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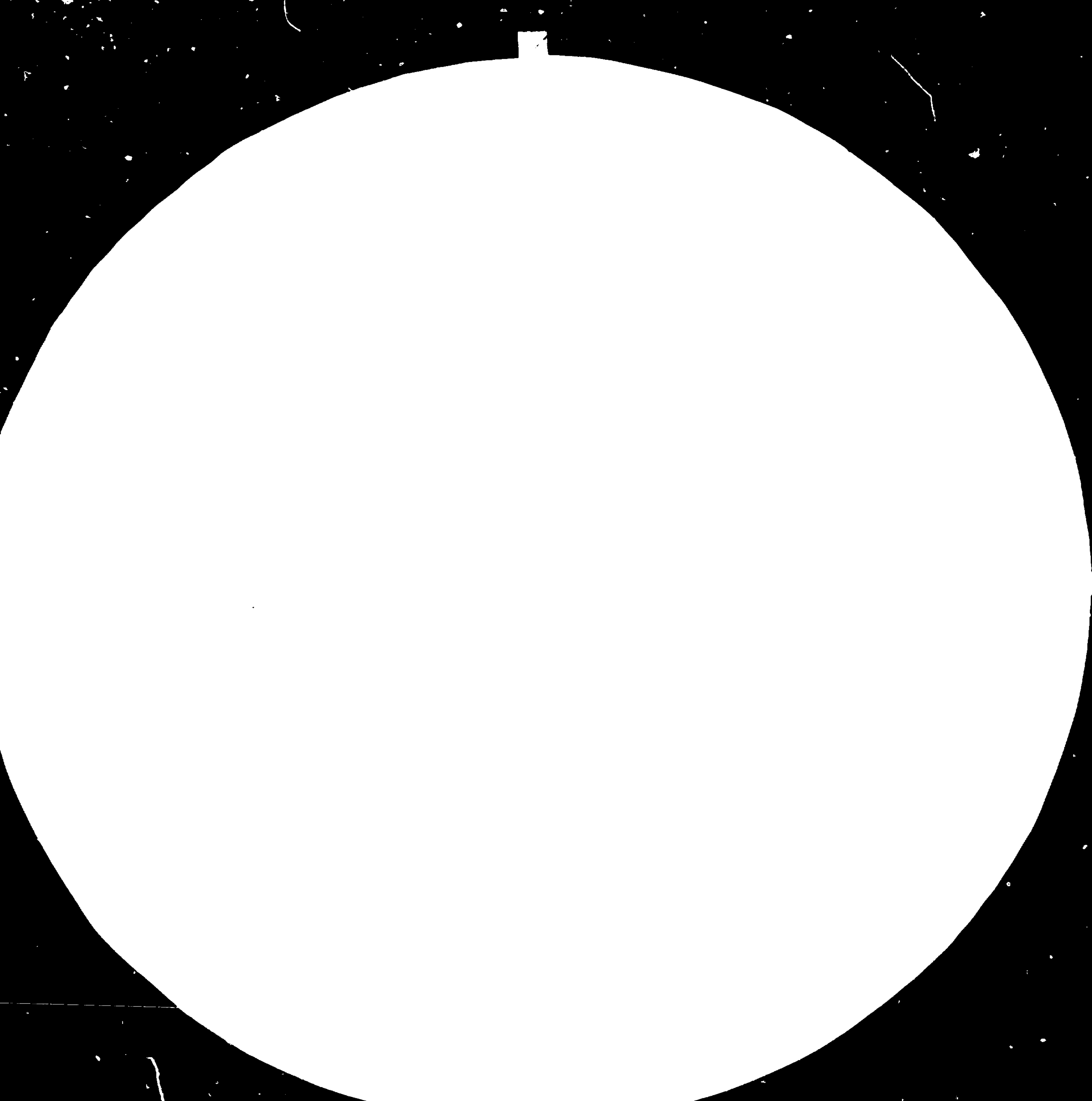

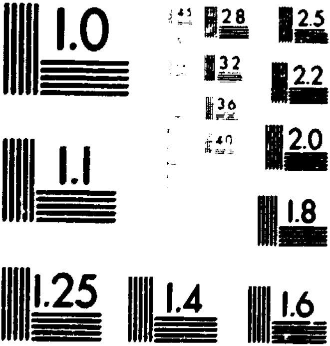

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COMMERCIALIZATION OF RESEARCH RESULTS OF RESEARCH INSTITUTIONS IN THE ESCAP REGION *

by

F. Neville Woodward **

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CONTENTS.

A. INTRODUCTION.

The industrial base in the Asian and Pacific countries, with a few notable exceptions, is relatively small, and consequently in-house R & D* activity is rare. Most of the industries in the region are of the small and medium type, whose need for R & D input is great but whose in-house capability is negligible. In most of these countries, therefore, Industrial Research & Service Institutes (IRSI) have been established at the instigation or with the assistance of Governments, which have invested substantial sums, and there is an increasing and rightful concern on their part that there should be some return on this investment in terms of economic and social gain. Unfortunately the commercialisation of the R & D findings of most government-aided IRSIs in many developing countries is very limited in comparison with what is needed by industry. The reasons for this are many and varied and will be considered in detail later : but at the outset it is important to emphasise that in the setting up and operation of IRSIs in developing countries, there are two basic principles which are fairly obvious but all too frequently forgotten: (a) IRSIs are set up primarily to help existing industries, and catalyse new ones; and (b) R & D plays a vital but relatively small role in the development and commercialisation of a modified or new product or process. If these two fundamental principles are forgotten, or not recognised, the usefulness of the institute is drastically reduced, and the end result inevitably will be disappointment or disillusionment on the part of government, sponsor, and staff.

To place the importance of industrial R & D in proper perspective, the steps that should follow, if the product of such research is to be converted into marketable products, must be considered.

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* Research and Development

This can best be illustrated by a diagram based on experience of the development of many new processes and products which reflect the order of magnitude of technical effort involved in successive stages.

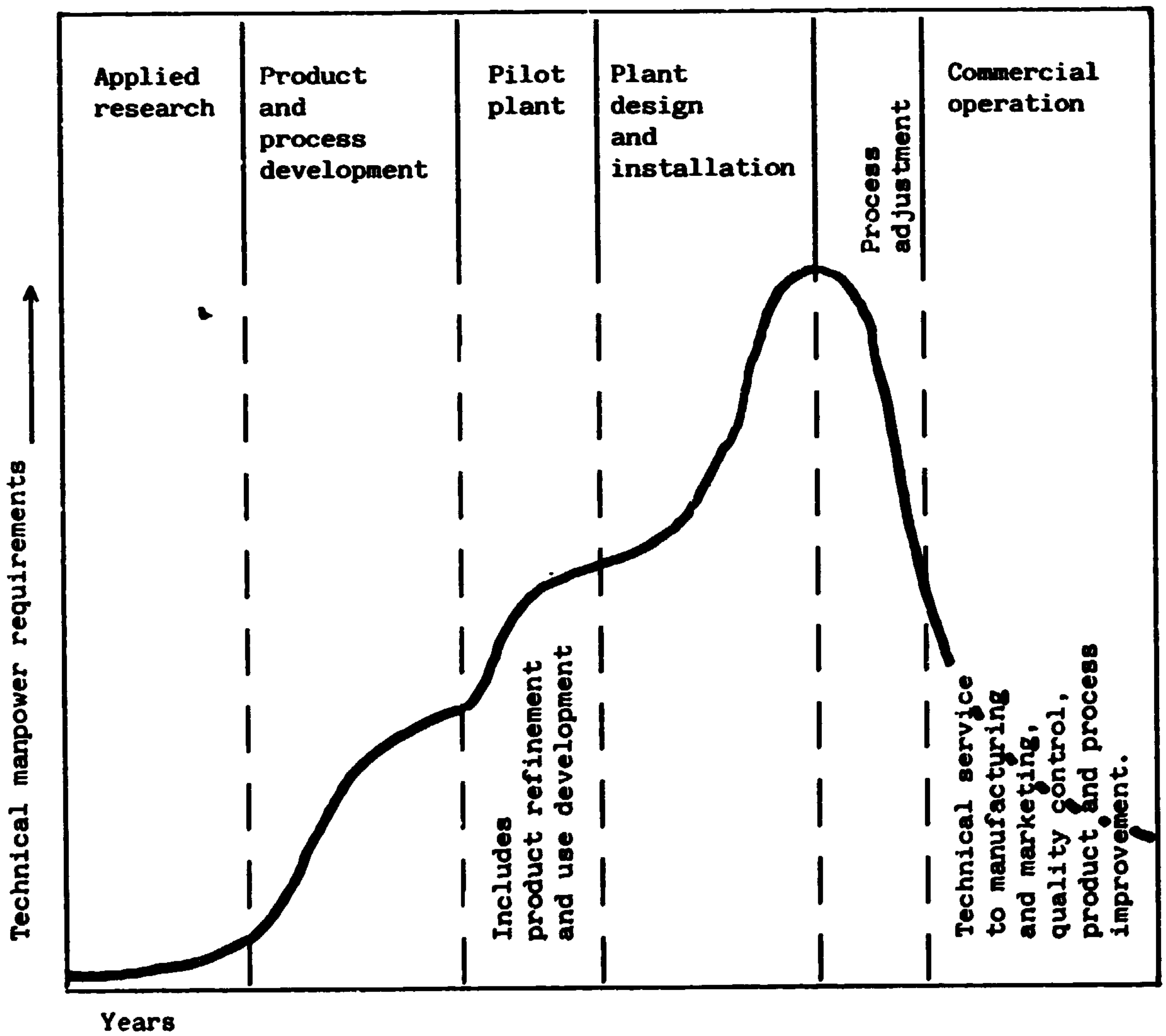


Fig.1. Technological manpower required at each stage of development.

In general it is safe to work on the assumption that the technical manpower, and capital outlay, required for the development, plant design and installation stages is at least ten times that needed for the initial applied research.

Before dealing with the techniques and actions required for the successful commercialisation of research results it will be helpful to consider the problems most frequently encountered by IRSIs in the conversion of their research results into marketable products.

B. PROBLEMS FACING IRSIs IN THE COMMERCIALISATION OF THEIR RESEARCH RESULTS.

These are of two main types viz:

1. Inherent limitations of most IRSI in developing countries.
2. Inbuilt handicaps frequently encountered but capable of being overcome.

1. Inherent limitations.

Limited base. Technically based manufacturing concerns, sufficiently large to operate their own R & D organisation, are in a much better position to commercialise their R & D findings than are the quasi-independent IRSIs most frequently found in developing countries.

Figure 2. shows the organisation chart of a typical medium-sized company, where there are technical, manufacturing and marketing directors answerable to a chief executive. In such a company the three directors interact and collaborate in the development and implementation of a corporate plan designed to manufacture and market a product resulting from its research department's activities.

The conventional "Third world" IRSI, on the other hand, is usually only concerned with technological and economic problems; rarely is it involved in marketing or in manufacture. Such IRSIs by their very nature are obliged to operate under a severe built-in handicap which cannot possibly be overcome unless the institute establishes and maintains good relations with the industry it was set up to serve.

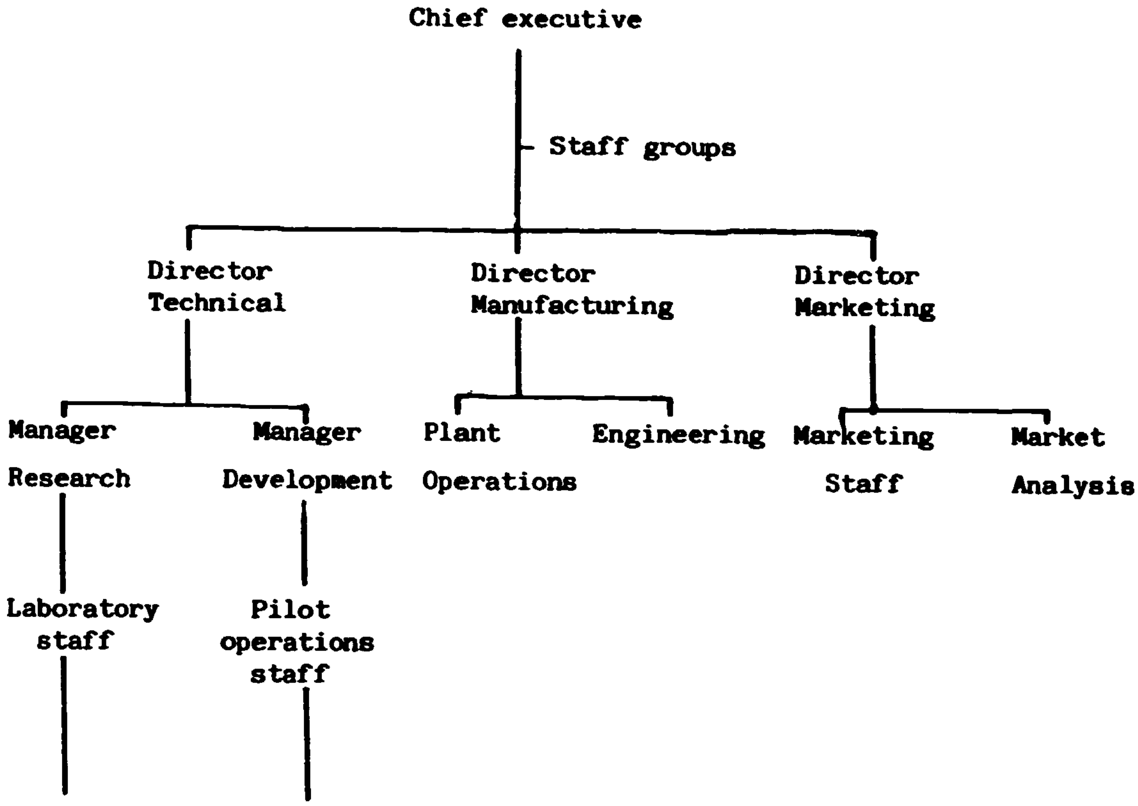


Fig.2. Typical organisation of medium sized firm

2. Inbuilt handicaps.

(a) Internal structural weaknesses of IRSIs. There are many internal structural weaknesses in the IRSIs which have affected their ability to commercialise the results of their research programmes, such as bad organisational structure and management, inability to recruit high-calibre personnel, lack of business-like approach and an appreciation that timely application of research results is more important to the businessman than pursuits of perfection. Often remuneration, job satisfaction and social status given to research workers are not adequate to attract the right type of people to IRSIs: comparisons are inevitably made with the prevailing situation in industry, in government departments and universities.

(b) Credibility and acceptability. A common malady afflicting IRSIs in the developing countries of the ESCAP region, even where a sizable industrial base exists, is the lack of acceptability and credibility on the part of the user industry about the usefulness and practical nature of research activities undertaken by IRSIs.

Among the factors responsible for this revealed by the 1979 UNDP/UNIDO joint evaluation of a cross section of IRSIs in developing countries - were the following :-

- suspicion by private industry of the IRSI - government relationship.
- lack of information about IRSI objectives and functions.
- lack of confidence in IRSI knowledge and experience and its understanding of the cost/benefit industrial motivation.
- belief that the IRSI operates in an "ivory tower" and that it is usually unwilling to commit itself to delivery dates.
- belief that IRSI fees and costs are unreasonable.

(c) Total package of services. Potential customers, particularly the small and medium industrialists, like to obtain not merely the process or the product design, but a total proven package of product, process and plant engineering, backed by professional and financial guarantees. Also, they usually need a much wider spectrum of services such as market research, product research, consulting engineering services, etc., along with the normal technology output from IRSIs; this they can rarely obtain from a conventional IRSI.

(d) Guarantees. Absence of specific financial guarantees from IRSIs about successful commercial-scale viability of their technology, tends to act as a barrier to commercialisation of research results.

(e) Protected markets. In many countries of the region, protected markets lead to attitudes among entrepreneurs which are not conductive to the use of R & D for adaptation or innovation. Compulsions of the market economy, to survive in business, to increase profits and to maintain or improve their share of business, which are the major motivations for using R & D on the part of industrial entrepreneurs under the stress of competition, are generally lacking.

(f) Indiscriminate import of technology. In market-economy countries of the region, sometimes there is too liberal a flow of imports which tend to subdue the innovative spirit among industrial entrepreneurs. While it is not being suggested that external competition should be completely eliminated, a judicious measure of protection for some period of time would appear to be necessary for development and growth of new industries, and would also provide them with a breathing period to improvise, adapt and innovate, leading to increasing use of local research output.

The effect of protected markets and indiscriminate importation of foreign technology upon a young small IRSI is frequently neither understood nor appreciated by government in many developing countries. That this is a real problem is evidenced by recent statements by two senior scientists responsible for directing a well established IRSI in India and for controlling national IRSIs in Pakistan respectively.

These are as follows:-

"The ability of an IRSI to make an impact in a developing country is greatly influenced by the tripartite relationship existing between the government departments evolving policies, industry and the IRSI. The IRSI has to interact closely with the government on the one hand, and with industry on the other. In this tripartite arrangement, the IRSIs in developing countries tend to be the weaker partners, the compulsions of the government and industry being towards short term solutions usually obtained from abroad and hopefully yielding quick results, the objectives of the IRSI being long term with its inherent inability to respond to short term needs except in isolated cases".

"One of the most challenging tasks of an IRSI is to devise ways and means for ensuring the maximum utilisation of the results of its research by offering its processes and products to industry for commercial exploitation. This task becomes very formidable in a developing country where the government policy is generally concentrated on accelerating the pace of economic development through horizontal import of technology. Obviously a serious lacuna in this system is that the prospective industrialists give preference to well tried imported technologies. This dichotomy in government policy in most developing countries creates a very serious problem for the scientists and technologists of an IRSI who in many instances are overwhelmed by a sense of frustration because of the fact that their efforts starting from the laboratory to an appropriate scale do not bear any fruits by way of industrialisation".

Faced as they are by so many limitations and handicaps, one can be forgiven for wondering if there is any real hope for IRSIs in developing countries to make any serious impact upon the national economy through the medium of commercialisation of their research results.

That this is possible has been proved by a number of IRSIs in the ESCAP region who have been, and continue to be, successful because they have organised themselves in a manner capable of overcoming or avoiding the problems outlined above.

The following is a synthesis of the techniques developed and successfully used by such research institutes in many developing countries in the ESCAP region and have withstood the test of time. These are of two main types: firstly actions that can be taken by, and within, the IRSI itself and secondly, the use of appropriate professional organisations outside the IRSI but working in association with it.

C. ACTIONS TO BE TAKEN BY, AND WITHIN, AN IRSI LEADING TO SUCCESSFUL COMMERCIALISATION.

A bewildering array of recommendations have been made in recent years by seminars and workshops staged to consider the problems involved in the conversion of research findings into economically viable products and processes.

One such seminar organised by UNESCO[2] produced 11 main and 17 subsidiary recommendations. Whilst a more recent UNIDO Workshop[3] made 22 principal and 20 minor recommendations. To complicate matters further, the two groups in many respects appear to hold different views as to what is required.

In-house studies of a wide variety of successful IRSIs in W.Europe and in the ESCAP region[4] clearly indicate that there are five principal "golden rules" which must be observed for there to be any chance of success.

In brief these are :

1. the IRSI must be industry oriented and there must be a continuing dialogue between the IRSI staff and the relevant industry.
2. the IRSI must be run as a business and not as an academic institute.
3. the IRSI's work programme must be based on what industry needs (as revealed by surveys and market feasibility studies) not on what the IRSI staff thinks it needs or should need.
4. before starting a research project, if at all possible, an industrial partner or potential partner should be found and, except in the case of demonstration units, the product or process developed in the IRSI laboratory should be scaled up with, or by, an industrial partner.
5. the IRSI must set up and operate a formal project evaluation system which reviews projects at regular intervals and keeps the industrial partners informed as to progress or lack of progress.

These five "golden rules" are described in greater detail in the next part of this report.

1. Industry oriented IRSI

For an IRSI to succeed, it is essential that the work, and what it is set up do, is understood by all members of the business community. This cannot be achieved by using conventional public relations techniques (open days, descriptive brochures, lectures, etc.) alone, useful as they are. Far more important and effective are personal contacts between senior staff members and members of the industrial community. Without such industry-oriented personnel at the institute willing to go out and talk to their counterparts in industry and government, poor communications inevitably result, and the institute is unable to "sell" its services.

What is essential in "selling" industrial research is that potential users see it as a positive contribution to their business. Unless an industrialist can be convinced that the institute can tackle his problem quickly, efficiently and at a reasonable - though not necessarily low - cost, he is not going to place work at the institute. Furthermore, if he does, and he is not satisfied with the results or the way they were reported, he will not come back; as "bad news travels faster than good", some clients or potential clients are likely to be lost.

A communication problem of an acute type is frequently encountered in developing countries, where large joint-venture firms rely primarily upon the foreign partner's home operations for such technical development work as they require. Rarely do these companies use the services of the local IRSI, particularly when, as is frequently the case, it is primarily an analytical and testing laboratory. The upgrading of the IRSI to a point where it can be of use to such companies, and ensuring that the latter uses the former, is difficult but can probably best be accomplished by the personal efforts of the chief executives of the two organisations, with support from government.

A technique developed by and successfully used in Norway to bring IRSIs, industrialist and government officials closer together also may be of interest to the developing countries in the ESCAP region.

Once a year a meeting is held over which the King of Norway presides, at which 400 invitees from industry, finance, academies and government are told what has been happening at the state-aided IRSIs. Each of the 17 IRSI directors is allowed exactly three minutes, and the use of visual aids, to explain the main findings of his research institute during the past year and the impact it has made on industry. This is followed by a question-and-answer session usually of a most searching type, often lasting up to three or four hours.

2. IRSI run as a business

It cannot be too strongly emphasised that an IRSI can succeed only if its staff realise, and can convince local industrialists and relevant government departments that the institute operates as a business organisation, in business to help them by undertaking work of practical and immediate value.

It is for this reason that not only the director, but also the majority of the IRSI senior staff members should either have had industrial experience, have worked at a successful IRSI elsewhere, or at least have a practical rather than an academic outlook.

It has repeatedly been found that if this is not insisted upon, communication with industry is poor, research projects tend to be academic rather than practical, there is an individual rather than a team approach to problem solving, budgeting and planning are indifferently carried out or are non-existant and there is no mechanism within the institute for the commercial implementation of its research results.

These problems all too frequently are a consequence of the fact that most directors of IRSIs in developing countries have received their scientific education in universities in industrialised countries, where prior emphasis is placed on research undertaken to add to the sum total of human knowledge, rather than applied research of immediate value.

3. IRSI work programme must be based on industry's needs.

Far too many IRSIs select research projects on the basis of what their scientific staff - who usually have no knowledge or experience of industry - thinks that industry requires. One remedy is for the IRSI staff member responsible for the project to seek the view of appropriate people within the industry concerned, and to try to identify a potential industrial partner before starting the project.

If he finds no enthusiasm for the project and fails to identify a firm interested in developing the anticipated research findings at a later stage, then normally it should be dropped.

Similarly, in-house research projects, even those financed by government, should have a useful objective. This is necessary not only to show institute staff that they are part of the business operation, but also to counter suspicions in the minds of would-be clients that the institute is too theoretical in its work. Neglect of this simple rule on the part of an institute's management has often resulted in serious trouble.

Apart from winning the confidence of key personnel in indigenous companies, which is a lengthy process and entirely dependent upon the ability of the IRSI staff members to build up a rapport with their industrial counterparts, there are three recognised and proven techniques for determining industry's needs. They are:- the use of survey teams and feedback from the institutes information and extension services.

Survey teams. Wherever possible a survey assessment of local industry's technology support requirements should be made before setting up a new IRSI. The information thus obtained will avoid mistakes in deciding the functions of the institute and in equipping and staffing it. Such surveys are equally important to established IRSIs which have not benefited from such a study before establishment.

One of the best survey techniques is that developed and applied by the Canadian National Research Council in the early 1940s and extensively used elsewhere since that time.

NRC realising that it had insufficient contacts with industry to know what its problems and aspirations were, and hence was failing in its duty, sent a team of over 40 technologists and economists to visit every secondary manufacturing firm in the country.

Their task was twofold, firstly to explain what NRC was and could do, and secondly to identify problems and help solve them. This exercise took several years to complete, and although it helped NRC clarify its thinking and made its investigations more purposeful, the follow-up from the firms visited was disappointing. However, the exercise was repeated on a reduced scale, calling only on those companies that had responded to the first visit, and from thereon the dialogue between industry and NRC continued to improve, playing an important role in the identification of national applied research priorities.

The same technique was used with great success more recently before setting up the Korean Institute for Science & Technology (KIST) thus enabling its founders to determine which areas were in need of technological research assistance on the national level.

In addition to these macro national surveys, the IRSIs Programmes and Planning group, should continuously be undertaking surveys (preferably in association with appropriate industrial organisations) to identify problems which, if resolved, should be of benefit to the national economy.

On no account should such surveys be attempted by mailing printed questionnaires.

The use of "feedback" from an IRSI's information and extension services will be outlined later in this report.

4. <u>For successful commercialisation IRSIs need industrial partners.</u>

Lack of attention to what happens with the research results once a project is completed, and an inability to take follow-up action, lessen clients' confidence and encourages an insular attitude among the staff of an IRSI. Too many IRSI tend to conduct their research investigations up to and including the pilot plant stage within the confines of the IRSI, and belatedly try to sell the idea to industry; usually, and not surprisingly, with negative results.

Before any research project likely to result in a new product or process of possible industrial value is commenced, an attempt should always be made by the IRSI staff to identify an industrialist or a company as a partner. Ideally, the company should be persuaded to pay the cost of the investigation under contract with the institute; but in most developing countries this rarely happens, as the view is taken that the institute's services should be free to taxpayers. As suggested earlier, before committing itself to undertaking an industrial research project, the institute should seek the views of individuals in the industry concerned as to its feasibility and desirability. During the course of these preliminary talks, it is almost certain that an individual or company will be identified who will be prepared to undertake the commercialisation stage at a later date. In this event, the potential partner should be kept informed as to the progress of the research project in the IRSI laboratories.

If it has not been possible to find a potential industrial partner at the outset, the next best thing to do is to find one when the IRSI research project has reached a stage when the product or process looks economically and technically feasible. If a pilot plant is required, and only if one is absolutely necessary, the plant should be erected in the factory by the company's construction staff with appropriate IRSI staff members as advisers. This is infinitely better than erecting the pilot plant at the IRSI, which rarely has engineers and engineering facilities. Also, the company should become involved at a relatively early stage, and the IRSI staff should get first-hand industrial experience.

If several companies in the same line of business are interested in the IRSI product or process, then either the firms concerned must come to an arrangement whereby the cost of commercialisation and the results thereof are shared, or more usually the firm on whose factory the pilot plant is erected and operated is given a six-month lead before releasing the pilot plant results to the others.

5. <u>IRSI must set up and operate a formal project evaluation system</u>

Project selection.

Research programming, which ultimately is the responsibility of the IRSI director, is one of his most important functions. It is universally agreed that there is no substitute for the exercise of judgement on the part of qualified and informed people in the selection of research projects. There is no magic formula or computer programme possible as a substitute for judgement in trying to maximize the value obtained from research in relation to the investment made.

If any IRSI director is tempted to confine responsibility for project selection to himself and to his staff, he should take note of the results of an American survey some years ago[5] of over a hundred industrial laboratories, which showed that more than half of the new project ideas came from outside the research department. The distribution of idea sources found was: research 45 per cent, manufacturing 16, marketing 16, management 11 and "others" 12.

In most IRSIs there is a programme and planning group answerable to the director, among whose responsibilities are the following : (a) to study the national development plan to identify projects where R & D can play an important role; (b) to undertake surveys, in association where possible with appropriate industrial organisations or associations, to identify problems requiring solution to improve the national economy, and (c) to evaluate commercial opportunities on a technical-economic basis for the utilization of indigenous resources.

Project types.

In well-established IRSIs, the research programme includes (a) background research (which produces research papers/patents or information of use to industrialists, planners and scientists engaged on applied research); (b) applied research which provides information on the potential uses of natural resources, long-range national problems and paves the way for the development of new processes based on indigenous materials and (c) product development work leading to clearly defined processes which, if economical, can be used commercially.

Distribution of research effort between these categories needs to be changed from time to time, but on the average one laboratory (PCSIR laboratory, Karachi, Pakistan) found that it has been as follows: (a) 15 per cent, (b) 35, (c) 40 and (d) ad hoc research 10.%
On the basis of its 1970 programme this laboratory was able to forecast that one of its units would develop 4 to 6 major processes, 12 to 16 medium-sized processes, and produce 40 research papers/patents, to within 20 per cent accuracy.

The importance of basing project selection particularly in categories (b) and (c) on the known needs of industry and the nation has already been pointed out, as has the advisability of discussing product development projects with appropriate industrialists before initiating.

Further points to remember in project selection and IRSI research programming are the need to undertake feasibility studies, and where possible a market analysis, before deciding whether or not a project is worth undertaking, and the importance of using a formal project system.

Feasibility study. A detailed feasibility study incorporating technological, economic, engineering and demand data, besides being an essential decision-making device, is an aid to finding users of research results. In many cases feasibility studies prepared by IRSIs have a scientific orientation rather than an economic and commercial bias, and this can be avoided if the IRSI sets up a small technico-economic unit.

Market analysis. One of the major difficulties in the IRSI commercialisation process is the non-availability of adequate and accurate marketing data for the new product or technology which the IRSI has developed on the laboratory scale. Before a research project is initiated, it is desirable to have a detailed demand study. This would also be useful in trying to interest a potential user in the research project.

Formal project system. Care must not only be taken in the selection of projects, but also in the way they are drawn up, implemented and reviewed.

Each in-house project, once it has been approved, should be written up in an agreed standard form and should indicate the title, the objective, an approximate programme outline, who will be responsible, how long it is expected to take, how much it will cost and what are the practical benefits resulting if the project is successful.

Sponsored research should be covered by a contract document signed, after agreement on terms, by both the sponsoring organisation and the IRSI. It should contain the information covered by the in-house project document above but be more explicit as it will be a legally binding document.

The British Government now applies this technique to all research projects undertaken on its behalf, whether undertaken by contract research organisations, universities, industry or even in its own research institutes. This has become known as the "customer-contractor" system[6] whereby the customer (Goverment) enters into an agreement with the contractor (the research organisation) to undertake an investigation on its behalf; the arrangement is covered by a legally binding contract in which such things as the objective, anticipated duration, and cost, etc. are spelled out. This system could be applied with advantage by the Governments of many developing countries.

Project review and evaluation. The project portfolio thus compiled should be reviewed and evaluated at regular intervals, probably every six months, guided by cost/benefit principles. Among the questions that should be asked are: (a) is the research being carried out according to the project plan ? (b) does it require a greater or lesser input of resources ? (c) is it going ot achieve its objective ? If the answer to the last question is "no" or if, on reflection, the objective originally conceived is no longer worth-while, then the project should be terminated. There will inevitably be opposition to this, it being easier to start a project than to terminate one; but once a decision to terminate has been reached it must be implemented without delay. There is the classic case of an IRSI in an Asian developing country (now merged with other institutes and completely reorganised) which despite having a large staff and excellent facilities, including many pilot plants, failed to get a single product or process industrialised during the first 16 years of its operation. Among the reasons for this were the fact that only 4 of the 600 staff members had had industrial experience, there had been no dialogue with the industrial community, and although 80 projects were in hand in 1969, many having run for over ten years, no evaluation of these projects had been undertaken nor had any been terminated. A subsequent review and evaluation of these 80 projects revealed that over half no longer served any useful purpose. They were terminated and replaced by a smaller number of new projects closely related to the immediate needs of local industry.

In this respect a useful lesson can be learnt from a survey of twenty large American chemical companies some years ago[5] which traced the fate of a typical original list of 540 ideas evaluated at the research department level as follows :-

92 were rejected by the initial screening procedure.

448 were eliminated in conference to consider new product selection.

92 were selected for preliminary laboratory study.

8 were sufficiently promising to warrant development projects.

7 were dropped at the semi-works stage.

and 1 survived as a viable commercial product.

D. COMMERCIALISATION USING APPROPRIATE PROFESSIONAL ORGANISATIONS OUTSIDE, BUT WORKING IN ASSOCIATION WITH THE IRSI.

These organisations are of three main types viz :-

1. National development research corporations.
2. Engineering consultancies.
3. Venture capital companies.

1. National development research corporations.

Some IRSIs attempt to do their own marketing The disadvantage of this has often been that the researchers, who know the S & T aspects extremely well, are rather weak on commercial matters. Even if there is a completely separate marketing group within an IRSI, it still is affected by the research environment in which it functions.

In some developing countries, to get over this difficulty, promotional agencies have been set up to finance development, commercialisation of research results being their primary function. The prototype of these agencies, now operating in many countries throughout the world, is the National Development Research Corporation (NRDC) established in the United Kingdom in 1948 as an independent public corporation to (i) "seek to license invention derived principally from government financed research ...." and (ii) "make available development finance either to support further development of invention up to the stage of potential industrial interest, or to support joint development projects with industry".

The Corporation undertakes the development, and exploitation of inventions assigned to it. These come mostly from government financed institutions (departmental research establishments, Research Councils, Universities, etc.) but also from private individuals and occasionally companies.

NRDC does not receive grants, but is financed by government loans. The Corporation's outstanding long term liability in respect to these loans, is effectively matched by its liquid resources.

Until 1969 NRDC ran at a loss, since then it has achieved a net profit before tax on an increasing scale and was over £10 million in the year ending 31 March 1983.

The following table (extracted from NRDC's 1982/3 Annual Report) gives details of income and expenditure over the last five years, and shows that revenue from licences has been the main source of income - due to a very few conspicuously successful inventions.

It will also be seen that direct foreign currently earnings from products licenced overseas has been significant.

Five-year financial summary

£ million
Years ended 31 March

Income and expenditure	1979	1980	1981	1982	1983
Licence income	18·10	16·86	18·83	22·12	25·19
Levies from joint venture projects	3·05	1·91	2·08	3·60	1·82
Other income	·18	·35	·97	·49	·37
Total income	**21·33**	**19·12**	**21·88**	**26·21**	**27·38**
Overseas income included above	14·95	13·59	14·63	17·91	22·79
Payments to inventors	2·83	2·69	2·87	3·53	3·66
Amortisation of projects	4·61	2·76	8·48	8·75	17·18
Net surplus before tax	12·92	11·85	8·43	10·39	2·33
Net surplus after tax	8·77	8·52	6·86	5·02	·96

Project and patent expenditure					
Project expenditure	6·10	8·81	12·45	11·56	11·83
Patent expenditure (including renewal fees)	·55	·64	·62	·85	·89

The histogram below summarises NRDC's current and overall development and licensing activities.

Fig. 3.

Sources of inventions and industrial projects considered by NRDC

	During 1982-83	Total 1949-83
Public bodies	1,208	21,488
Companies	325	6,324
Private individuals	496	20,717
Total	2,029	48,529

Assessment

Patent rights assigned to the Corporation

During 1982-83	Total 1949-83
172	7566

Joint ventures with industry

Project investment 1982-83

34 New projects
Authorised expenditure: £2·26M

30 Further authorisations on existing projects
Authorised expenditure: £2·75M

273 Current projects
Authorised expenditure: £48·58M

Further development to assist licensing

Project investment 1982-83

49 New projects
Authorised expenditure: £1·11M

43 Further authorisations on existing projects
Authorised expenditure: £2·31M

365 Current projects
Authorised expenditure: £20·24M

Licensing

UK licence agreements

60 Completed during 1982-83
469 Current at 31 March 1983
2,064 Completed 1949-83

Foreign licence agreements

10 Completed during 1982-83
117 Current at 31 March 1983
316 Completed 1949-83

Licensed inventions earning revenue

37 New revenue earners 1982-83
316 Current revenue-earning inventions
1,080 Revenue-earning inventions 1949-83

Although revenue from bioscience inventions has dominated that from all other activities, the Corporation from the outset has deliberately spread its efforts and investments over the whole range of technology excluding only nuclear energy and defence.

It has been primarily responsible for the establishment of two new industries - hovercraft and electronic computers. It financially assisted research on, and successfully exploited one of the most significant groups of antibiotics discovered since penicillin - the cephalosporins. Similarly it assisted development in such widely diverse technologies as selective herbicides, fuel cells, the first linear motor hovertrain to exceed 100 m.p.h., energy and materials conservation.

Whilst it is difficult to quantify the gross amount of new industrial production, NRDC has helped to generate in the UK, estimates on the basis of domestic royalties and levies received; shows that in 1977 alone, the amount was approximately £100 million, whilst the accumulated total over the previous ten years was about £600 million.

In September 1981, NRDC was merged with the National Enterprise Board, and is now operating under the title "British Technology Group" to provide " a major new force for promoting innovation and investment in British industries".

The British NRDC has been taken as a model by many countries, including India and Japan. The National Research Development Corporation of India, set up in 1953, resembles the British NRDC in every significant respect, except in that it is State controlled (Officially a "Government of India enterprise") and receives grants as well as loans from the government.

Under its charter "all R & D institutions operating on governmnet funds must refer their technologies, processes etc. to NRDC of India for patent assistance and for arranging their commercial exploitation". In consequence, NRDC receives processes and patents for development mainly from public sector research organisations such as the Council for Scientific & Industrial Research (CSIR),, Indian Councils for Agricultural and Medical Research, Indian Institute of Science, Indian Institutes of Technology, Defence R & D Organisation, Bhabha Atomic Research Centre and other publically supported research and educational institutions.

The technologies submitted are mainly (80%) suitable for the small scale sector as they are more employment oriented and less capital intensive. Technical and economic assessments can usually be made by NRDC staff without recourse to further experimental work but if necessary consultants are brought in to help with assessment.

NRDC finances such projects as are identified as being of national importance, meant to fulfil well identified national goals. They should hold promise of making direct impact on the national economy in terms of export promotion, import substitution, exploitation of untapped indigenous resources, population control, utilisation of industrial wastes, establishment of new industries, creation of job opportunities, increase in food production, improvement in public health etc.. The projects should generally help attain national self reliance.

NRDC,where necessary, finances up to 50% of the expenditure required to establish pilot plants,to build prototypes,and to set up demonstration units to render laboratory know how suitable for commercial exploitation..In the case of sophisticated technologies involving investments of more than Rs.5 million, NRDC takes part in the equity of the company which has been specifically formed for commercialisation of these technologies for the first time.

NRDC also offers technologies to interested entrepreneuts on turnkey basis taking up responsibility for forming a consortium of suitable consulting engineering firms,R & D organisations,equipment suppliers etc.

To ensure that every useful invention generates national wealth and benifits the inventor NRDC insists that the invention has to be patented and the patent assigned by the inventor to the corporation. On the successful exploitation of the invention, the Corporation retains 30% of the royalties and premiums collected and passes the balance of 70% to the inventor after he has repaid the original expenditure incurred by NRDC.

When the development work is not successful, NRDC writes off its share of the expenditure on the project. The equipment bought for the work is sold, and the proceeds shared between NRDC and the collaborating organisation in the ratio of their financial contributions.

NRDC processes are made known to entrepreneurs and other interested bodies through the medium of advertisments in newspapers and technical journals and twice a year brings out a list of patents and processes available which is distributed free. "Invention Intelligence" and "Awishkar" its two monthly journals published in English and Hindi respectively highlights promising developments in Indian R&D institutions.

NRDC's financial structure and performance to date. The corporation has a paid up capital of Rs. 13·7 million and unsecured loans totalling Rs. 11·7 million, which as in the case of NRDC/UK is more than covered by its liquid resources. It has a total staff of 132.

NRDC of India so far, has licensed 1000 processes of which number, 500 have beeb successfully commercialised and during fiscal year 1983-84 the industrial units based on NRDC technologies have produced goods worth Rs. 1200 million.

The following table extracted from the Corporations 1982-83 Annual Report shows that the major source of income is from royalties (54% of total Rs. 13·5 million last year); that the grant received and interest payable thereon are increasing and that NRDC has had a surplus after payment of interest but before tax every year since 1973.

Fig. NRDC record over the last ten years. (Rs. Million)

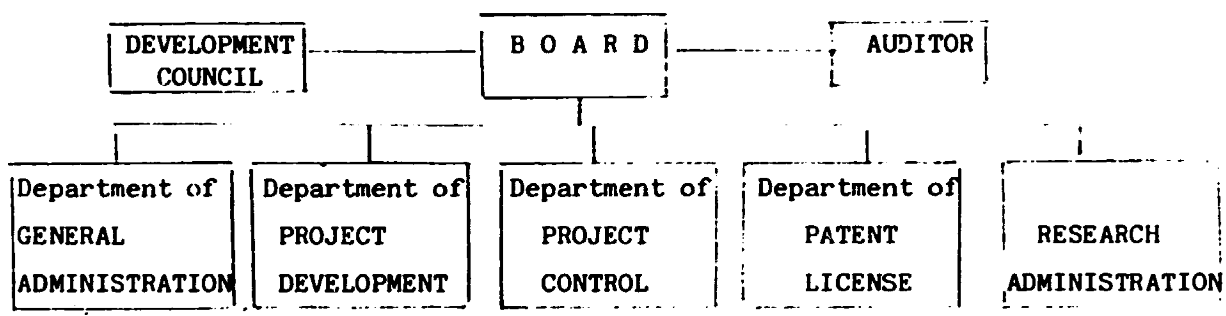
	1973-4	1974-5	1975-6	1976-7	1977-8	1978-9	1979-80	1980-1	1981-2	1982-3
Gross royalty	1.44	1.66	4.50	5.15	4.50	4.68	5.65	7.28	8.51	7.23
Gross premium	1.65	2.04	1.71	1.60	1.54	1.89	1.63	1.10	1.73	3.29
Other income	0.44	0.56	0.66	0.97	1.23	1.24	1.98	1.98	2.41	2.94
Grants received	-	-	-	0.10	0.14	0.19	0.36	0.60	0.92	1.95
Interest part to Government	0.16	0.13	0.21	0.34	0.46	0.57	0.67	0.74	0.98	1.06
Surplus	0.03	0.15	0.57	0.70	0.59	0.62	0.75	0.88	1.09	0.51

The Research Development Corporation of Japan (JRDC) was established in 1961 as a national corporation subsidised completely by the Government. It is devoted "solely to the task of bringing promising research projects to the attention of industrial circles in order that they could be fully exploited by industry, the cost of development being borne by the Government. Thus JRDC plays a basic role between research projects in all technological fields and assumes full responsibility for undertaking the development work".

Currently (30 September 1983) it has a capital of 22,796 million (= US $ 100 million) and a staff of 200.

Its planned turnover for 1983 was 7576 million (=US $ 33 million).

The organisation of JRDC is shown below : -



The Development Council consisting of ten members, is of prime importance in that it advises the JRDC President on the :

- basic policy of the Corporation
- selection of research projects for development
- evaluation of the success or failure of the development projects.

JRDC's activities and modus operandi, in brief, are as follows :-

Originality, importance for the national economy and difficulty in industrialisation are the essential points in all JRDC's development projects.

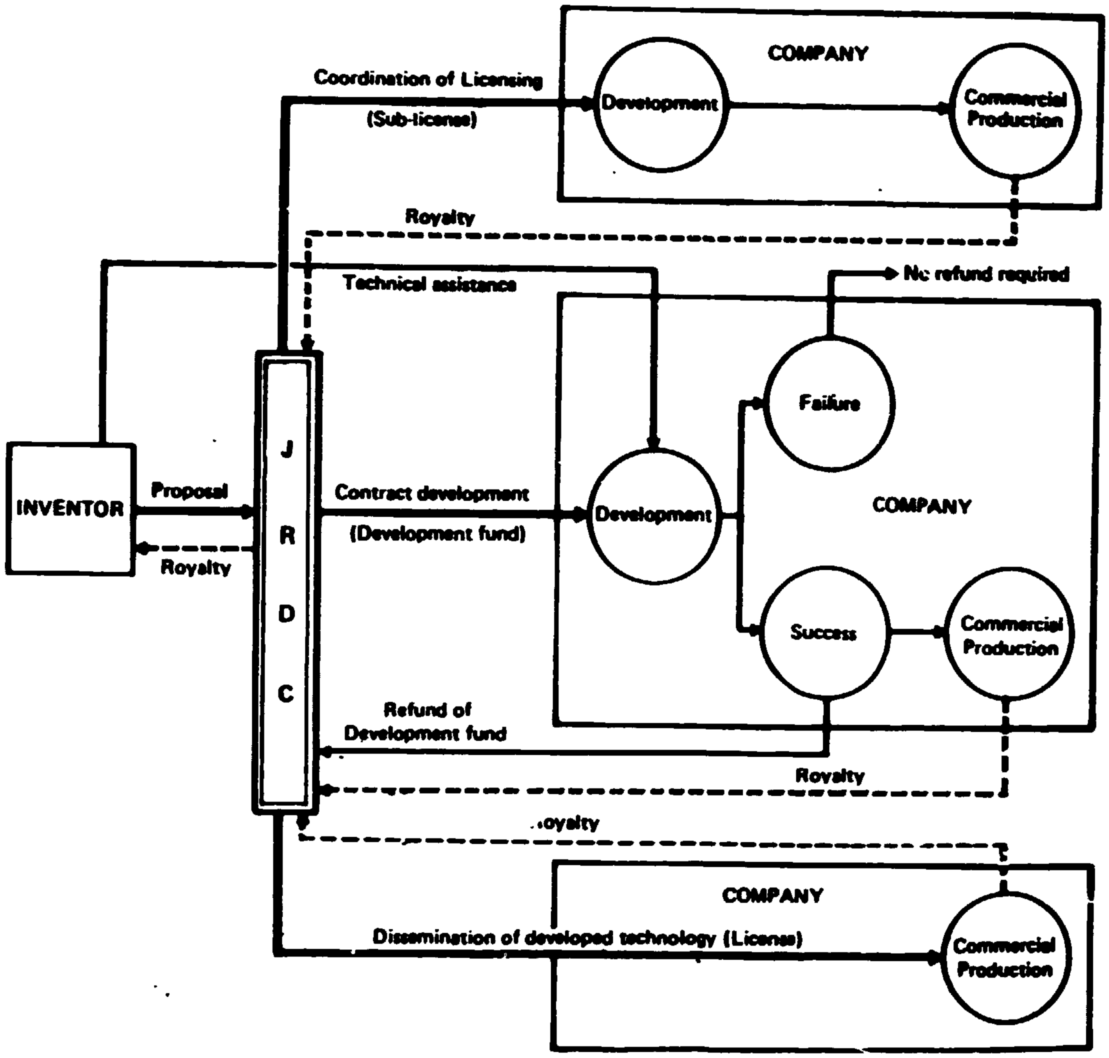
With this in mind JRDC collects extensive information on research, organises proposals for development and selects suitable firms and projects for development after final appraisal by its Development Council. As soon as a proposal is authorised JRDC fixes the development programme and conditions with the chosen company. JRDC bears direct expenses of the entire fund for development.

During a development project, JRDC monitors its advance and facilitates technical assistance by the inventor.

When a development is completed, JRDC, after hearing the opinion of the Development Council, determines whether it was a success or failure. If a development is judged to be a success, the company is authorised to commercialise the new technology under a renewed contract and pays royalty depending on its sales, half of which as a rule, is paid to the owner of the technology. The development expenses paid by JRDC to the company are to be refunded in interest free annual installments within 5 years. In the case of failure, the company is freed from the obligation to repay the development expenses.

In implementing a developed technology priority is given to the company that has been commissioned by JRDC, but if a second or third company files application for implementation, JRDC may grant the license to the company after considering the market requirements and licensing conditions. Royalty paid by the new developer is divided between the owner, the commissioned company and JRDC.

The activities of JRDC are shown in summarised form in Fig. 4 below.



Currently JRDC is operating 229 development projects principally inelectrical engineering and electronics (38), chemical engineering (39), medical sciences (32), and energy and resources (25). So far it has licensed 186 inventions.

The <u>Korea Technology Advancement Corporation</u> (K-TAC) was established as a private corporation in September 1974 by the then Korea Institute of Science and Technology (KIST) - now the Korea Advanced Institute of Science and Technology (KAIST) - specifically to commercialise more effectively its research findings. It is now jointly owned by KAIST (70%) and the Korea Institute of Machinery and Metals (KIMM)

K-TAC's major activities include the following :

a. commercial promotion of domestic R & D results and foreign technologies.
b. sales of know-how and related support activities.
c. sales of prototype equipment and byproducts resulting from KAIST R & D.
d. R & D project sponsorship.
e. management consulting and other relevant activities.

The decision to accept new technologies for commercialisation is made in consideration of the following factors after a comprehensive feasibility analysis has been performed :

a. aid to medium and small scale industry.
b. probability of resulting import substitution, and/or export promotion.
c. probability of good financial return

<u>K-TAC's Role in Commercialisation</u> K-TAC accumulates capital in the form of cash and know-how from KAIST. With this know-how from KAIST and from other domestic and foreign sources, K-TAC conducts extensive feasibility studies.

If a particular study shows promise, K-TAC then draws up a project plan, and recruits potential clients. K-TAC prefers to sell know-how through a licensing agreement providing that the clients are capable of applying the technology involved. When potential clients insist on a profit guarantee rather than a technology performance guarantee, K-TAC provides an equity contribution to demonstrate its faith in the technology. If K-TAC finds that a given technology holds great promise and has a pressing need for commercialisation but sees no potential clients, K-TAC may go into business on its own, hoping that interested clients will soon appear. In such cases K-TAC organises a new business and initiates such commercialisation activities as raising funds and constructing a plant.

K-TAC prefers to transfer operations and ownership of its businesses to private entrepreneurs as soon as these firms have a stable foundation. The revenue generated by these sales is then reinvested in other commercialisation projects. Thus, K-TAC's capital could be referred to as a revolving fund. Its revenues are made up from realised equities, dividends received and fees for customer requested feasibility studies on R & D commercialisation. The profits from commercialisation are returned to KAIST.

K-TAC has established a close relationship with the Korea Long Term Credit Bank (KLB) as well as a concurrent cooperative relationship with the Korea Credit Guarantee Fund (KCGF). In addition, K-TAC is supported by the Government via such measures as the Technology Development Promotion Law. These conditions have all contributed greatly to K-TAC's success.

In addition to the commercialisation of KAIST's know-how, K-TAC is also currently engaged in technology transfer by exporting the processes and know-how developed at KAIST.

Over the years, KAIST has undertaken approximately 2,500 research and development projects. On the average, about half of the projects were sponsored by industry.

A considerable portion of these developments are presently being used by Korean industry. These processes are often suitable for other developing countries due to their appropriate production capacities and optimum process design, and can be competitively exported.

K-TAC Performance to date. K-TAC started with $ 60,000 in capital and began to seek know-how for commercialisation from available KAIST technologies. It has sold about 2 million U.S. dollars worth of KAIST-generated technology to Korean industries. Some typical items are fluorinated refrigerants, copper plated steel wire, modacrylic fibre for wigs, antibiotics and agricultural chemicals. Beginning in 1976, K-TAC also created 7 joint venture companies in the fields of ceramics, specialty metals, agrochemicals, antibiotics and optical fibre communication. Holdings in two of these companies, both in agrochemicals, were later sold to its partners after the companies attained a stable and profitable position. With the capital thus generated, K-TAC is in the process of creating four new companies.

Through its successful operation over the last decade, K-TAC has grown to a corporation with paid-in capital of more than 1.2 million U.S. dollars, and has also become a project development company affiliated with most research organisations under the Ministry of Science and Technology.

As is common in other developing countries, commercialisation projects are mainly aimed to decrease Korea's dependence on imports. These import substitution projects, since they have an existing domestic market, are more likely to be successful than those involving entirely new products. K-TAC's activities in the coming years will, therefore, be concentrated primarily on the development of as many import substitution projects as possible. In order to achieve this objective, K-TAC will endeavour to unite technology-based industries from abroad with businesses and entrepreneurs in Korea by offering a wide range of services including technical and managerial assistance : the sale, licensing or purchase of domestic and/or foreign technology, and the establishment of new enterprises based on appropriate technology.

Indonesian Agency for the Assessment and Application of Technology (BPPT) was set up in August 1982 by Presidential Decree; as a non departmental government agency, directly under, and responsible to, the President of the Republic.

Its basic responsibilities are :

- to formulate general policies ......regarding programmes for the assessment and application of technology requisite for national development.
- to provide overall, and integrated coordination of the execution of such programmes.
- to provide services to both government and private organisations in the assessment and application of technology for national development.
- to conduct activities in technology assessment and application which support government policy on the application of technology for development.

Amongst the seven functions defined is one "to develop and foster basic and applied sciences relevant to the application of technology and to coordinate programmes for their successful application in technology and industry".

2. Consulting engineers.

The very small proportion of IRSI research results which are successfully commercialised is due not only to poor contacts between IRSIs and industry as already mentioned, but also to the lack of design and engineering support.

Consultant engineering organisations, unlike IRSIs are market oriented and keep a close watch on what is needed by way of product and technology in their areas of specialisation and can assist IRSIs to commercialise their research findings by :

- R & D project identification.
- conducting market surveys for new products and processes: such surveys can attract potential users, and bring them in touch with the IRSI.
- undertaking techno-economic appraisal and value analysis of R & D programmes to evaluate well in advance the commercial potential of a research project undertaking feasibility studies covering technical, engineering, economic and commercial aspects of a research product so that the potential user is able to make a decision based on all aspects of the project rather than on the basis of IRSI technical information alone.
- engineering complete plants round the technologies developed by IRSIs and providing guarantees.

Realising their pivital role, some countries in the region have already set up consulting and design engineering organisations both in the public and the private sectors. India for instance has pursued a deliverate policy of promoting the establishment of local consultant engineering firms : currently there are well over 70 offering a complete range of engineering services in most secto .

Governments of other Asian countries would be well advised to encourage the development of local consulting engineering organisations.

3. <u>Venture capital companies</u>.

Such companies are common in the Western World, but until recently were rarely seen in developing countries.

As their name implies, their function is to inject capital into - usually small - firms aiming to develop new technologies, which are considered too risky for conventional funding. Because of the risk involved, such companies are usually backed by government, through the medium of banks and finance corporations.

Typical of these is the Korea Development Investment Corporation (KDIC) incorporated in December 1982 as a limited liability venture capital company by the seven Seoul based short-term finance companies. Its function is "to foster and strengthen the technology intensive small and medium industries through equity investment and/or equity type investment in Korea".

Currently it has a paid up capital of W 6750 million (=US $8.4million) and has invested W 2200 million (= US $ 2.8million) in ten of the 232 companies/entrepreneurs who so far have solicited support.

Whilst venture capital companies are not set up specifically to commercialise IRSI research findings, they can act as "marriage brokers" between IRSIs and potential users.

E. IRSI ASSISTANCE TO SMALL AND MEDIUM SIZED FIRMS

In developing countries, the sectors where IRSIs can contribute in a significant manner are not those based upon licenced imports, but rather those in the small and medium sized industry sectors. In responding to the needs of such sectors the problems faced by an IRSI are both challenging and daunting. By their nature they cannot be based upon know-how generated in industrialised countries which in general is characterised by energy intensive and manpower shy techniques. In developing countries, commercial sources of energy tend to be scarce and there is usually a plentiful supply of inexpensive manpower which can be trained.

The assistance that IRSIs can give small and medium sized firms, should therefore be aimed, not so much towards encouraging them to compete with the developed countries, but rather to evolve products and manufacturing processes appropriate to local needs bearing in mind the inherent limitations outlined above.

The assistance an IRSI can provide to this end covers a wide range of services -

- market surveys
- feasibility studies
- cashflow projections
- raw material surveys
- estimate of capital outlay and running costs for buying and operating a particular plant.
- identification of appropriate engineering consultancy services.
- help in recruiting and training staff.

In addition to these, most IRSIs can, and do, provide such routine services as :-

- chemical/microbiological analyses
- calibration and standardisation
- instrumentation and instrument analyses.
- QC testing
- patenting

How these services can be set up and used has been described in a recent UN publication[7].

To maximise the assistance an IRSI can provide to small and medium sized firms, the institute must be able to determine what are their most urgent needs.

To this end, feedback information from two of the IRSIs most important routine technical services, i.e. the Technical Information Service and the Extension Service is invaluable.

Technical Information Service. The Technical Information Department is one of the most important in any IRSI. It must be able to collect information from various sources - not least from its own library - and also store, retrieve, interpret and disseminate it. In the provision of these services, the department will require copying machines, microfilm readers, etc. and be able to arrange for the speedy translation of papers published in foreign languages.

The more sophisticated ones will be able to abstract relevant papers and record all available sources of information on specific subjects and in association with the Institute's technologists, issue at regular intervals, summaries of information of use to specific industries.

A very important function of this department is to provide an industry enquiry service to answer questions raised by industrial companies, government departments, financial institutions and the business community.

This service is normally provided by a special unit working in close collaboration with the IRSI's industrial liason unit. If properly operated it provides to the institutes management an invaluable source of feedback information as to the needs of indigenous industry.

Extension services. One of the weaknesses of IRSIs in many developing countries is the lack of effective industrial liason and technical extension services. Such services have proved to be very effective in agriculture where most problems facing farmers are known, and although this is not the case in manufacturing industry, it has been found that an IRSI "industrial liason officer" (ILO) with responsibility for frequent visits to industrial firms, can, if versatile and technically qualified (usually a chemist or an engineer) and backed by his IRSI, perform a number of valuable functions.

In general an ILO's duties should include :

- to visit local manufacturing and processing firms to acquaint them with the facilities available at the IRSI and the relevant work being carried out at other local and foreign research organisations.
- to ascertain and discuss the technical problems with which the company being visited is faced.

In the majority of cases the ILO should be able to give an answer to the latter immediately. If he cannot he must ask the IRSI's Technical Information Department to supply one from its records or by discussion with the appropriate staff member. For advice of this nature, no charge should be made.

If however, experimental work has to be carried out to provide an answer, then an estimate of the cost must be made, and if this is accepted; the report prepared on completion of the work should be sent to the client by the ILO so that he can maintain personal contact. The ILO should also ensure, that the industrial client is satisfied with the service provided by the IRSI and has been able satisfactorily to use the information provided.

Whilst such public relations devices as promotional literature, open days, conferences, etc. are valuable, experience has shown that the part played by an IRSI's information and extension services, and by personal contacts in the commercialisation process cannot be over emphasised.

Demonstration units. In the event that the IRSI is unable to interest any company in the industrialisation of one of its products or processes during laboratory development, a technique used by some IRSI is to erect and operate a pilot plant itself and use it as a demonstration unit. This is an expensive operation but does have certain attractions. Firstly the operation of a small scale plant as a demonstration unit, besides being useful as a means . "selling" the idea, provides a sufficient amount of the product to be able to undertake limited customer-acceptability and toxicological tests and market surveys, and to accumulate useful processing and engineering data. In other works, the demonstration unit enables the institute to provide the "package deal" preferred by most entrepreneurs in developing countries.

Secondly it is of particular value to small and medium sized firms; who have neither the skills nor facilities to do the development work themselves, and who not infrequently purchase the IRSI's pilot plant to manufacture the relatively small amount of product their business requires.

This technique has been used by several countries in the region. The following shows how the method has been used with success on the national scale in Pakistan.

PCSIR pilot plant operations. In the mid 1950s there were few manufacturing companies in Pakistan sufficiently large and sophisticated to be able to carry out their own research or implement the research findings of others. To meet this situation, the constituent research institutes of PCSIR embarked upon a number of pilot plant studies or processes developed in the laboratory for the manufacture of products for which there was a known need. These were of two types: first, those designed and fabricated for a specific process or purpose (silica gel, terpene hydrate, terpiniol, "Petkolin" pesticide and guanidine nitrate): and second, studies using standard unit operations equipment (waterproofing compositions, sulphur dyes, nicotine sulphate, opium alkaloids, polystyrene foam, high-protein foods, etc). Many of these processes were subsequently leased out. In the late 1960s, with the growing strength of Pakistan industry and PCSIR itself, the latter was able to take a more positive attitude towards the commercialisation of its research findings, resulting in the successful methodology currently in use

When laboratory-scale work has been completed, a preliminary report is prepared and circulated widely through PCSIR's own Bulletin, and Chambers of Commerce and Industry,in an effort to find someone willing to finance pilot plant development or take the process direct to the utilisation stage. If this fails, and the process is still considered commercially feasible, it is scaled up in the Pilot Plant Design and Development Division in the Karachi or Lahore laboratory. On completion of this work, the process is advertised in the technical and lay press, and applications are screened by a review committee which awards the process to the most suitable applicant. Sometimes details of the process and product and the pilot plant itself are given or sold at cost to the successful applicant, or alternatively a non-exclusive, royalty-free transfer is arranged.

This strategy has been followed during recent years in the case of 55 processes involving a total investment of 25 million rupees.

It is almost impossible to assess the impact of the work of a government aided IRSI on the national economy, because an assessment in quantitative terms is extremely difficult to make as well as there being many hidden benefits.

One such attempt was made however in 1974 when it was estimated [8] that the annual combined turnover of 134 Pakistan manufacturing operations based on PCSIR technology during the period 1953 to 1973 was Rs 33 million resulting from an estimated research expenditure of Rs 101 million. Insufficient data were provided to enable a check on these figures to be made nor was any assessment of profitability given.

F. NATIONAL TECHNOLOGY POLICIES REGARDING COMMERCIALISATION INCLUDING INCENTIVES AND PROMOTION LAWS.

It would seem that few developing countries in the ESCAP region have policies specifically designed to encourage commercialisation of research results, or offer incentives to that end.

As will be seen from the following assessment of the situation in three countries in the region, there are definite moves in that direction.

India

The Government of India's "Technology Policy Statement" (Dept. of Science and Technology, New Delhi January 1983) contains the following statement under the heading "Fiscal Incentives".

"Suitable financial mechanism will be established to facilitate investment on pilot plants, process demonstration units and prototype development in order to enable rapid commercial exploitation of technologies developed in laboratories. Linkages between scientific and technical institutions and development banks will be strengthened. Fiscal incentives will be provided in particular to: promote inventions: increase the use of indigenously developed technology and enhance in-house R & D in industry".

As already mentioned, NRDC of India has been actively involved in commercialisation for over 30 years.

Republic of Korea (ROK)

Although ROK does not have an integrated official policy on the commercialisation of research results, it has two organisations backed by the government - K-TAC and KDIC (described earlier in this report) - set up for the purpose.

Pakistan

Although Pakistan, like ROK has as yet no official policy on commercialisation, (its draft National Science Policy is currently under review), through the medium of the Pakistan Council of Scientific and Industrial Research (PCSIR) it has for many years placed great emphasis on the need for its research findings to be utilised.

The following extract from a PCSIR publication,[9] indicates how this is effected.

"When laboratory work was completed, a preliminary report was prepared and circulated widely through Chambers of Commerce and Industry. by means of bulletins in order to find parties willing to finance pilot plant development or take the process directed to the utilisation stage. In case this did not succeed and the process was considered commercially viable, it was scaled up using its (PCSIR) own resources and the process thereafter released to industry". Since 1974, the Federal government has released substantial funds for major pilot plant studies.

G. MECHANISM FOR REGIONAL COOPERATION TO ACCELERATE COMMERCIALISATION

Multi national cooperative research; particularly of a type to help industry is extremely difficult to organise. One of the main reasons for this difficulty is that manufacturing industry in mixed economy countries - as are most in the ESCAP region - is by definition, competative. This means that, with rare exceptions, cooperation can only be effected when the research to be developed has national or regional, rather than commercial value.

In its literal sense "commercialisation" usually means the development of a product which can be manufactured and sold at a profit. In the context of the present Workshop it is suggested that the definition should be broadened to cover the development of products or processes which, if used or implemented, would benefit the national economy.

1. Existing regional organisations.

On this basis, it is helpful to examine the operation of such organisations as already exist in the region : whose aim is to organise cooperative research in a particular field in several countries, in such a manner that the end result is of benefit to all the countries involved and suggest how they could possibly be improved.

The most important of these are :

(a) Association of Science Cooperation in Asia (ASCA)

(b) ASEAN's Committee on Science and Technology (COST)

(c) Regional Centre for Technology Transfer's Technological Network Programmes.

(a) ASCA is an intergovernmental body with twelve supporting nations: Bangladesh, Burma, India, Indonesia, Japan, S.Korea, Malaysia, Pakistan, Philippines, Sri Lanka and Thailand.

ASCA has no permanent secretariat and holds meetings in alternate years in one or other of the member countries. Its deliberations appear to be general rather than specific, and it is generally considered to be too large and too political, effectively to stimulate joint research.

(b) ASEAN/COST COST is one of nine specialist committees and is supported by five countries in the region : Indonesia, Malaysia, Philippines, Singapore and Thailand : unlike ASCA it has a permanent and effective secretariat.

Although in the past it has been slow in developing joint research projects of ultimate application value, it is currently processing four joint food/nutrition research project - supported by Australian government funds - as well as a major non-conventional energy cooperative research project involving laboratories in all five ASEAN countries.

(c) ESCAP/RCTT : Technological Network Programmes. RCTT "is engaged in establishing technological network programmes in technologies identified as important and relevant to the countries of the region".

Amongst the programmes being implemented are : -

- Electronics
- Food processing
- Leather processing
- Low cost building materials
- Medicinal and aromatic plants
- Rice husk cement
- Sponge iron
- Design engineering capabilities
- Machine tools and metal industries
- Building capabilities
- Industries based on local resources.

These network activities involve "the identification and bringing together of R & D and other institutions involved in the specific activity under the auspices of RCTT to formulate a plan of action which includes assignment of responsibilities amongst the participating institutions". The progress of these programmes is reviewed at joint meetings, so that everybody will know what has been done, be able to assess progress and offer suggestions for further work. At the conclusion of the activities identified, it should be possible for all institutions and countries to share this experience and utilise the results of the R & D for establishing the industry in their own countries.

The first network programme to be completed has resulted in the development of a rice husk cement industry in several ESCAP member countries.

In addition to the multinational cooperative projects stimulated by the above intergovernmental bodies, there are also a number of bilateral cooperative projects in the region. Typical of these are those operated jointly by KAIST and TISTR, Bangkok, and LIPI,Jakarta respectively concerned with the development of high nutrition, low cost foods using Thai indigenous resources in the first case and the extraction of nickel from low grade Indonesian laterites in the second.

2. Successful organisations outside the region

As the efforts of ASCA, COST and RCTT have so far met with only partial success, UNIDO/ESCAP may wish to examine two techniques used successfully in the Western World to assess their applicability, or otherwise, to the ESCAP region.

The first of these, developed by the five Scandanavian countries [10] is operated by the Scandanavian Council for Applied Research (NORDFORSK) founded in 1947 " to promote and organise cooperation in the field of scientific and technical research and the utilisation of research results between the five Scandanavian countries".

The members are the Chairman and Directors of the Scientific and Industrial Research Councils and Academies of Engineering Sciences in the five countries and the small permanent secretariat is based for four year periods in rotation amongst the five Scandanavian capitals.

NORDFORSK, which has no laboratories of its own, draws up a research programme annually which is carried out by appropriate laboratories in the individual countries using local facilities and finance. The results obtained are shared and wasteful duplication of effort is avoided. The decision as to whether, and how, the research results thus obtained should be utilised is left to the member governments.

Amongst the projects initiated by NORDFORSK in recent years are the following : air and water pollution; fibre re-inforced composite materials; creativity problems and foundry research.

The second technique which might be worth examining is that developed and applied successfully by the Organisation for European Economic Cooperation (OEEC) and its Paris based successor, the Organisation for Economic Cooperation and Development (OECD), over the period 1954 - 67.

This has been described in detail in two UN publications[11,12] but can be summarised as follows :

Under the aegis of OECD's Committee for Scientific Research (CSR) cooperative research groups were set up consisting of national experts in the field of interest.

The experts were nominated by the CSR delegates of the countries interested in the project, and at the first meeting of the group of experts they elected their own chairman, and after examining the state of research on the topic in each country represented at the meeting, a coperative programme of applied research was drawn up by the experts. Each offered to do part of the work for which his country or laboratory was particularly suited. The national experts attending these meetings, represented their governments and knew in advance to what extent they could commit their respective laboratories. This was important as the cost of the research undertaken in such programmes was borne by the participating countries or laboratories. OECD's contribution was only to act as catalyst, and provide the venue for meetings - usually at its Paris headquarters - and the secretariat,including interpreters.

The agreed programme was carried out in the individual laboratories and at regular, usually six monthly, intervals, further meetings were held to review progress and modify the programme if found necessary.

It is always difficult to measure the benefit obtained from research in a company or country: this is equally true in the case of international cooperative research.

However in the case of OEEC/OECD's 23 year programme it is possible not only to identify a number of significant successes (c.f. low-shaft blast furnace, biological fouling of ships hulls, metal fatigue, water and atmospheric pollution, aircraft and industrial noise and road research) but also to assess the accrued benefits in a more general way.

It has been estimated that the involvement of 1200 - 1500 scientists and technologists in 500 laboratories on 50 - 60 OECD/CSR cooperative projects during the period 1965-7 was equivalent to the establishment of a very large, interdisciplinary research institute with an annual budget of over US $10 million.

What is perhaps more important is that all this was done without having to erect expensive buildings or purchase costly equipment and without disruption of the scientific community.

It would seem that insofar as the initiation and coordination of international cooperative research projects aimed at benefitting the national economies is concerned, RCTT and ASEAN/COST unwittingly are starting to function like OECD/CSR. They differ however in the way the cooperative projects are financed. It would therefore, obviously be to their advantage, to examine in detail the development and operation of the idea by OECD to learn from its experience in handling hundreds of cooperative research projects - and utilising the results therefrom - over a period of 23 years, what techniques lead to its undoubted success and what mistakes were made and hence should be avoided.

H. ROLE OF UNIDO and ESCAP

Of the many recommendations made at the November 1975 Korea/Japan Workshop on the Commercialisation of Industrial Research Results, perhaps those most worth re-iterating are that UNIDO should -

- encourage regular contacts between IRSIs in the region.
- arrange at regular intervals Workshops similar to those held in Korea/Japan in 1975 and due to be held in Bangkok in October 1984.
- help member governments establish regional cooperative research programmes.
- prepare, in collaboration with other relevant international organisations, a guide based on experiences in the commercialisation of research results.
- assist developing countries in the region in setting up information systems, training programmes, R & D policies, mechanisms for financing the commercialisation of research results, and linkages between IRSI in developing and advanced countries.

In addition to the above, UNIDO/ESCAP could play an import role in helping IRSIs commercialise their research findings by persuading ESCAP member governments to -

- actively promote collaboration between IRSIs and industry.
- place development contracts with national IRSIs.
- provide fiscal incentives and direct grants, particularly to indigenous firms, to commercialise the most promising IRSI research findings.
- encourage the development of local consulting engineering organisations,
- encourage indigenous IRSIs to undertake as much work as possible - for government and industry - for payment under contract.

- establish an "industrial seed corn fund" to support the infra structure required for industrially financed applied research. This fund should provide a sum equivalent to say 25% of the money earned by an IRSI through contracts and consultancies with investigations for the public and private sectors.

It is further suggested that ESCAP should examine the possibility of improving the effectiveness of existing cooperative research organisations in the region by applying some of the techniques successfully developed by OECD/CSR and by NORDFORSK.

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APPENDICES.

Selected case histories of successful commercialisation of IRSI research results.

1. INDIA.(NRDC). Benzyl Chloride.
2. Japan.(JDRC). High purity iron oxide by chlorine process.
3. Pakistan.(PCSIR). "Jutoid".
4. United Kingdom.(NRDC). Cephalosporin.

Case history No. 1 - NRDC of India.

BENZYL CHLORIDE.

Benzyl chloride is an important intermediate for a variety of chemicals, such as phenyl acetic acid, phenylacetamide, phenobarbitol, benzyl cyanide, pathidine, amphetamine, benzyl alcohol, benzoic acid and benzoate. These chemicals find extensive application in pharmaceuticals, perfumary, textile chemicals, dyes and intermediates.

Benzyl chloride is usually obtained by chlorination of toluene in the presence of actinic light, the reaction being carried out to the extent of 30-60% only. The unreacted toluene and benzyl chloride are then isolated by distillation of the crude mixture which leads to decomposition and/or polymerisation thus affecting the yield of product.

The process developed at the Regional Research Laboratory (RRL) Hyderabad overcomes this problem by introducing an inorganic or organic base in the reaction mixture during, or after, the removal of dissolved hydrogen chloride. As a result, a yield of up to 90% of the theoretical value is obtained and a purer product.

RRL has carried out work on a pilot plant scale of 200kg./day. The main raw materials required are toluene and chlorine. Based on this process, two plants are already in operation in India having a production capacity of 15 MT a year.

Case history No.2.

RESEARCH DEVELOPMENT CORPORATION OF JAPAN

High Purity Iron Oxide by Chlorine Process (Success)

Source: Tokyo Institute of Technology
Development cost: 77,100,000
Development period: 3 years and 3 months

Aim of the project:

The project aims at the production of high purity fine iron oxide by combined process of chlorination and oxidization. This fine iron oxide provides the material for a high quality ferrite.

Process of Development:

Scrap iron is chlorined at 450-500°C to obtain gaseous crude ferric chloride from which impurities are eliminated by the difference of boiling point of impurities. The refined ferric chloride obtained by the refining process is oxidized by hot air to produce the high purity fine iron oxide.

Although we obtained satisfactory results at the chlorination and refining processes, yield of iron oxide at the final process was not so good as expected and considerable impurities from the equipment were mixed.

Development was focused on correcting the defect of incomplete reaction on the oxidizing process; the development was turned back to a basic study on the oxidizing process itself.

As a result, it was ascertained that the reaction in dry state makes the reaction temperature high and mixture of impurities from material of the equipment increases.

The bottleneck of the development was cancelled by addition of moisture to the air at the oxidization.

Thus the hoped-for targets in purity and particle size of the iron oxide were attained.

Case history No.3.

Development of "JUTOID" matting for roof water-proofing by the Pakistan Council for Scientific and Industrial Research.

The problem of producing 'rubberoid' type of material for water-proofing of roots was referred to PCSIR by the Ministry of Defence.

Work on the laboratory scale was restricted to evolving a bitumastic composition in which jute fabric could be impregnated to give the desired product. On completion of this phase, pilot plant with a capacity to product 8000 ft^2/8 hrs was designed and fabricated at a cost of Rs. 15,000.

About 30 batches were taken out over a period of 10 weeks and despite all variations in the coating, humid temperature and composition of the molten mass used for impregnation, not a single satisfactory sample was obtained.

Success was finally achieved when a very unusual method - that of direct spraying of water on the "jutoid" sheet as it came out of the impregnated mass gave a much better product, than that obtained on the laboratory scale. Eventually this process was commercialised and incidentally gave the largest financial return to PCSIR over the years in the form of royalties.

Case history No.4. United Kingdom (NRDC).

Cephalosporin

The cephalosporin story started in Sardinia soon after the second world war when there was a worldwide search for antibiotic producing organisms following the stimulus provided by the isolation and use of penicillin. The late Professor Brotzu of the University of Cagliari found, in a local sewage outfall, an organism that in simple experiments displayed anti-bacterial properties. The organism, a cephalosporin fungus, reached the late Lord Florey at the Sir William Dunn School of Pathology, Oxford University, in 1948 via Dr Blythe Brooke, an ex-British Medical Officer of Health in Sardinia.

The production of the antibiotic material by fermentation, its isolation, and chemical structural work on purified material, were undertaken by Professor F P Abraham and his colleagues at the Sir William Dunn School in association with a team at the Medical Research Council's (MRC) Antibiotic Research Station at Clevedon, led by Mr B K Kelly. The MRC, in addition to funding all the work at Clevedon, also financially supported the work at Oxford as did NRDC later on in the project.

The organism proved to be remarkably versatile, producing not one but at least seven different antibiotics. The most interesting was a substance called cephalosporin C — observed first in 1953. It was non-toxic, had a substantially wider anti-bacterial spectrum than the penicillins available at that time and indeed appeared to have a close chemical similarity to them. It was also active against penicillin-resistant organisms which were an increasing danger in hospitals and it did not produce allergic side-reactions which are observed on occasions in patients undergoing treatment with penicillin.

The Brotzu organism produced such minute amounts of cephalosporin C that it was impossible to produce adequate quantities to enable the research work to continue at a reasonable speed. Consequently in 1956 NRDC sought the help of the British pharmaceutical industry who could bring to bear all the variety of skills and facilities which had been developed for the production of the well established antibiotics such as penicillin and streptomycin. At that time only Glaxo Laboratories was willing to help. Even so, because of the problems posed by the handling both of the organism and the cephalosporin C end product, the production of the larger, albeit still very modest (100 gramme) quantities then required, proved to be a formidable task even for the combined resources of the MRC Station and the industrial company.

NRDC generally co-ordinated the collaboration it had now established between the Oxford University, MRC and Glaxo workers and by 1958 adequate quantities of material were forthcoming. Soon afterwards, Professor Abraham and the late Dr Newton elucidated the total chemical structure of cephalosporin C. Professor Dorothy Hodgkin and her colleagues, also working at Oxford University, confirmed it using sophisticated X-ray crystallographic techniques. All this work justified the earlier assumption that cephalosporin C was chemically similar to but nevertheless very significantly different from the penicillins.

The level of anti-bacterial activity of cephalosporin C itself was very low. Thus, in spite of the important biological properties referred to above, had it proved impossible to increase its activity by chemical modification, it was probable that cephalosporin C itself would have had only restricted use in medicine eg. against the dangerous penicillin resistan .

Cephalosporin *continued*

staphylococcus organisms. Modest progress had been made in this direction even before the full chemical structure was known. However, of fundamental importance to the potential future use of the cephalosporins was the dramatic demonstration by Professor Abraham and Dr Newton that cephalosporin C could be degraded to a so-called 'nucleus' 7-ACA (7 amino-cephalosporanic acid) and that a variety of different side-chains could then be attached to this nucleus producing many new cephalosporins with substantially enhanced cativity and even with improved anti-bacterial spectra compared with cephalosporin C itseif. These findings confirmed that there was considerable medical and commercial potential in what could now be identified as a new and probably large group of antibiotics.

NRDC protected all these results, to the extent that they were inventive, by filing patents on a worldwide basis and much (other than relevant) information was retained as knowhow. Nevertheless, because much of the work had been and was still being undertaken in a university academic environment and over a long period of time, it was inevitable that the majority of it would come into the public domain relatively quickly through publication in scientific papers, albeit not until patent protection had been filed. Recognising this and the very substantial development problems still requiring solution before serious attempts could be made to identify and develop commercially useful end products and related manufacturing processes, NRDC from 1959 onwards was concerned with developing a worldwide licensing strategy to maximise the UK public benefit as well as that of the Corporation.

Over a period of time it was decided to grant a number of options of limited duration for generally non-exclusive licences. Five were granted in the USA, two in Europe, one in Japan and one other in the UK in addition to the licence granted to Glaxo. Few of these companies, apart from Glaxo, made significant progress that was commercially relevant at that time. Eli Lilly (USA) made very important breakthroughs early on in respect of both process technology and end products, and later on the Japanese company, Fujisawa, also developed useful end products. In the event, Eli Lilly, Smith Kline and French (USA) and Fujisawa became licensees in addition to Glaxo, but it was 1964 before the first medically useful cephalosporin antibiotics were marketed. These were injectables and it was even later, 1969, before products capable of being taken orally were launched.

Subsequently a number of other companies have become licensees of NRDC. All of them have now made their own contributions to improving the manufacturing technology and or in developing new medically useful cephalosporins. About a dozen different cephalosporins are now in use or under clinical trial. As a group they perform a major role in the treatment of bacterial infections in humans, being not only very effective but also extremely safe drugs.

Annual world sales of cephalosporins now exceed those of the semi-synthetic penicillins and amount to more than £600 million. Cumulative sales based on UK manufacture by Glaxo exceed £275 million, a large proportion of which (95%) has been for export. NRDC itself has already earned more than £50 million in royalties. The inventors have benefited substantially from the Corporation's royalty income through revenue sharing arrangements between NRDC and the Oxford University inventors and through awards made by the

MRC to its workers. The Oxford inventors have set up trust funds through which a substantial proportion of their income is made available for the support of medical and biological research.

In addition, as a *quid pro quo* for giving overseas licensees access at an early stage to existing NRDC inventions and knowhow and undertaking a commitment to include also any future patents and knowhow that it might acquire, NRDC was able to negotiate access for NRDC's British licensees to overseas licensees' development patents and knowhow, on a cross-licensing basis on advantageous terms.

NRDC has obtained in the High Court substantial extensions of term for both of its basic UK patents—six years for the original cephalosporin C patent and four years for that concerned with the nucleus. In obtaining these extensions the Court set new guidelines by which extensions of term may be granted based on the concept of inadequate remuneration, and a number of pharmaceutical companies have subsequently presented similar cases to the Courts.

While NRDC's extensive cephalosporin patent portfolio has been decreasing over the last few years as patents expire with time, one or more of the basic patents will persist until 1982 in some major countries such as the USA. Potentially, therefore, substantial further royalty income can still be anticipated for some time to come.

Penicillin, discovered and isolated first in the UK, was unprotected and during the war its development and large scale production were necessarily and very advantageously undertaken in the USA. Consequently its commercialisation was controlled in the patent and knowhow sense from outside the UK for some years after the war. By contrast, the cephalosporins and related knowhow were well protected from the beginning and were licensed early in their life, ensuring not only royalties to NRDC but also a substantial flowback of knowhow and access to overseas development patents for the benefit of the UK.

The cephalosporins are already one of the largest royalty earners ever to have emerged from academic research and represent an excellent example of the type of basic invention that NRDC was expected to handle when it was established in 1949. □