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

This document has been produced without formal United Nations editing. The designations employed and the presentation of the material in this document do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations Industrial Development Organization (UNIDO) concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries, or its economic system or degree of development. Designations such as "developed", "industrialized" and "developing" are intended for statistical convenience and do not necessarily express a judgment about the stage reached by a particular country or area in the development process. Mention of firm names or commercial products does not constitute an endorsement by UNIDO.

FAIR USE POLICY

Any part of this publication may be quoted and referenced for educational and research purposes without additional permission from UNIDO. However, those who make use of quoting and referencing this publication are requested to follow the Fair Use Policy of giving due credit to UNIDO.

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

We regret that some of the pages in the microfiche copy of this report may not be up to the proper legibility standards, even though the best possible copy was used for preparing the master fiche

08948

Distr.
LIMITED

ID/WG.301/2
1 June 1979

ENGLISH

United Nations Industrial Development Organization

Expert Group Meeting on Technology Development and Self-Reliance in Developing Countries

Vienna, Austria, 18 - 23 June 1979

THE STRUCTURE AND FUNCTIONING OF TECHNOLOGY SYSTEMS IN DEVELOPING COUNTRIES*

by

O.A. El-K[illegible]oly**

* The views 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.

** Assistant Director General for Science and Technology, The Arab Educational, Cultural and Scientific Organisation (ALECSO), Cairo, Arab Republic of Egypt.

id.79-4827

C O N T E N T S

==========

INTRODUCTION

1. A major debate on development has been gathering momentum on an international scale over the last few years, questioning both ends and means. Technology figures prominently in all the discussions. Preparations for the forthcoming United Nations Conference on Science and Technology (UNCSTD) have intensified the debate and focused attention on many important issues. Discussion of the role of technology in development, while proceeding in a variety of directions, seems to have taken place mainly on two levels. The first, which is essentially socio-economic, with political overtones, addresses itself to the formulation of development policies (including by definition technology policies). The second drops rather precipitately to consideration of programmes on an almost purely "technical" level and in a fragmented manner. Discussion now focuses on specific practical problems, while remedies are sometimes proposed without proper consideration of the context within which the proposed action will take place. It is not surprising that programmes are not always successful. Their impact on the isolated problems they address themselves to has been minimal. The multitude of such "micro" actions - conceived and implemented within a narrow perspective - has failed to produce significant changes.

2. This report is a preliminary attempt at ordering the "technology" problematique within a clear conceptual framework

and to reveal some of the "grey" areas considered responsible for the lack of continuity in thought and action. It is hoped that such a framework will be recognised and agreed upon. Programmes - both at the national and international levels - would then be considered within it. Priorities would be established on a more solid and realistic basis, and prerequisites for actions will not be overlooked. Action would, hopefully, become more coherent and effective. Furthermore, it would be possible to check the multitude of actions against this model and to identify where emphasis has been laid so far, and where gaps have been left without appropriate action.

TECHNOLOGY SYSTEMS

3. It is generally conceded that "technology" is the engine of "development" and that industrial development is a key element in overall development. However, such rather glib statements have been of late the subject of close analysis and scrutiny. This has been brought about by the disappointing results of developmental effort in the "Third World" on the one hand, and the growing dissatisfaction with its outcome in the "Advanced World", on the other. Gradually, the social values, objectives, structure and dynamics are becoming more prominent in discussions of what used to be "technical" issues. The emphasis in the past has been on growth and on increasing the gross national product (GNP), mainly through establishing a strong industrial base with its concommitant paraphernalia of research institutions and trained manpower in scientific-

technological research. Experience has revealed, however, the failure of this approach, inspite some commendable achievements in certain sectors in some developing countries. We now speak of the "double gap", of the persistence of wide-spread poverty in developing countries, of disaffection of the young generation in the developed world, of "limits to growth" "outer limits" and of "global" problems.

4. The developing countries now realise that their efforts to create an "indigenous base", an "autonomous capacity" in technological matters, or any of the terms used to refer to a national technology system, have on the whole not been successful. In many developing countries, technology choices are still being made by alien expertise. They still lack the ability, or the opportunity, to make their own choices. The "appropriateness" of technology is now being closely examined in relation to economic, social and environmental objectives(1). This is, of course, a sweeping generalisation that applies with varying degrees of accuracy to the situations in Mexico, Burundi, India or Papua-New Guinea. The purpose of this part of the report is to try to clarify some fundamental issues relating to the structure and functioning of a technology system, particularly in the social and economic environment of a developing country.

---

(1) e.g. The International Forum an Appropriate Industrial Technology Organised by UNIDO in Delhi/Anand, India, 20-30, November, 1978.

5. The word "technology" is used here to mean the sum total of acquired knowledge and experience that is used for the production of goods and services, within a specific socio-economic system, to meet a social demand that defines the volume and types of these goods and services. Certain concepts implied in this simple and inclusive definition are worth underlining :-

5.1. We speak here of the sum total of knowledge and experience (information and know-how), rather than of the products (goods and services) of the application of this know-how. The latter are the products of technology and not the technology itself. The know-how of producing large steel castings could be used to produce a tank turret or a turbine impeller.

5.2. It is the social demand which decides the end product, and indirectly the choice, of a technology. This end product, could be fertilisers or cosmetics, buses or armoured personnel carriers. The first question to be asked is not "what technology?", but rather "technology for what ?".

5.3. This occurs within a socio-economic framework which fixes the human and material resources available for the application of a technology to produce the goods and services for which there is a social demand. This framework could well be a serious constraint on such operations in ways other than the limitation of resources. Social values and attitudes, established norms of behaviour and the education system are some examples of the ways in which the socio-economic framework affects the application of technology in a society.

6. Technological activity is thus seen as a social operation which involves several elements linked together in what we might call a "technology system" operating as part of a larger social system which imposes certain constraints on it. Fig.(1) is a graphical attempt at clarifying the manner in which the basic elements of the system are linked together, and interact with one another. The diagram eliminates a number of "secondary" components in an attempt to focus attention on some ideas considered essential to the argument, rather than denying their existence or relevance in other contexts.

7. There are at the commanding heights of the social pyramid the organs of national decision-making[(1)] that formulate the policies and strategies of development in society. These policies are in fact answers to questions such as "development for whom ?" and "by whom?". Such policies will clearly reflect the basic orientations of society as regards its internal social structure, stratification and relations, as well as its foreign relations both on the regional and international levels. The development policies define the overall objectives of development and the chosen paths for achieving them. A national development policy implies, by

(1) Including, hopefully, organs of popular participation in policy decisions.

definition, the existence of a technology policy which is an integral part of the national development policy. The difficulty, so far, in most developing countries has been that such a policy has been "implicit" rather than "explicit " - a phenomenon we shall address ourselves to later on.

6. It might be worthwhile here to draw attention to a peculiar gap, halfway between this level and the next ones and which seems to have received little attention so far. We refer here to technological strategies. This field - as the late Maximo Halty Carrere so aptly noted - has met in developing countries with "reactions varying from indifference, to incredulity, to benign neglect. Indifference from those who concentrate on economic policy and instruments; incredulity from those who dispose of the issue by establishing national research councils or institutes; and benign neglect from those who are content with dabbling in the field of "science and technology policy"[1]. Failure to examine carefully this crucial link between policies and plans in technological development is believed by the writer to be responsible for the failure of many technology plans in developing countries.

---

(1) Maximo Halty Carrere: "Technological Strategies for Developing Countries", IDRC Latin American Regional Office monograph, undated. The untimely death of Carrere last year has interrupted a very promising line of research.

9. Next comes the planning organs which draw up detailed plans for the fulfillment of national objectives as defined by development policies. It should be emphasised here that, in the present context, we do not refer only to the plans drawn up by the ministries, councils or committees of planning. We should also be concerned here with all the other plans drawn up outside these state organs. Every investor, no matter how small his investment is, and each entrepreneur (or group of entrepreneurs within any of the approved forms of association), all these are in some way or the other, planners of their own activities. They react, with enthusiasm or reluctance, to the development policy of their society and its general orientations. They all participate in satisfying the social demand for the goods and services that technology can provide, spur the technology system to create new technologies to satisfy new social demand, or - regrettably - to reate demand, hat is very often unnecessary or harmful, for the products of a technology.

10. The sum total of all this is a group of plans, "public" and "private", for the multitude of activities in a society. We are particularly concerned here with the activities of the three "operational" components of the technology system, viz :-

10.1. Scientific institutions: including esearch in universities and scientific research establishments or learned societies. They produce new knowledge about the world around us. This knowledge is, by definition, universal and free. It is the common heritage of mankind and is transferred, on the whole, freely and at no cost.

10.2. Technological institutions: such as R & D centres, pilot plants and test fields, consulting services, design centres, technological information systems, standardisation, testing and calibration facilities..etc. These could be said to "transform" scientific knowledge into technological "know how" capable of application in realistic situations with all the problems and constraints these situations bring about.

10.3. Production facilities: that apply technological "know how" (which is basically information), in combination with other material and human resources and within a particular organisational and managerial framework (a plant or a factory), to produce goods and services.

11. These three components are - or should be - closely linked in a viable technology system by strong feedback linkages that form closed loops for the effective exchange of experiences gained, the transmission of new demands for better performance and innovation, as well as the provision of better facilities for meeting these new demands. Such effective interaction, spurred by social demand, is the source of technological breakthroughs. Three specific points need to be underlined here:-

11.1. The three components (S,T,P) on which most arguments are usually concentrated are directly affected and completely under the control of the development policies and plans. It is these policies and plans which define, a priori, the role of each component and the magnitude of its contribution to the overall development effort.

11.2. It is not out of place here to emphasise once more the decisive role social demand for certain goods and services plays in defining the outputs of the national technology system, leaving that portion which it could not satisfy to be imported so as to reach full satisfaction of social demand.

11.3. It is generally recognised that the linkages between these three components in most developing societies are weak, ineffective, and sometimes non-existent,a point we shall dwell upon at length later on.

12. We finally add two more components of special significance in this context :

12.1. A major one, namely public and private sources of investments needed by social activities from national savings representing the difference between total output and consumption.

12.2. A sub-component of the services sector, namely the education and training establishments responsible for supplying society, and particularly the three operational components (S,T,P), with their needs of trained manpower.

13. The whole system operates within an overall constraining frame of an intellectual "climate", a system of social values, attitudes and norms of behaviour, as well as current legislation. The direct impact of this on policies, strategies and plans and in defining the composition of social demand as a result of a

chosen life style is obvious. What is sometimes overlooked is the indirect impact on the science and technology components of the system. For example, taxation laws, import controls (or their absence), customs duties (high or low), restrictions (or facilities) for the influx of foreign capital and labour, affect profoundly the performance of the S & T components. They constitute, in fact, an "implicit" science and technology policy.(1)

14. All societies interact with the outside world and receive a certain amount of foreign inputs. The magnitude of such inputs depends on the kind of national control exercised on these inputs and the "effectiveness" of the operational mechanisms exercising this control. We distinguish between two basic types of such inputs, viz. information and resources. Information flows in as one of two inputs :-

14.1. Ideas, values and life styles: Facing these and exercising control on their inflow and effects are the prevailing value system of society. This is not necessarily the "official" set expounded by state or political organs. We need not emphasise here the essential and decisive difference which could exist between these and the explicity, or implicitly, prevailing set of values. This is, in many cases, too flagrant to be ignored.

---

(1) IDRC's project on science and technology policy instruments provides ample and interesting examples of "implicit" science and technology policies from several countries in Latin America, the Middle East, southern Europe and Asia. See F.Sagasti's Main Comparative Report, IDRC-109e, 1978.

14.2. Scientific knowledge and technological "know-how": While the first usually flows freely without significant difficulties, the case with the latter is basically different. It is a commodity on the world market for which there is a booming market. Transfer of technology occurs, as has been amply demonstrated, within a framework of flagrant "asymmetry" between the buyers and sellers in this market(1). National control on technology transfer is exercised through legislation and monitoring systems.

The two main kind of resource inputs are :

14.3. Financing: This can drastically influence development planning, regardless of the nature of the source (international, multi-laterla, bi-lateral, governmental or private), through the conditions stipulated for, or conducive to, the inflow of such resources. This is an issue relating also to technology transfer, which is often considered an acceptable reason for foreign financial participation. The state exercises control on these resources through foreign investment laws and international agreements.

---

(1) UNIDO's Technological Information Exchange System (TIES) and the Industrial and Technological Information Bank (INTIB) are commendable examples of international effort to redress this asymmetry.

14.4. Goods and services: which include raw materials, semifinished products, capital and consumer goods and all forms of "software". National control on these inputs is exercised through import control legislation, custams duties, ..etc.

15. Technology systems in developing countries have proved so far to lack viability. We distinguish here three characteristics of a viable technology system :-

15.1. Ability to effect scientific and intellectual advances, as distinct from technological application.

15.2. Effective response to stimulation and programming of its activities. In recent decades, directed technological development on a large scale has become familiar. There exists a large degree of correlation between inputs of resources to a viable technology system and its output in the form of applicable new technologies.

15.3. Active participation in the international market for technology, whether as buyer or seller, and from a position of equality and relative strength. Its transactions are cost-effective and profitable.

16. It would be useful to look a little more closely at the manner in which the dynamism of a technology system makes it viable. This is seen(1) as the consequence of two mutually reinforcing spirals of change :-

---

(1) H.Cleveland and I.M. Abdel Rahman: Science, Technology and the Future, as yet unpublished study prepared for UNCSTD.

16.1. A "micro loop", (Fig.2), links together "know-how" with resources (capital, labour, productive facilities and marketing) to provide consumers with products they are ready to pay for. Reinvestment in more capital, benefits to workers, and especially R & D, generates innovation. Social organisations, linking these functions together controlling their operation, and safeguarding the interests of the various actors (entrepreneurs, workers, consumers), close the loop and keep it spinning peacefully.

16.2. At the macro level, there are hundreds and thousands of these micro loops, some spinning at a steady rate, some running down and some gathering momentum. Together, they form a certain level of technology, a value system and a set of social organisation and authority (public or private). Changes in level of technology, in values or in authority may well disturb the system. When a new state of equilibrium is achieved in an "advanced" society, it has so far been on a more sophisticated and complex level of technology. Development has been spiral, rather than circular.

17. Technology systems in developing countries do not exhibit such behaviour, neither on the "micro", nor on the "macro" levels. They usually suffer from some, or all, of the following basic shortcomings:-

17.1. Absence of some of the components of the system, or their ineffective operation. In developing countries emphasis is usually placed first on building-up production facilities with varying degrees of success. At the other end of the scale, it has been common practice, for reasons we need not go into here, to build up a so-called "scientific research" capability quite removed from the production facilities. Technological institutions seem to come last and are perhaps the most difficult to establish and to man effectively.

17.2. Absence of a well-defined technology policy that is an integral part of development policies. As noted earlier, (para.13), this does not mean that there are no "implicit" policies that have a direct effect on the operation of the technology system.

17.3. Weak or misguided control on foreign inputs, which have a profound effect on the performance of the technology system. Of particular significance here is the flood of publications, radio and television broadcasts and recordings pouring from foreign mass media into a country. Drastic changes in the value system and life style (and hence the nature of social demand) are brought about by this overwhelming influx. Such changes are - to say the least - not always desirable or properly timed.(1) Of more concern to us here is the inadequate control and monitoring of technology transfer transactions.

---

(1) The debate in the last General Assembly of UNESCO on freedom of communication is closely related to this issue.

This should not be interpreted as a plea for "isolationism" or "autarky". It is simply a call for level-headed, well-informed formulation of policies and properly-guided and sure-footed implementation of a policy. There is obviously no place for haphzard and hesitant handling of matters of vital importance, in a situation in which we are all groping for the establishment of a new international economic order.

17.4. "Inappropriate" value systems and norms of social behaviour and relations. We mention here as examples the attitude to manual (and intellectual?) labour, the predominance of family or tribal bonds, standards of discipline at work, the adoption of irrational and obscurantist attitudes in dealing with complex situations in real life, individualism (dictatorship ?) in decision-making, diluted public awareness of targets and of the responsibility of individuals or groups in their achievement.

17.5. Inadequate financing of the technology system. Advanced countries spend something like 2-4% of their GDP on science and technology. Developing countries spend 0.2-0.3 %, of their GDP, or about one tenth, in relative terms. This may come up to 100 times less, in absolute terms.

18. It is common practice these days to couple science with technology, even in common parlance. Although we realise that technology is as old as civilisation itself, yet we are keenly aware of the strong relation that now exists between the two.

We, quite rightly, appreciate the role science plays in technological innovation and of the continuously decreasing time lag between scientific discovery and technological application of such discoveries. This relation has taken a new turn of late in the industrialised countries. A report of the U.S. National Academy of Sciences refers to the fact that :

> "The most important invention in the pursuit of modern (as opposed to older) applied science is the big mission-oriented industrial or governmental laboratory. In fact modern science can hardly be discussed without reference to these homes of applicable science. These institutions derive their power from three sources: (1) their interdisciplinarity and the close interaction between basic research and application; (2) their methodology for precipitating and organizing coherent effort around big problems; (3) their ability to adapt their goals to the requirements of their sponsors[(1)]".

19. It is, however, a fact of life that such is certainly not the case in the developing world. The use of the phrase "science and technology" in such situations is in the writer's view responsible for a good deal of confused thinking and muddled action in developing countries. "Scientific" institutions mainly staffed by people with little experience in

---

(1) Hammond, R.P.: "Applied Science and Technological Progress". A Report the Committee on Science and Astronautics by the National Academy of Science, 1967.

technological practices, and in search for venues of active participation in the national development effort, are becoming more and more involved in "practical" problems with very little - if any - scientific content, and not proving particularly successful at solving them. Technological education, under the influence of developments taking place in the developed countries as well as certain internal social pressures, is becoming more concerned with theory, analysis and basic and applied science, rather than with technological practices and professional expertise. The term R & D is often used to describe activities or institutions in developing countries which could not possibly be classified as such in an industrialised society. The application of these terms and classifications developed for use in other environments is misleading and often leads to incogruous results (1).

20. As against the strong bond and interaction between S & T in an industrialised society and the massive flows of "know-how" from these two components to production, we find a situation in developing countries, fig. (3), characterised by :

20.1. A dichotomy (or at least absence of active interaction) (2) between the national scientific effort and the

---

(1) Z.Nasr, economic adviser of the Kuwait Fund of Arab Economic Development gives an interesting analysis of the problems of applying the classifications of UNESCO (based mainly on the OECD famous "Frascati Manual") on developing countries. "A Proposal for Establishing an 'Arab Fund for Scientific and Technological Development' ", unpublished report of KFAED, April, 1978.

(2) We refer here to relations that are cost-effective for the national economy and ignore formal tenuous relations based on rare examples of producing "achievements" that are not worth a fraction of the money spent on them.

technological base. Against this there are usually strong relations with foreign science. Part of this is healthy, necessary and inherent in the nature of science. However, it also means concern with the scientific problems of the "rich", imitation of foreign institutional organisation of science, recourse to training of scientists abroad, etc. This isolation of the national science community leads directly to "brain drain".

20.2. A small-sized national technology base. This is split into two almost separate parts. One is "modern" and the other "traditional". The modern segment (if it exists at all) is usually the weakest component in the whole technology system. In contrast with the national science base, it has minimal relations with foreign technological institutions. The traditional sector, representing the heritage of "know-how" acquired over centuries of activity in local conditions, is fast dwindling. Little effort is made to develop it through infusions of research to reveal the scientific core of the wisdom of generations of practitioners.

20.3. Finally, a rift between the technology and production components. The latter[1] relies almost entirely on the importation of technological "know-how" (technology

(1) We refer here to "modern" production facilities. "Traditional" production seems to have disappeared almost completely in the industrial sector in most developing countries.

transfer , either as informa ion (software) or embodied in the form of hardware and semi-finished products. It is worthwhile to note here that sometimes the achievements of the indigenous S&T effort flow "up" to industrial society, only to return - as economically viable technologies - to their country of origin(1); but at a price.

21. The sum total of all this is a situation in which the micro loops of technological development are not spinning, while the cycle of development, on the macro level, is "circular" rather than "spiral" (para.16). Behind this failure to achieve self-reliance, equity and growth, lies the absence of an autonomous capacity to :

21.1. Formulate policies, draft and implement national plans (ordering national priorities - mobilising resources consensu and conviction).

21.2. Make appropriate technological choices (exercise well-informaed social control over technology).

21.3. Change and adapt imported technology (based on systematic analysis of national as well as foreign experiences).

21.4. Exploit effectively (judged by socio-economic criteria) the imported technologies.

21.5. Innovate and deal effectively, whether as buyer or seller, in the world technology market to the economic advantage of the country.

---

(1) e.g. The BMA Cane Diffusion, Egyptian Process.

21.6. Maintain the national cultural identity while dealing with the outside world.

We are concerned here with building up an autonomous capacity in technological matters, since this is fundamental to the fulfilment of self-reliance in any sense we choose for the term.

TECHNOLOGICAL STRATEGIES FOR DEVELOPING COUNTRIES

22. The issue we now address ourselves to is how do we go about the task of creating, or enchancing, an autonomous technological capacity ?, i.e. end up with a viable technology system as characterised before (para.15). We assume here that questions relating to policy, i.e. the definition of goals and objectives have been answered and that our concern now is to define a strategy for implementation. The argument now proceeds whatever the goals set, the life style chosen, or the prevailing value system, even though the practical outcome will be pre-conditioned by them. We are now searching for a definition of major options and directions of action for bringing about the desired technological change. The questions we are now seeking to answer are of the type: where to act ? (direction), what actions to take ? (type), and to what expent ? (intensity), in order that self-reliant technological development is brought about. We are dealing now with the dynamics of transforming the weak, dismembered and ineffective technology system into a viable one. This involves balancing various conflicting requirements and taking decisions on the choice of a major option in compliance with the soci-economic criteria adopted for overall development.

23. It is important to underline here the fact that decisions of this nature are not taken at the level of the operational technology components (S.T.P. in Fig.1) themselves,

nor is this done at the higher level of the planning organs. Such strategic decisions are the prerogrative and responsibility of the top level authority in development planning, hopefully close to the policy decision-makers. It is the author's belief - based mainly on his knowledge and experience of developing countries in the Arab Region and Africa - that this vital link is missing - both on the level of professional expertise and the acquisition of knowledge, as well as on the organisational level and providing the decision-maker at the very top with any form of analysis or tentative answers as pre-requisites for a well-informed policy decision.

24. It is a fact of contemporary life in developing countries that development has to rely on substantial imports of technology. Most attempts at grappling with the problem of technology transfer seem to go through a stereotyped sequence of "implicit"(1) strategies, each stage being - more or less - a reaction to the previous one :-

24.1. There is usually a preliminary phase of haphzard importation of foreian technology reflecting an almost non-existent capacity for technological choice, coupled with a strong drive for development.

24.2. Next comes a more ordered, but still not-too-selective phase, reflecting the acquisition of limited experience

(1) In the sense that they reflect hindsight rather than a premeditated line of action.

in technology transactions, as well as exploitation of the imported technology.

24.3. Accumulation of bitter experiences and failures leads, in many cases, to a third phase of protectionism and restrictions, which are usually carried to extremes that are self-defeating.

24.4. This is usually followed - again by way of extreme reaction - by a relaxation of controls and an increased flow of foreign inputs.

25. This "wobbly" path in dealing with foreign technology is mainly due to the failure of the indigenous technological capacity to participate in the process of technological development, as can be seen in Fig.(4) :-

25.1. Initially, at the early stages of industrialisation, the need for substantial foreign inputs (software, hardware and even resources) leads to low (or no) demand for the services of the embryonic (or non-existent) S & T system, to its neglect and marginalisation.

25.2. As industrialisation picks up momentum, the need for foreign inputs continues to increases.

25.3. This leads, in turn, to further weakening and marginalisation of the S & T components in the indigenous technology system(1) and again to more foreign inputs. The

(1) By now, some attempt is usually made at building up these components, but their isolation from the P-component remains due to weak social demand.

"circular" path of technological change is thus closed.

In this way, the two next phases of healthy development, namely that of orderly selective control of foreign inputs, and finally that of technological "diplomacy" are never reached.

26. The core problem of a technology strategy for self-reliance is to strike a balance between foreign inputs and inputs from the indigenous S & T components in a viable technology system that breaks this vicious circle of increasing technological dependence and replaces it by a development "spiral" on the macro level (para 14.2). This is a task that involves :-

26.1. Regulating the flow of technological foreign inputs which pour mainly into the P-component. This includes better information on available alternative sources and supplies, adequate criteria for the selection of appropriate technologies and improved negotiating and contractual procedures.

26.2. "Unpackaging" foreign technology and gradually increasing the share of the indigenous system, i.e. strengthening the T-component and increasing the share of the P-component in the total package. It is also likely, at least in some cases, that the S-component might become involved. It should be mentioned here, however, that analysis of the strategies adopted by some countries in the "imitative" phase of technological development shows that significant changes can be brought about with very little national R & D.

26.3. Increasing demand for the services of the S&T components of the system, i.e. removing the barrier between them and the P-component (Fig. 3).

The basic problem is clearly two-fold and involves linking the system components effectively and regulating foreign inputs wisely. The question now is how does any strategy bring about these desirable changes.

27. This is not the place for a review of the state of the art of formulating technological strategies. Suffice it to state here that analysis of experiences from a variety of political and social systems seems to indicate that similar strategies can be adopted by different socio-political systems[1]. The appropriate strategy, as might have been expected, is mainly related t the stage of techn logical develc ment reached by the country rather than to the political orientation and social organisation. The choice of a technological strategy for developing countries is governed by three sets of constraints:-

27.1. International: and inherent in the prevailing international economic system and the resulting world trade pattern and international division of labour, as well as the crucial role played by foreign investments (particularly TNC's) and international financing practices.

---

(1) M.H. Carrere: op.cit.

27.2. National: resulting from the "dualism" of the economy and the predominance of the modern sector which usually adopts an import substitution strategy in industrialisation favouring foreign technological inputs.

27.3. Structural: due to the weakness and isolation of the S & T components discussed above (paras.17 and 20).

28. Since a technology strategy depends on the stage of development, we would expect that strategies will change continuously as a country develops. Furthermore, considerations of the size of the national economy and the resource endowment (both material and human) are bound to affect the choice of strategy. However, we may present here some very general guidelines indicating main courses of action within the framework of the constraints outlined :-

28.1. The international constraints call for some form of protectionist action. In fact, the control of foreign technological inputs is a crucial element in any strategy under the conditions now prevailing on the international scene. Needless to say that this "dangerous" tool (para. 24,3) has to be handled selectively with the final aim of achieving liberalisation under conditions of a suitable blend between foreign and indigenous technologies.

28.2. The national constraints call for action in two directions. The modern and traditional sectors in the T & P components should be linked together technologically, economically and socially, by active exchange of semi-finished and finished products. On the other hand, industrial development strategies have to be reviewed and harmonised with technological strategies.

28.3. The structural constraints should be attacked directly through deliberate action, such as greatly increased spending aimed at effecting the missing linkages, stimulation of the capabilities and the demand for the services of the indigenous technology system.

29. Through combinations of deliberate stimulation and sensible protectionism, and acting selectively (concentrating on certain sectors or components) an evolutionary process would be set in motion. A dynamic approach involves a series of actions suited to the stage of development reached, in a sequence that would lead the country through the " imitative" and "defensive" stages to that of parity and symmetry on the international level.

30. To sum up, technological strategies should ensure the establishment of a dynamic integrated technology system, both at the micro - and macro-levels,that ensures the effective contribution of technology to development. Technology will be living, growing and effective in a country when the components of the technology system generate dynamic, integrated and cyclic micro loops in harmony with the cultural identity, development objectives, value system, structures of public and private authority and characteristics of the productive sector, i.e. in macro dynamic equilibrium (para. 16.2). In each case, locally-generated, as well as imported technology will be needed

in a blend that stimulates development. Diverse technologies will have to be used simultaneously, ranging from revived traditional techniques to the most modern and sophisticated technologies, according to the type of production and market conditions. The phased strategy for bringing about the desired pattern of development will have to take into consideration the constraints of on ever-changing national, regional, and international scene.

31. The field of analysis and formulation of appropriate technological strategies for developing countries is one that merits a concentrated effort so that the gap between policies and plans is bridged and in order that national targets stand a better chance of being achieved. There are still many outstanding problems seeking a solution. We have alluded in passing (para. 28) to considerations relating to the size of the economy and the resource endowment and might add here also the role regional action could play in certain cases. The author hopes that UNIDO will take up this issue and initiate a comprehensive action programme in this vital field.

SELECTION, ADAPTATION AND INNOVATION

32. It was stated before (para. 26) that the core problem of a technology strategy for self-reliance is two-fold. It involves, on the one hand, managing foreign inputs, and stimulating indigenous supplies of technology, on the other. The first task implies a well-developed capacity to choose from a variety of available inputs and - since none would have been usually tailored to the needs and conditions in the country - to adapt the imported technology and its products to ensure that it operates effectively in its new environment. The second task, viz. the stimulation of indigenous technology supplies, means a capacity to innovate. Innovation here implies a good deal more than the bright idea and the working model on the scale of the "scientific toy" or show piece. It implies the ability to complete in the market place (national or international) with existing technologies and products and be economically attractive. It involves all three operational components of the technology system and involves also the two functions of selection and adaptation.

33. Fig. (5) is a rough outline of the sequence of main activities involved in the process of technology

selection and adaptation. There are three decisive inputs in this sequence, viz. information, criteria for selection and legal and contractual practices. Each one of these has been the subject of concern, discussion and action on the national, regional and international levels. There is, however, a growing feeling among most developing countries that the total impact of activity at the various levels on the actual practice and outcome of technology transfer has so far been undecisive. While recognising that the main cause for this unsatisfactory state of affairs is the prevailing international economic order, it is still true to say that a good deal has yet to be done to ensure that optimum use and maximum benefit is made of available knowledge and resources. There is, generally speaking a failure in delivery systems which leaves the final beneficiary of such activities, especially on the national level, and who is responsible for technology selection and adaptation, either uninformed, unimpressed, or even hostile. This is a situation which is not unrelated to the marginalisation and dismemberment of some components of the technology system and its vulnerability to the onslaught of well-coordinated compaigns of introducing particular foregin technology inputs at a particular time.

34. UNIDO has been particularly concerned with problems of industrial information, in theory and in practice. Its on-going activities have been developing continuously. The "Development

and Transfer of Technology Series", heralding the establishment of INTIB as an on-going activity, and even the system of consultations, are two recent and welcome additions to its other activities in this field. It is generally conceded that the best means of dissemination of information is by national technological information services. These must be demand-oriented and effectively coordinated in some form of network involving the sources of information. It is the author's view that we are still searching for a model of a "poor man's" information service that will prove to be adequate, as well as cost-effective in the environment of most developing countries. The role of the communicator of information is a crucial one and should - if carried out in an active mode that seeks contact with the end user rather than respond to his queries - be far more critical to the efficacy of the information service than the huge and sophisticated data banks in "advanced" countries and in international organisations. The demand for information in a developing environment is most likely to change fairly rapidly and to be very diffuse in its scope. The information supplied should be digested and available at a level matching the expertise of the user. Only an experienced information officer who is a professional technologist and a good communicator can face this challenge. This is a very rare breed that will take time and effort to develop.

35. As regards selection, one should mention here the important role "UNIDO Guideslines for Project Evaluation" has played in most developing countries. It has established

itself as a basic and widely-used manual. This is now strongly supported by the outcome of the "International Forum on Appropriate Industrial Technology". The final report of the Forum specifies in detail action programmes, at the national and international levels, in a number of key sectors. We may now look forward to a consolidated approach to the problems of evaluation and selection based on a clear definition of "appropriateness", workable methodologies for selection and sufficient information on local conditions and the outside world. It is felt, however, that environmental considerations have yet to be integrated in the methodologies and practices of selection and that they will not be simply equated with pollution to the exclusion of other vital factors in the environmental package. One might also add that the selection technique should take fully into consideration the technology strategy pursued by the country, since this could have a considerable impact on technology choice, specially in a long-term perspective. Finally, the organisational problem of fitting the technology selection activity in the system has yet be solved satisfactorily in many cases, particularly in transactions involving the private sector. Experience should be analysed and the lessons learnt disseminated as widely as possible.

36. The issues involved in negotiating technology deals have also been the subject of considerable action, particularly by UNCTAD, and should now be clear to negotiators from developing countries. A code of conduct will hopefully be agreed upon in one form or the other. However, the acquisition of skill and

experience in negotiations tak s time and is ritically dependent on supplying the negotiator with reliable and up-to-date information. UNIDO's Technological Information Exchange System (TIES) is most welcome here and it is gratifying to note that it is expanding rapidly.

37. We shall delay discussion of the problem of adaptation and address ourselves to innovation (Fig.6). Scientific research institutions in developing countries are quite capable - inspite of all the problems they face - of producing scientific ideas that are potentially of value if properly developed and exploited. In most cases, the technology system is incapable of bridging the gaps between the laboratory, the factory and the market place. The main reason for this is the weakness - or absence - of the T-component in the system and the perennial problem of marginalisation. The crucial stage here is that of engineering treatment of a new idea. Here past experience, coupled with economic study and market research, transforms the scientific idea or discovery into a techno-economic reality that can be put through the mill of industrial exploitation and production. This type of activity requires skills that are neither those of the scientist, nor the production engineer- the two breads likely to exist in a developing society. This situation is also related to ability to adapt imported technology and products to local conditions, since the skills and activities involved are basically the same. In fact, the author believes that national participation in the adaptation of imported technology is the best way of building an indigenous capacity for linking up the S - and T-components in the technology

system. It should, however, be remembered that innovation is not the prerogative of the scientist. The practitioner at any level (particularly at the shop floor level) as well as the end user are sources of significant innovative ideas of considerable potential. The great advantage of these ideas is that they often reflect first hand experience and deep insight into the actual needs of the user. They are often capable of producing working models; but considerable engineering effort is needed to transform the basically-sound concepts into an economic reality.

38. Our attention is now focused on the indigenous capabilities in the engineering and design field within the F -component. It is worthwhile noting here that while developing countries have had no great difficulty in fostering scientific research establishments and in allocating funds for them, they have been rather lukewarm or shy in supporting technological institutions, and this at a time when they were actively engaged in intensive industrialisation programmes. Until quite recently, they spoke of science policies and plans and addressed themselves to the foreign and international organs responsible for science, rather than technology. The word technology has crept in almost surreptitiously and is - in many cases - no more than a fashionable addition. In the few cases where the progress of industrialisation has brought about some interest in building technological institutions, these - in common with their sisters in science - have not left much impact, nor have they been cost-effective. Apart from the general

diagnosis offered in this report for such symptoms, it should be remembered here that design and engineering organisations usually specialise in certain sectors of industry, while the majority of efforts in institution-building in countries at a rather early stage of industrilisation have been addressed to the setting up of general purpose design and engineering institutions which were unable to give specialised advice in specific sectors. In the meantime, and almost independently of government action, most developing countries have now national private consultancy and design offices in architecture and structural engineering work that are actively involved in the construction industry.

39. The functions of consultancy services in industry have been classified[1] as :

39.1. Design and engineering services: in the planning and implementation of projects, i.e. from concept to commissioning.

39.2. Adaptation services: comprising process and product changes, the utilisation of local raw materials ...etc.

39.3. Economic services: involving economic planning, market studies and financial analysis ...etc.

39.4. Management services: covering the multitude of controls for administration production, finance, marketing and personnel, ..etc.

39.5. Training and manpower development.

---

(1) UNIDO: Manual on the Use of Consultants in Developing Countries.

Experienc: with foreign cons itants has rev aled - apart from its negative effect on building an indigenous capability - certain basic problems, e.g. their unfamiliarity with local conditions, insensitivity to national aspirations and objectives and the difficulties of retrieving vital information which exists but is not systematically classified and stored. The outcome has been the choice of inappropriate technologies, low utilisation of local resources and skills, higher investments and increased running costs, as well as little, or no transfer, of "know-how" to the country.

40. Since this is basically a transfer of skills, it has to be admitted that the existence of an indigenous technological base of a minimum size and level of expertise is essential if transfer of "know-how" is to take place. Developing countries fall into th ee distinct groups n this respect :

40.1 That in which this base does not exist as yet and where foreign consultants (contractors and even operators and managers) carry out all the processes involved. Such countries lack also an indigenous capability of keeping track of the activities of the consultants, let alone evaluating or influencing their actions.

40.2 A second group still relies heavily on foreign consultants; but possesses a "nucleus" of indigenous expertise capable of defining objectives and assessing performance - usually with the help of expertise from other states who are a little further ahead in their development, or from regional or international specialised agencies.

40.3 Finally, comes the group of countries possessing sizable, but incomplete, consultation potential. This is either a publicly - owned organisation, or government department, or an independent private firm.

41. National involvement in consulting work naturally depends on the size and capabilities of this base. Careful fostering and development of the existing potential is reflected almost immediately in the extent of "unpackaging" of imported technology and the idenfification of an ever-increasing role for the indigenous technology system in the various stages of study, design, fabrication, erection, commissioning, management and adaptation - without, of course, jeopardising the safety or economics of the project. It should be a major consideration in technology strategies and might perhaps take precedence on efforts exerted so far in building a so-called R&D capability (para. 19). It will also result - if local consultants are kept well informed of developments on the international arena - in improved selection procedures, based on better knowledge of local conditions.

42. Of course, this is all much easier said than done, for it runs up against considerable obstacles. There is the lack of credibility, the fierce competition from fóreign well-established consulting firms, the shortage of suitable personnel, of information and the long gestation period needed to attain an effective and reliable level of performance. Various methods can be tried to overcome these difficulties. The main courses of action are :-

42.1 Joint ventures with foreign consultants. This could be a very effective method of rapid development, provided that the national elements are actively involved and that the final aim is to have an independent national consultancy service. Cooperation with foreign partners from the newly industrialised countries (NIC's) should have priority as they will be more sensitive to local conditions, material and social.

42.2 In certain sectors, where considerable experience in project design and implementation has accumulated in the government departments concerned, these have been developed by the active support of the state into independent consulting firms of considerable size and ability.[1] The economicsof such organisations could, however, be a problem if a continuous demand on their services cannot be guaranteed.

42.3 A recent trend has been the creation of regional, rather than national, consulting firms. This ensures the attainment of a "critical" size of expertise and multidisciplinarity, better knowledge of local conditions and more secure work loads that provide a good opportunity for consolidation and rapid expansion.

Whatever the method we choose for fostering indigenous consultancy services, the effort should be selective and directed to specific services in consultancy or in specific sectors according to the demand of the economy.

---

(1) In Egypt today there is - apart from a large architectural state-owned firm- publicly-owned consulting firms in most public services, in the iron and steel and cement industries.

43. A strong consultancy capability has important economic advantages. In the short-run, it would reduce the cost of foreign technological inputs (know-how and hardware), improve negotiating skills and position and initiate work on adaptation of imported technologies. In the long-run it ensures, through better linkages between the S,T,P components of the technology system, an increasing capacity to unpackage and alter the"technology-mix" in favour of indigenous technology. The author hopes that this will be considered as a plea for giving this capability more attention and for redressing the balance between it and the "R & D" establishments which have so far had to lion's share in efforts to create an autonomous capacity in science and technology. It should figure prominently in technology strategies aimed at creating a viable technology system in which micro loops are spinning and the macro spiral of harmonious development leads to increasing technological complexity, sophistication and self-reliance.

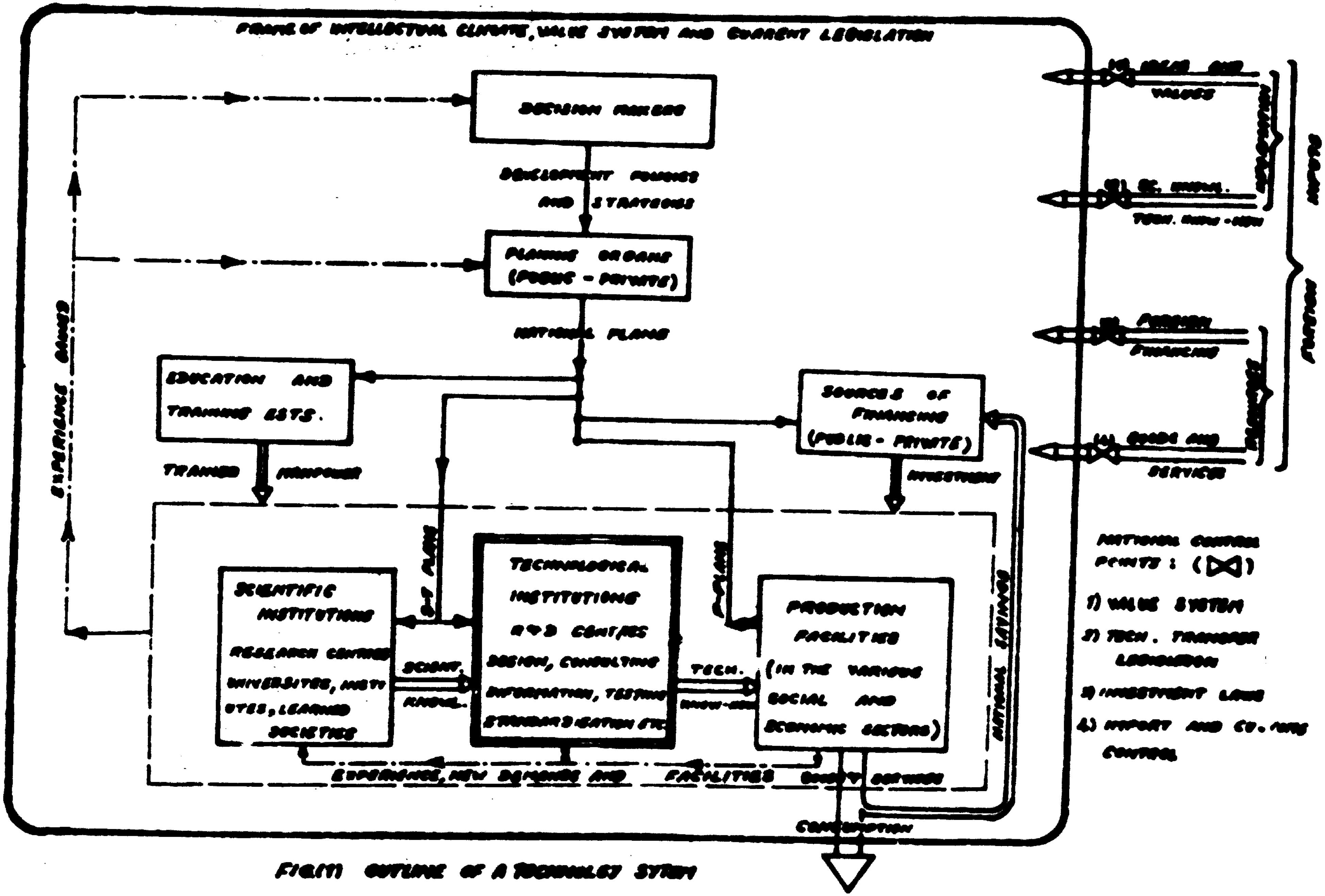

FIG.(11) OUTLINE OF A TECHNOLOGY SYSTEM

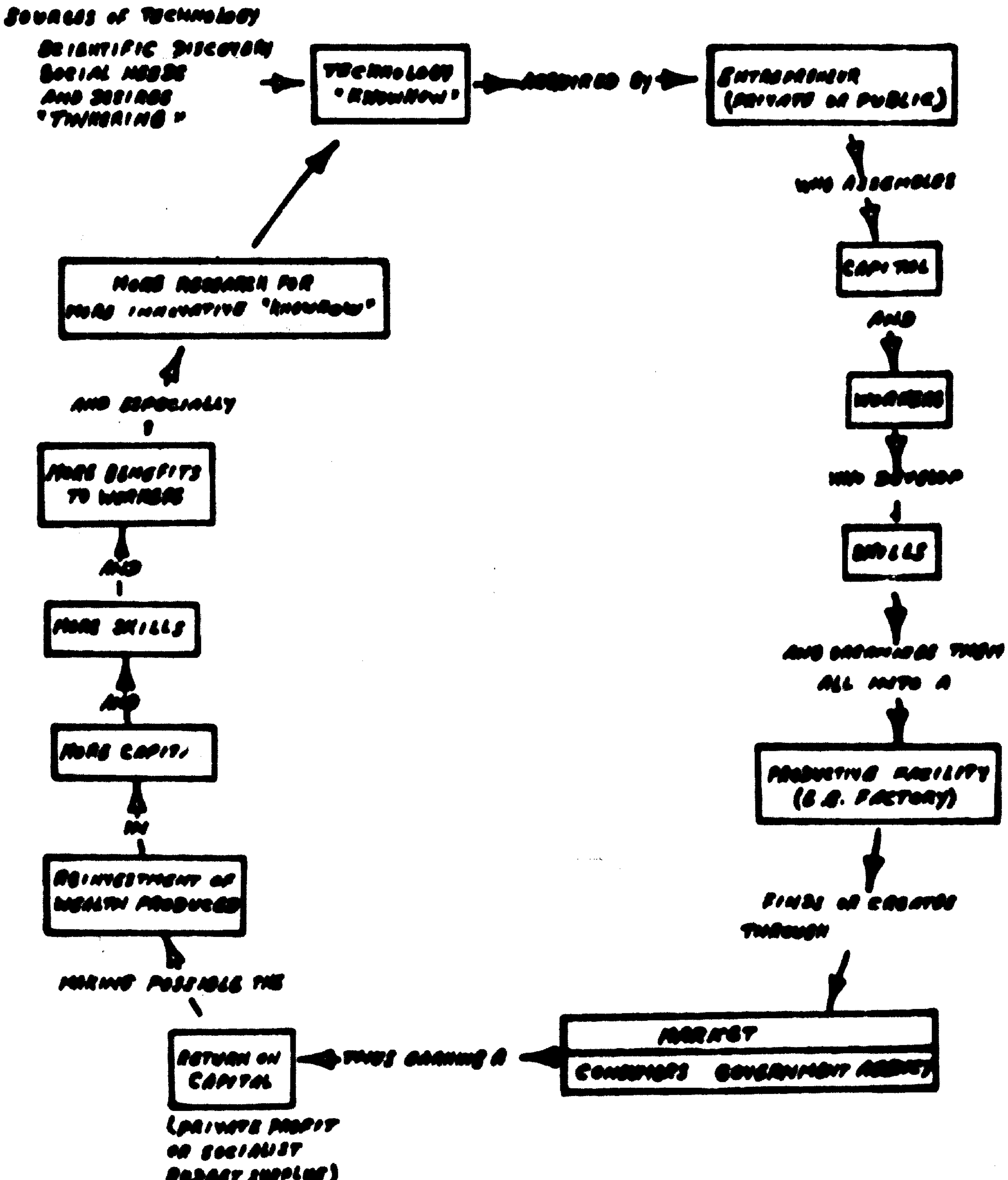

FIG (2) TECHNOLOGY "MICRO LOOP"
(AFTER CLEVELAND & ABDEL RAHMAN)

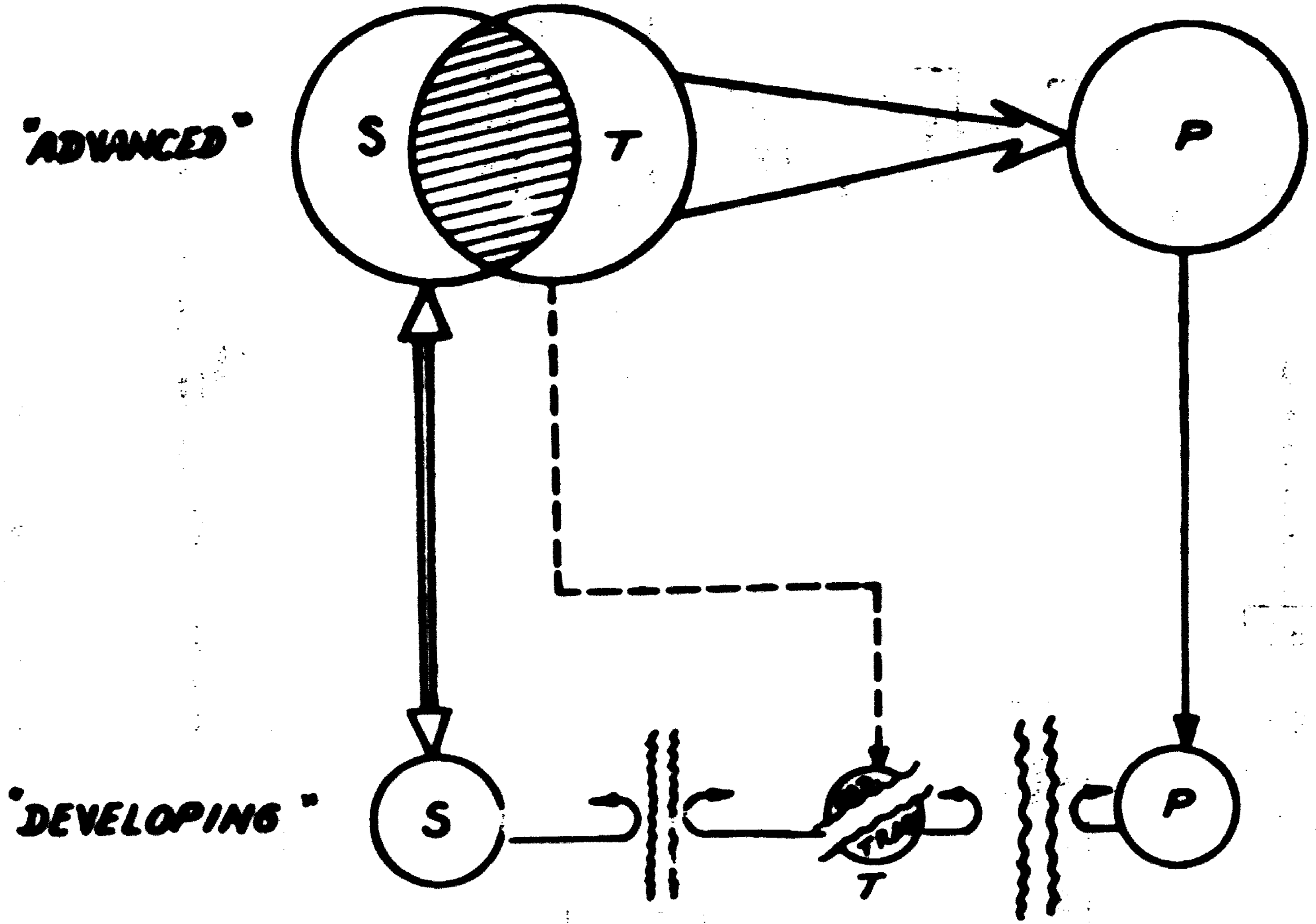

FIG. (3) S T,P COMPONENTS

(DEVELOPING & ADVANCED COUNTRIES)

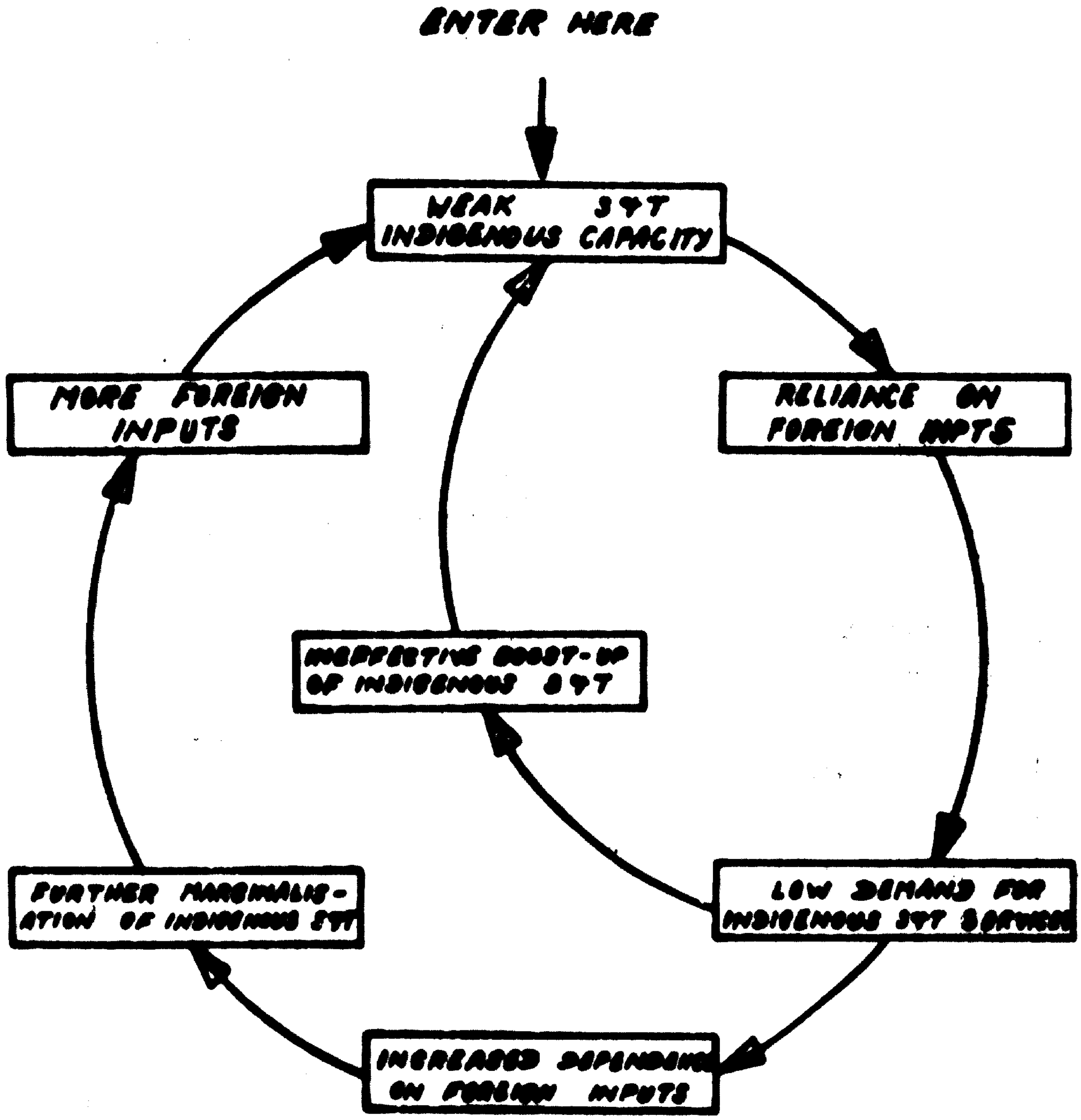

FIG. (4): A "VICIOUS" CIRCLE

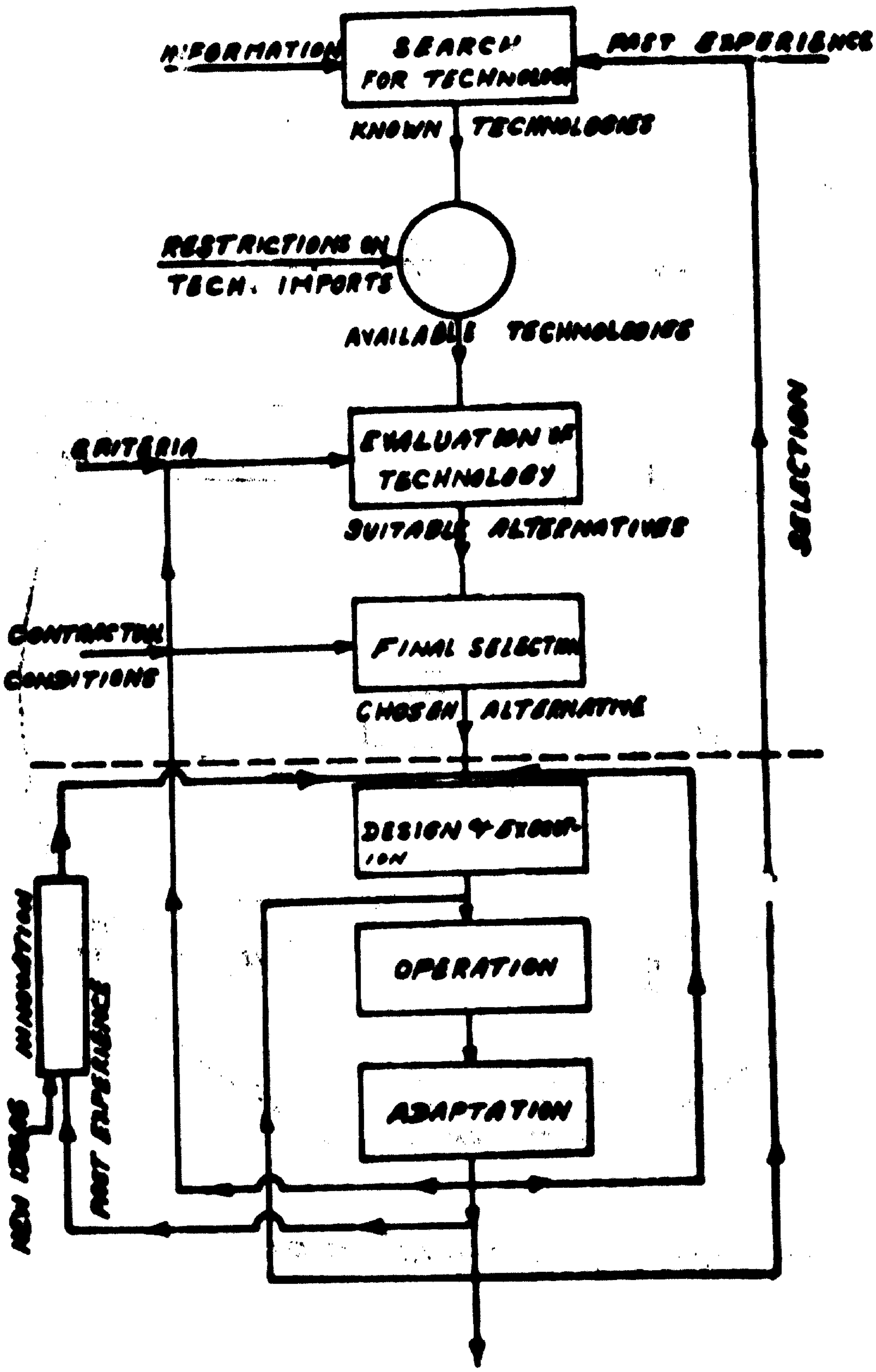

FIG (5) SELECTION AND ADAPTATION

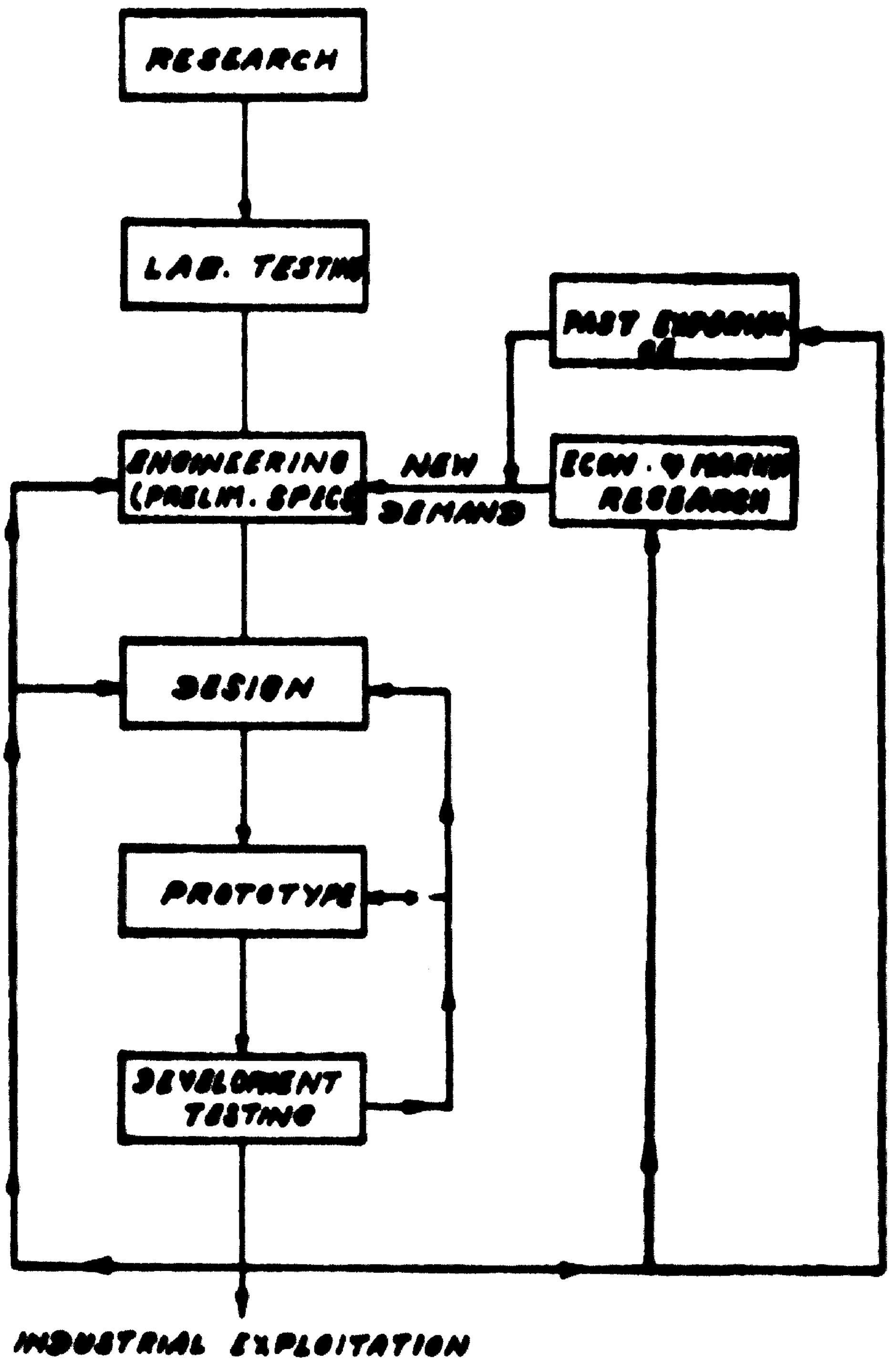

FIG (6) INNOVATION

B - 89

80.02.07