in the technology choice in heavy industries are the relatively few sources for technology supply, the heavy demand which it poses on available financial resources and the need for integrated development of human capabilities, technologically as well as managerially. Many of aforementioned factors cause a development trend towards operations on an ever increasing scale. This may well be justified in industrially advanced countries, where at present most of the new technological developments originate. Unmistakably, this creates for the developing countries a widening of, what could be named the "applicability gap". In view of the realistic needs to obtain a

better utilization of available natural resources in the developing world, a change, or at least a differentiation in the above-mentioned technological tendencies is needed. This deviating direction should not merely adapt or renovate older technologies, but should have itself also basic innovations originating from technological research and development work undertaken in the environmental setting of the developing world. Geographic and other factors in the presently industrialized countries deviate often strongly, and would therefore not provide the correct surroundings to undertake such research. Energy technologies are in this respect a typical illustration. Only relatively recently, research efforts are directed towards better utilization of solar energy, in most developing countries abundantly available on a yearround basis. A new impetus is needed to place these R & D efforts in the context of the surroundings of their actual application.

8. Within the sector of light industries, the favourable employment-capital ratio is particularly pronounced in the small enterprise sector. As the size of the enterprise grows, organizational and other requirements generally pose demands which diminish to some extent the aforementioned employment generating advantage. Choice of technology in smaller enterprises is to a large extent unit-oriented, i.e. related to a particular process-unit or machine suitable for the production of certain products or to perform certain service functions .. A broad range of knowhow supply sources is generally available, although foreign exchange and similar statutory considerations may in many instances limit in practice the options available. Development policies aiming at stimulating technological growth of the small enterprise sector should to the extent possible provide for a liberalization of such statutory restraints. Moreover, local know-how sources should be encouraged to participate in the broadening of this know-how supply pattern.

9. Geographic and other basic factors will determine to which degree heavy or light industries require emphasis in the context of the industrialization process. Large countries with rich endowment of natural resources are generally in a better position to give emphasis to a heavy industry approach. On the other hand, in almost all countries, employment considerations are of great impor-

tance, posing the need for explicit policies to stimulate light industry and particularly the small enterprises sector. A predominantly light industry oriented approach would logically fit the initial development requirements of countries with relatively few natural resources. As industry progresses towards higher levels a corresponding evolution of technology development policy is needed and which can, considering the timespan of each development stage, be undertaken in step with the national multi-year planning cycle. In this evolution, a forward diversification may emerge out of the heavy industry sector, and a backward integration pattern out of the growth of light industries. From these developments new growth-points arise, and their maturing are transition-elements towards more advanced stages of industrialization; which, as indicated earlier, requires progressively adoption of more selective technological development approaches.

10. International and regional cooperation factors exert also an interplay on abovedescribed policy-making process. Of an overriding influence are, for instance, the international trade agreements, whose provisions and restraints are often major considerations for the technology choice in the sector concerned. The multifibre agreement in the textile field is a typical example. Market aspects are also a determining component on the regional scene and may facilitate development of intra-sectorial specialization, rational choice of technology and better utilization of capital and natural resources. Export considerations may further warrant an upward orientation of technology-choice to meet external quality requirements. Such interplays may, in turn, generate spearhead-effects on the domestic scene, accelerating the growth of industry to more advanced stages. The maturing of industry - as may be reflected, for instance, in a stabilizing share of the manufacturing industry vis-à-vis other sectors of the national economy - will warrant the adoption of more sophisticated technological approaches. Qualitative and efficacy aspects - which, at all stages, are factors directly affecting technology-choice - attain at these advanced stages special prominence in the strategy for further pursuit of technological and socio-economic advancements.

IV. TECHNOLOGY DEVELOPMENT AND THE DISPERSAL OF INDUSTRIAL ACTIVITY

11. Locational aspects determine in a decisive way the economics of technology applications and the possibilities for technologies to serve as spearheads in the national modernization process. For these applications, supporting technological inputs, notably power and utilities, are needed, as well as institutional services, such as training and specialized expertises. These supporting requirements cause a certain agglomeration effect. Proximity to endusers is another locational consideration. The availability both of supporting facilities and enduser concentrations give to urban areas a certain gravity force to attract establishment of industries in their surroundings. National development considerations - comprehensively encompassing national resource development, employment and other aspects - may, however, point towards the need for effectuating a dispersal of industrial activities in a different pattern than aforementioned. To this end, a deliberate effort is in many instances required. A preplanned approach - rather than a corrective approach as at present undertaken in various industrially advanced countries - is needed, and would be imperative in the development requirements of densily populated areas.

12. In the modernization of the rural communities, which comprise two-thirds of the inhabitants of the developing world*), the incorporation of technology is a vital factor. Through technology new avenues and perspectives can be opened. In the first place it directly supports the farmer's work; it provides new possibilities for extending the range of his activity to more distant areas through improved preservation and transport; it opens new possibilities for utilization of agricultural by-products, and it can, among the other possibilities, which are in this context not explored in detail, provide for supplementary income in periods of seasonal slackness in agricultural activity. Development of new technological oriented capabilties aims to bring to the rural population more economic stability and an evolutionary yet dynamic change. It is with this object in view, that technology is to be incorporated in policies aiming for rural modernization.

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*) ref. annex II

13. Present technologies have only in a few instances taken the abovementioned application patterns into account. They have, as mentioned earlier, largely evolved on the basis of experiences gained in industrialized countries with a widely different socio-economic pattern. Although the share of developing countries in the world industrial production is still rather modest, a certain basis has been established capable of generating some innovative contributions directly related to the advancement requirements of the developing world. In certain instances, a maturing towards the third stage referred to in an earlier chapter is reached, i.e. a rather advanced stage where a systematic international institutional support can be expected to yield positive results. Such international institutional efforts would be greatly enhanced, when an international framework can be evolved, which can stimulate a suitable environmental climate for these technology development efforts and can provide an identification of, and increased means to pursue priority areas.

14. A number of sectorial areas have been selected by UNIDO for a first systematic attempt to evolve such an international cooperative effort. Amongst these sectors, the following are objects relevant to the development requirements of the rural populations :

(a) equipment and tools, suitable for modernizing small acreage farming;

(b) processing, preservation and storage technologies suitable for operation in predominantly rural areas; possibly within the context of agro-industrial and light industry complexes of a relatively modest scale;

(c) short distance transport equipment to facilitate movements of persons and goods and the linking up of rural communities with national transportation systems;

(d) manufacturing (and energy) technologies suitable for dispersed production of household, living, primary health care, communication and educational requirements.

The abovementioned objects are illustrative and a more comprehensive enumeration is needed for a programme on the longer term. Monitoring

such technological development needs, taking also a differentiation towards various regions and levels of development into account, is also a function, which need explicit recognition in the context of the aforementioned international policy framework.

15. Special efforts are needed to provide for the development requirements of the low-income groups, which constitute major segments of the urban and rural populations. According to World Bank estimates approximately 85 % of all absolute poverty is in the rural areas, and would comprise a quarter *) of the total population of the developing world with major concentrations in a few areas. Technologies suited to prevailing conditions, i.e. effectively operable in environments with very few infrastructural and institutional facilities, are needed; particularly in relation to water supply, soil conservation, shelter-construction, logistics, storage and distributive systems. Such priority would also extend towards related maintenance, repair and productive facilities. In the further development, the aforesaid areas listed above in relation to the rural populations in general would also apply.

16. Besides natural resources development to meet industrial supply requirements of advanced countries, the better utilization of natural resources to support domestic industrial development constitutes a separate dimension to which technological research and development efforts need to be more closely focussed. Often it is optimal to undertake a first stage processing at or near the place of the resource deposits. This aspect constitutes a separate, and for countries with rich natural resource endowments a major element in the locational strategy for deploying technology. Besides the processing methods itself, energy, materials-handling, quality-grading and environmental control are integral parts of the technology concerned. A disaggregation of this package into its separate components, possible substitution by components optimally related to prevailing conditions, and incorporating innovative improvements for which general applied research is needed, would often yield a restructured and often more adequate technology. The fostering of

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*) ref. annex II.

process engineering skills are in this connection an important asset, which requires specific identification in the context of a technology policy framework. To related international cooperation aspects similar considerations, as described in the previous paragraphs, apply.

V. FUNCTIONAL ASPECTS IN TECHNOLOGY DEVELOPMENT.

17. Although many older reflections on the subject of industrialization and technology development exist, the UNIDO Industrial Development Conference (UNIDO I) convened in Athens in 1967 is the first systematic and comprehensive compilation of experiences on a world scale. Several stages, well beyond UNIDO II (Lima, 1975) and UNIDO III (scheduled for 1980), are further needed before a mature universal approach can be available. A pragmatic approach oriented on main areas of industrial development has in the preceding text been adopted rather than a functionally oriented one, which can at best provide a partial perspective. Other than on an ad hoc basis, it would therefore be immature to evolve on such functional considerations priority criteri . Analytically, however, certain insights have been generated from which technology planning in the developing world can derive appropriate benefit.

18. At the level of unit-equipment, application of ergonomics can, for instance, contribute to adaptations more suitable to the physical and environmental conditions in developing countries. Input-output analyses have provided primary assesments from which improvements have originated for plantsystems, areawise agglomerations and sectorwise developments. These analyses directly contributed to the evolution of employment-oriented concepts and interrelated capital-intensity considerations. Inter-industry and inter-sectorial analyses have provided further insight in the aggregate effects of a developing industry from an economic as well as a social point of view. To there insights the mathematical and statistical sciences contributes a further refinement. These might provide useful indications as to the direction and needs for evolving new technologies suited to the industrialization requirements of the developing world, and on which some illustrative examples have been mentioned in earlier paragraphs.

19. Furthermore, new technology-oriented methodologies have come into being, based on insights in the longterm development and application patterns of products and processes. At the enterprise level, product lifecycle patterns are at present already widely used for determining future courses of action; in a horizontal sense, to establish the appropriate product-mix, and, vertically, to determine forward and backward integration strategies. Similar analyses apply on a more aggregate level for the guidance of area-oriented and sectorwise structural developments. In the further aggregation beyond national structures, four broad groups of application patterns seem to emerge in the industrialization process of the developing countries as focal points for the deployment of industrial technology, namely:

(a) materials-resources oriented application patterns
(b) employment oriented application patterns
(c) demand or market oriented application patterns
(d) living environment oriented application patterns

Within each group a rich variety of technology-applications can be distinguished, which evolves towards further enrichment parallel with the progress of industry itself.

20. Of particular importance is also the progress made in understanding the process of innovation; because innovation is a basic characteristic of technology, perceivable in all strata of the industrialization process. Actually, industrialization as a whole is to the developing world an innovative process of a very high order. Starting with the inflow of foreign technology, a diffusion of its innovative effects takes subsequently place, which will ultimately have to result in a modernized society, in which technology has become an integral part. This flowcycle takes place as a constant interaction with the technologically more advanced world, and insight in the diffusion process is a critical element in guiding the dynamics of these developments. Findings of a national commission*) may in this connection be quoted, indicating that in the United States during the first half of this century a shortening of the average incubationperiod for new techno-

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*) ref. National Commission on Technology, Automation and Economic Progress, Washington, D.C., U.S.A.

logical developments occurred from thirty to nine years. A japanese study*) appraising the effectiveness of the introduction of imported technology noted, that prior to 1900 more than a quarter of the imported technological innovations required more than ten years before their industrial applications were realized. In the decade following the second world war, this proportion has been reduced to less than five percent, and from 1955 onwards practically all imported innovations found application within one year after its introduction. Effective incorporation of external technological innovations has also been a major factor contributing to the postwar reconstruction of West-German industry. Furthermore, in order to ensure the effectiveness of their innovative capabilities, the smaller West-European countries rank foremost in the deployment of scientific and engineering personnel in specialized fields.

21. Insight in the implications of uncertainty-factors for policy-formulation, decision-making and control is another area from which a further useful refinement of methodologies have evolved. Their integration with technological concepts can be found in technological forecasting methods, by which the viability and evolution of technologies can be appraised, permitting also a more discriminate approach to the selection and deployment of technologies. These new methods and insights are of vital significance for developing a technology development strategy aimed at reaching the industrialization aims in the shortest possible time. Past experience in the industrialized countries have, as indicated earlier, shown, that a halving is possible of the overall duration to reach industrial maturity. With the new insights a further substantial shortening seems well feasible.

VI. AREAS OF INDUSTRIAL TECHNOLOGY POLICY

22. The role of technology in the development process as outlined in the first two chapters has been elaborated in the subsequent text with respect to heavy and light inudstry development and to policies aiming at geographic dispersal of industrial activity and towards generating benefits of improved livelihood to all sectos of society. Methodologically, an evolution is sought by which the various

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*) ref. Science and Technology Planning Agency. Tokyo, Japan

functional considerations affecting technology planning will find an integration with sectorwise and regional industrial development approaches.

23. To the industrialization process, technology is the core-element from which productive capabilities are generated essential to the modernization of the economy and society of the developing world. Outlining this function in the perspective of a longer term development framework is therefore a major cornerstone for establishing policy measures required to guide the process of technology transfer, absorption, diffusion and adaptation, and the fostering of national innovative capabilities.

24. On shorter term, i.e. for periods corresponding with the nultiyear development cycle adopted for national planning, technology development would require, that a number of specific policy measures are evolved. Relevant to the particular stage of development, this set of policy measures would have

(a) to specify the emphasis to be given to heavy and light industries respectively;
(b) to identify basic industry sectors and the approach to be adopted for related technology development;
(c) to enumerate specific measures for encouraging light-industry oriented technological development, and particularly for the small enterprise sector;
(d) to outline a location-oriented approach enumerating desired technology concentrations and dispersal patterns;
(e) to direct special efforts towards providing technological means meeting the development needs of population groups living at subsistence level;
(f) to provide in a comprehensive manner for the development of technical and scientific personnel and of the institutional structure in the various fields of industrial technology;
(g) to outline measures for international cooperation.

A relatively long gestation period is needed to evolve mature technological capabilities. To this growth process continuity and consistent policy-orientation is of great value. In the short term programmes an incorproation is needed of distinct linkages to the longer term perspectives.

Annex I

Annotation on the Country Data illustrating the Relationship between Scientific and Engineering Personnel and the Growth of Manufacturing Industries in Developing Countries

The sample data illustrating the relationship between scientific and engineering personnel and the growth of manufacturing industry relate to developing countries with more than ten million inhabitants, and for which comparable data are available. A summary of these data is contained in table I.

The sample covers 14 countries. Measured in terms of contribution of the manufacturing industry to the gross domestic product, the degree of industrialization varies from 6 to 28 percent. The corresponding levels of per capita income ranged from US $ 115 upto US $ 1875. Although the criteria overlap each other to a certain extent, three subgroups can be distinguished :

- countries with 6 to 11 percent share of manufacturing industry to GDP, and [illegible] per capita income levels upto US $ 200.-
- countries with a share of manufacturing industry to GDP upto 18 percent and/or per capita incomes in the range upto US $ 650.-
- countries with manufacturing industries contributing to GDP more than 18 %, and per capita incomes extending upto US $ 2000.-

The number of scientists and engineers per 100 000 inhabitants ranges in the sample from a level of about 30 upto 1550. It should, however, be noted, that the term scientists and engineers include graduates of third level education in all types of sciences. For about seventy percent of the sample the number of persons with natural sciences and engineering as basic disciplines could be estimated; resulting in an overall proportion slightly below fifty percent.

Table I - Country Data on

Share of Manufacturing Industry in GDP and Number of Scientists and Engineers

country	baseyear	population million p. (1)	per capita income (US$) (2)	mfg.contr. to GDP (%) (2)	scientists & engineers	
					persons 3)	pers. per 100 000 inh.
Argentina	1974	25.1	1 875	28	390 000	1 554
Bangla Desh	1973	73.2	115	6	23 500	32
Brazil	1970	92.5	1 190	19	541 330	585
Burma	1975	30.2	115	11	18 500	61
Iran	1972	30.6	620	14	127 795	418
Iraq	1972	10.1	420	9	63 645	630
Kenya	1972	12.1	155	11	3 955	33
Korea, Rep. of	1975	35.3	495	28	460 055	1 303
Nigeria	1970	55.1	130	6	19 855	36
Pakistan	1973	66.2	122	14	111 000	168
Peru	1974	15.2	470	23	84 925	559
Sri Lanka	1973	13.1	190	10	6 845	52
Sudan	1971	16.1	150	9	13 790	86
Thailand	1975	41.9	320	18	20 290	48

Sources : 1) U.N. Demographic Yearbook
2) U.N. Yearbook of National Account Statistics
3) UNESCO Statistical Yearbook

ESTIMATES OF THE DEMOGRAPHIC PATTERN IN DEVELOPING COUNTRIES

developing countries in	total popul. in sample		urban population (%)		rural population (%)	
	million pers	%	range	average	total	of which low-income groups
Latin America	285	100	35 - 75	50	50	8
Asia	935	100	8 - 50	25	75	30
Selected countries in S-Europe, M-East and N-Africa	145	100	35 - 45	40	60	..
Africa	185	100	6 - 35	10	90	34
total sample	1550	100	6 - 75	30	70	26

Sources and annotation : U.N.Demographic Yearbook, and IBRD Sector Policy Paper on Rural Development. The sample comprises approximately 75 % of the total population in the developing world in 1970/71. To allow for statistical contingencies and urbanization tendencies, the data are presented in rounded off form. The term lowincome groups relate to per capita incomes reflecting living at mere subsistence level.

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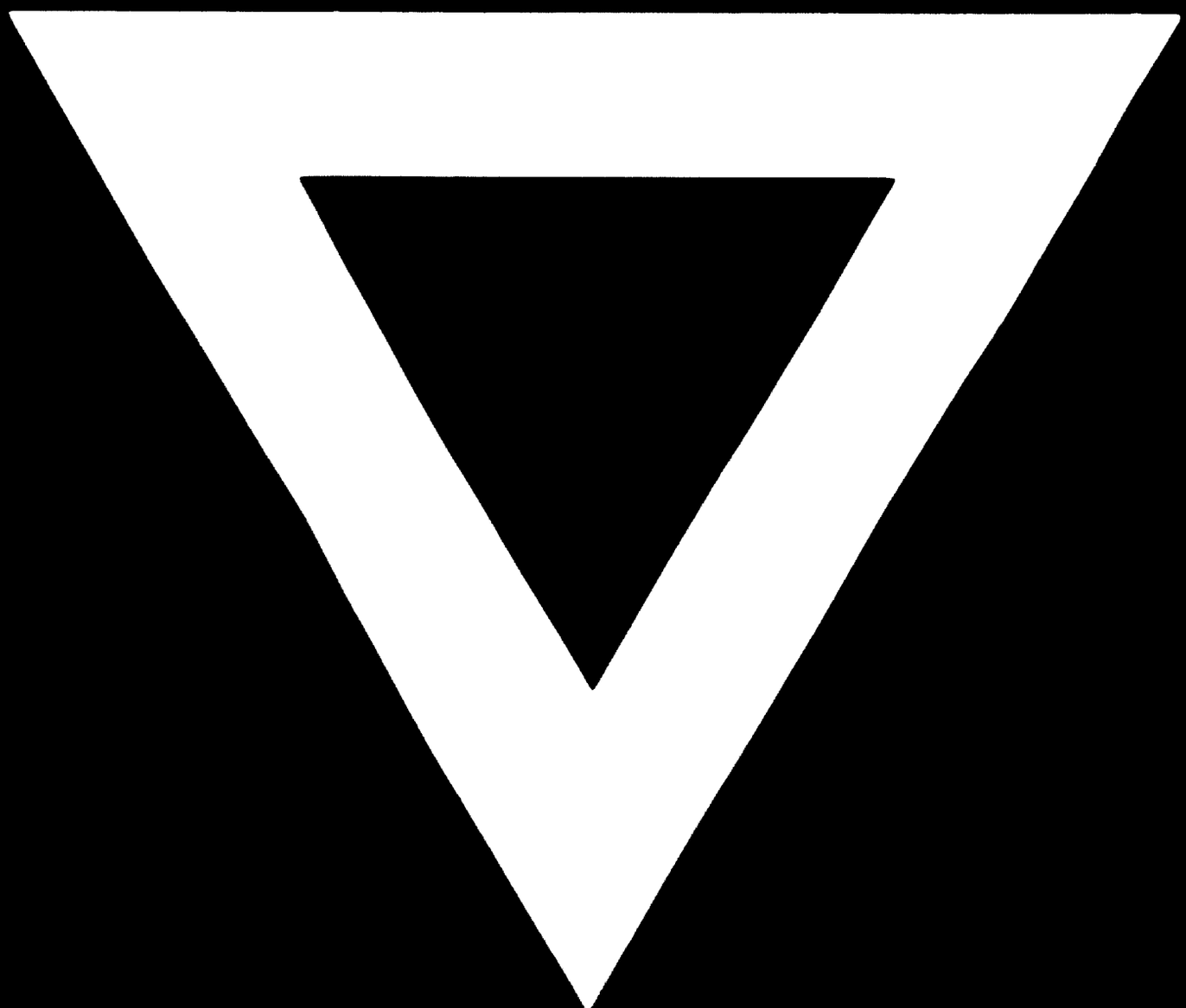

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