CASE STUDIES ON INDIGENOUS
INDUSTRIAL R & D UTILISATION

Prepared by

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INDIGENOUS R&D UTILISATION: CASE STUDIES ON INDIAN INDUSTRIAL SECTOR

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CHAPTER I

UTILISATION OF INDIGENOUS R&D: A SYNOPTIC VIEW
I. OBJECTIVES OF THE STUDY

In the early meetings of the consultative group and the discussions among consultants, the following objective of the study emerged, which was to guide the case writing work:

".....to analyse the technological, managerial, commercial, environmental and other factors governing utilization of indigenous R&D activity in India and to draw conclusions relevant to faster, effective and widespread utilization of new technological developments."

II. BACKGROUND

There have been many studies of transfer of technology in India: some, by those involved in R&D function, users and managers.

Perhaps the most interesting was NISTADS' work (1984) on 'Transfer of Technology from National Laboratories to Industry'. This was modelled on the international pattern of comparing successes and failures and finding reasons for each: very much on the lines of SAPPHO investigations in the 1970's.

The NISTADS' work undertook 17 case studies, pairs of
successes and failures mainly to understand the strengths and weaknesses of the CSIR laboratories. The findings adding greater insights into the management process in these institutions.

Seventeen cases is a small number and one option was to choose a larger statistically significant number to validate NISTADS’ findings. We rejected this approach and thought that it would be more useful to adopt a policy format of enquiring into alternate structures of technology transfer used in India and try to understand the process of what happens in organisations when they successfully (or unsuccessfully) convert research findings into commercial activity.

In all our deliberations we were conscious of the external factors that critically influence both the structure and process in a regulated ambience of Indian Industry; but perhaps we were not quite prepared for its significance which the case studies brought into focus.

Being strategy-structure-process oriented, our enquiry resulted in a small number (11) of case studies which enquired in some depth as to what happened in specific situations. The critical factor was not numbers but attempt at recording the reality in the organisations and when more than one was involved, also at the interface.
If one were to put it differently, it was an inquiry into the interaction that take place between the "worlds of learning and practical action which continuously changes the frontiers between discovery and practice".\(^2\)

III. SAMPLE CHOICE

Being a "non-quantitative" study, the choice of the sample was a purposive move to cover a wide range of technology levels from the simple to the complex. The industries chosen reflected in some ways the level of state of the art.

They also reflected the production structures which was popular in each segment: whether it was highly organised as in the case of Automobile and Steel industries or small and scattered as in the Building industries. The ownership factor, whether it was private or state-owned also got its share of attention.

Appendix II gives a list of case studies undertaken.

Each case study drew on the expert knowledge and long association of each consultant with particular situations. The consultants not only helped to identify critical issues, important contacts, informations but also participated in field visits and discussions. This enriched the work considerably.
IV. METHODOLOGY

As case writing was the core of the activity, field visits and discussions with key persons become as important as collecting background information from secondary sources. To help our discussions we prepared an indicative questionnaire which was more a checklist for us than one which we asked the respondent to fill in.

Appendix III gives details of the questionnaire.

It was not always possible to get answers for all the questions we raised, partly due to lack of information, unwillingness and confidentiality. Perhaps our greatest payoff was in getting key actors "talk" about what they thought had happened in individual cases of technology transfer. They would certainly not be "objective" but the 'bias' could give us insights into the process which is what we found was learning.

V. RESEARCH ISSUES

Review of literature indicates that technology transfer could be described as a multilateral flow of information and options which at specific turning points take the shape of formal programmes of action e.g. design documentation, process parameters, marketing and advertising plans. These flows are not unidirectional.
Along with turning points there are critical stages where stop-pend-go decisions get taken which determine the successful onward movement of the process.

These decisions are results of interactions between many actors in the game, each with a unique utility function, language, blind spots and propensity to synergistic action. The understanding of the process of negotiation at the critical stages is a very useful input for deeper insights. As far as we know, there are not many studies of this kind, at least in India.

Apart from issue of process, there are also problems of structure. It seems possible to identify five distinct activity segments spanning the entire area from the sparking of an idea to meeting consumer needs. Each one of these is a distinct managerial job. Each has a specific organisational structure, strategy, skill requirement and conflict resolution style. The following table illustrates the complexity:

<table>
<thead>
<tr>
<th>SEGMENT</th>
<th>OUTPUT</th>
<th>OBJECTIVE</th>
<th>STYLE</th>
<th>CRITICAL FACTORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. RESEARCH</td>
<td>-Blue print</td>
<td>-Unique prototype solution</td>
<td>-Wide ranging</td>
<td>-Information intellectual intercourse</td>
</tr>
<tr>
<td></td>
<td>-Pilot Plant</td>
<td>-Successful production scaling up</td>
<td>-Methodical debugging</td>
<td>-Understanding process/equipment limitations</td>
</tr>
</tbody>
</table>

5
Appendix IV gives a model, the validity of which the case studies would test out.

VI. FINDINGS

The case studies have brought out a rich crop of insights (each one could be converted into a monograph) for the policy makers but the most significant relate to:

- The significance of adaptative innovation
- Multiple perceptions of research findings
- External factors and successful utilisation of R&D
- Alternate models of structure
- Risk evaluation
- Partial success and policy
ADAPTATIVE INNOVATION

Our case studies indicate that the bulk of R&D effort in India was adaptative than original innovative. This is not as value judgement on our research but to hypothesise that adaptative research model has its own unique set of demands for its success and is not the same as similar to the classical model of invention - innovation - commercialisation.

For example, the successful adaptative research needs an ability to spot a development that has promise, in the world of science and technology. This needs multiple skills of understanding technology as also business. The spotting is not, and cannot be, left to the prospective commercialiser of R&D. For example, in our study of Coco Butter substitute the role played by the R&D group in giving a distinct turn to product development: or the problems encountered in fly ash utilisation by CBRI researchers.

Finding solutions to problems posed by the clients is not a familiar home ground for researchers.

The policy issues perhaps revolve round the sensilisation of researchers to entrepreneurial requirements; the clients understanding of selection of probable successful areas; and, equally important, a structure where such exchange is possible and is encouraged.
Our studies indicate that where it existed, the process was one step nearer success.

Then, where does 'invention' take place? Does it, or more appropriately, should it take place in the Universities, unrecognised 'skunk shops' referred to in the literature on excellence, which are 'havens' of creativity where at the most a small group works at its pace, apparently unconnected with main stream R&D activity.

The links between invention - adaptative innovation and the R&D Utilisation structure needs some rethinking, particularly the place of Universities or Institutes of Technology (Indian IITs for example).

MULTIPLE PERCEPTIONS OF RESEARCH EFFORT

This is not a new fact or finding. In a complex chain of relationships perception do vary. But what is significant is the criss-cross of interests, subjective opinion and substantial conflicts of interest that our case studies threw up.

An indication of the complexity is given in the table below:
<table>
<thead>
<tr>
<th>Researcher</th>
<th>Risk Taker</th>
<th>Implementor</th>
<th>Policy Maker</th>
<th>Consumer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fly Ash</td>
<td>Solution to a national problem</td>
<td>Cost benefits are not attractive without acceptable subsidies</td>
<td>How to provide a good research idea</td>
<td>See no distinct USP</td>
</tr>
<tr>
<td>Cocoa butter</td>
<td>Have found a product</td>
<td>Yes. There are many bugs in it. We have patience</td>
<td>Research needs production sensitisation</td>
<td>Good export potential but are we paying a fair price to tribals? Suspect unequal sharing of benefits</td>
</tr>
<tr>
<td>Sponge Iron</td>
<td>1. Have found a viable process</td>
<td>Some willing to take risk: They suspect viability</td>
<td>Shop floor practice belies research claim. Need much more work</td>
<td>Too selective a raw material demand. Risk takers asking too many subsidies</td>
</tr>
<tr>
<td></td>
<td>2. Have improved the process we have bought</td>
<td>Recognise adaptive research. But selectivity remains</td>
<td>Took a long time to solve the problem. But we did</td>
<td>Makes too many demands on the system</td>
</tr>
<tr>
<td></td>
<td>3. Have a process for the small man</td>
<td>Not sure</td>
<td>Not tried yet</td>
<td>Would prefer to watch</td>
</tr>
<tr>
<td></td>
<td>LCV Engine</td>
<td>Not sure. Further development by foreign research group. Lets try alternate use</td>
<td>Let us use it in a tractor</td>
<td>Mkt. forces seem to push towards efficiency. But this is no original research</td>
</tr>
<tr>
<td></td>
<td>1. Have a product</td>
<td>2. Have two options</td>
<td>Let us try the longer term option. Delay is acceptable</td>
<td>Not yet tried</td>
</tr>
<tr>
<td></td>
<td>Both options seem to be attractive</td>
<td>Let us try the longer term option. Delay is acceptable</td>
<td>Wait and watch</td>
<td>Not yet tried</td>
</tr>
</tbody>
</table>
3. Have a product. It makes a good fit in Operation. Quite good Acceptable. It is just the complete product. Yes, but not the state of art. Could do with improvements.

one component of a complete product. Yes, we will try it inspite of its drawbacks.

<table>
<thead>
<tr>
<th>Rifa-mpinic</th>
<th>Have a product</th>
<th>MNC pricing policy makes the research solution un-economic.</th>
<th>Costs are higher than imports</th>
<th>There is a conflict. What price indigenous research?</th>
<th>Should I pay higher for indigenous research?</th>
</tr>
</thead>
</table>

The conflict of interest these case studies throw up are of two kinds: those which needs to be sorted out within the organisation or between organisations involved in the process, and those which needs support of the wider society.

Even 'successful' research utilisation needs subsidies (e.g. spongeiron), protection (chlorosilanes), not to speak of the immediate and ultimate consumer interest as in the case of Rifampicin where a leprosy patient would ask "what is the price I have to pay for Rifampicin if it were from indigenous research?"; and equally valid entrepreneurial question "should society not pay for development of technological self reliance?"

The first type of conflict is familiar to managers as they have successfully worked out coping mechanisms. The
in-house research model has its share of frayed tempers: inability or unwillingness to see another point of view. Inter organisational stone walling is a well documented phenomenon.

Our case studies point out that conflict resolution of this sort needs a formal forum where these are sorted out, accepted as reality and solved (may not be to the satisfaction of all - solved none the less). This is possible if the system provides or throws up a 'product (R&D here) champion'. He could be from any of the participating teams (organisations). Failure is where there is neither a forum nor a person.

The second type of conflict is more difficult to resolve because it involves considerations of Political Economy. The best one could suggest is a sensitive public debate which gently (or not so gently) nudges decision makers to move.

Conflict is not always undesirable: some amount of jousting is necessary to clear the air of self importance - where actors play from functional strengths. Successful R&D users seem to have handled conflict resolution better.
EXTERNAL FACTORS

At the start of our work we were aware of the importance of Government Policy on R&D Utilisation.

But our case studies highlight its seminal role. Indian Government is committed to encourage and foster indigenous technology and research. Large sums of money are spent and the country has an impressive pool of talent and institutional support (CSIR). However, the interdependencies in a regulated economy can become more than a handful to deal with.

For example, contrary to public postures, in a regulated economy there can be no independent technology policy. It is and will be a part of the regulatory mechanism which consists of policies of:

- industrial licencing: the barriers to entry and exit
- import policy: custom duty structure, the protection - free trade options.
- the law regarding patents: the protection of intellectual property
- price control: the socialist concern about preventing profiteering and providing entitlement of scarce goods to the poor.

While each of them have an accepted societal benefit, the mix is not always synergistic. The policy conflicts do
get solved but perhaps slowly - too slowly for the technologists and the entrepreneurs.

For example, political economy seems to influence all aspects of R&D activity from choice of area (e.g. import substitution R&D), to taxation, to control of competition through industrial licencing.

These issues are not peripheral to successful R&D utilisation. They sometimes make all the difference between success and failure.

Here, there are two policy questions: One, how does one sensitise the inter, intra-organisational systems in enterprises to be sensitive to these issues? Two, how does one generate an ambience where these issues get discussed and decisions taken?

Inspite of considerable political will in the country to support the quantum jump in building technological capability, this interface remains clouded and sometimes unproductive.

The case study examples are Rifampicin and Cholorosilanes, where the import policy converted competent research into a business failure.
ALTERNATE ORGANISATIONAL STRUCTURES

Our case studies provide a rich variety of organisational structures. For example:

- Classical in-house corporate research model of private industry (Hindustan Lever)
- Cooperative industry sponsored research (Automobile Research Institute: Diesel Engines)
- National laboratory - Public Enterprise
- National laboratory - NRDC - private user
- CDot - User (Electronic PABX)
- Technology import (Sponge iron)

The variety of structures encountered was not planned but a result of the sample choice we made (in a way it validates our selection).

There have been both successes and failures in each structure. We feel that while structure is important it is not the main factor which influences the outcome of R&D transfer.

In this, we differ from literature which supports in-house corporate model as the most efficient method of technology transfer.

We have no evidence to say that one model is always better than the other.
All our successful cases have some commonalities such as:

- the existence of a need or a compulsion for using R&D: this could be due to business, political economy, or entrepreneur urge

- asking the right business questions: as distinct from technology or science questions

- formulation of a research proposal in that light

- a technology transfer matrix which is sensitive to science, business and political economy

- formal conflict resolution mechanisms

- a determined progress chaser or a product champion

- a research philosophy; and

- a court of last resort: the final appellate authority.

While structure and process are inter-related, the process issues seem more fruitful for influencing successful R&D outcome.

It is the sensitiveness to the inter-relations, preparedness to anticipate possible disfunctions, and readiness to intervene, which seem to distinguish success from failure.

RISK EVALUATION

Risk is not a concept which excites the R&D work. It is more a managerial or entrepreneurial concept. In our
case studies we found that understanding and evaluating business risks was the most important part of R&D utilisation.

There are five stages in R&D utilisation where risk evaluation needs attention. The following table gives the stages and who could help at these stages:

<table>
<thead>
<tr>
<th>STAGE</th>
<th>WHO CAN HELP</th>
</tr>
</thead>
<tbody>
<tr>
<td>A During the search for options</td>
<td>Some body more familiar with the technology market.</td>
</tr>
<tr>
<td>B Research to Development</td>
<td>Some body less starry eyed than the researcher.</td>
</tr>
<tr>
<td>C Pilot Plant</td>
<td>Some body who asks engineering and equipment questions.</td>
</tr>
<tr>
<td>D Commercial Production</td>
<td>Some body like Technology/Engineering Consultant.</td>
</tr>
<tr>
<td>E Investment Decision</td>
<td>Some body who helps to evaluate commercial risks.</td>
</tr>
</tbody>
</table>

These could be 'inhouse' or 'external' but should be outside the usual decision making matrix involved in technology transfer.

Each stage needs specific expertise which may not be available (even if it is, it may not be adequate) in the formal R&D utilisation structures.
We feel that this is where a formal 3rd party intervention could be of help. Our case studies indicate that if this was available, many of the failures could be avoided.

In a manner of speaking, the suggestion of a third party interface in R&D utilisation is our major contribution to research. We suggest further work in this area.

CONDITIONS FOR SUCCESS

It would be useful to compare the conditions of success we have found in our case studies to the findings of Sappho studies. To quote Rothwell et.al.:

"Five main areas of difference between success and failure have emerged. These are:

1. Successful innovators were seen to have a much better understanding of user needs.
2. Successful innovators pay more attention to marketing and publicity.
3. Successful innovators perform their development work more efficiently than failures but not necessarily more quickly.
4. Successful innovators make more use of outside technology and scientific advice, not necessarily in general but in the specific area concerned.
5. The responsible individuals in the successful attempts are usually more senior and have greater authority than their counterparts who fail."
The differences in emphasis are partly cultural and partly due to the research design we have adopted.

PARTIAL SUCCESS AND POLICY

Literature classifies failure of utilisation for whatever reason, as unsuccessful.

We wonder whether such a sharp distinction does not lose out on understanding the complexity of the process.

We feel that it is possible and necessary to evaluate success at each stage in the process so that timely remedial actions could be taken.

For example, in the fly ash case - working with the ultimate users, in Chlorosilanes case with trade policy makers, and Sponge Iron case with input suppliers and engineering industry.

Each one of these 'failures' or 'blocks' in the system need specific policy remedies. Future policy intervention seems to lie in that direction.
NOTES

1. These meetings were many. Some of them bilateral, others in larger groups. Some of the consultants were also members of the Consultative Group. List of participants is given in Appendix I.

2. Harry Wolf: Basic Research and Industrial Enterprise.

3. We have used the word "innovation" as opposed to "invention", in the manner it is used in literature.

APPENDIX - I

LIST OF INDUSTRY CONSULTANTS AND MEMBERS OF THE CONSULTATIVE GROUP

A. Consultative Group

1. Dr. E.C. Subba Rao
   Director, Tata Research and Design Development Centre

2. Dr. K.N. Johry
   Head, International Scientific Collaboration Council of Scientific & Industrial Research

3. Dr. Ashok Jain
   Director, NISTADS

4. Dr. H.R. Bhojwani
   Joint Adviser, Council of Scientific and Industrial Research

5. Dr. N.C.B. Nath
   Chairman, FAIR

6. Dr. N.P. Singh
   Secretary, Technology Policy Implementation Committee

7. Dr. Amulya Reddy
   Chairman, Department of Management Studies, Indian Institute of Technology, Bangalore

8. Mr. K.V. Srinivasan
   Director, Department of Scientific & Industrial Research

B. Industry Consultants :

1. Dr. C.V.S. Ratnam
   Consultant

2. Prof. B. Nag
   Director, Indian Institute of Technology, Bombay

3. Dr. B.L. Amla
   Director, Central Food Technology Research Institute, Mysore
4. Dr. S. Ramachandran Consultant
5. Dr. Nitya Anand Consultant
6. Dr. R.K. Bhandari Director, Central Building Research Institute, Roorkee
7. Dr. C.G. Subramaniam Consultant
8. Dr. K. Ramachandran Director, Automotive Research Association of India
APPENDIX II

LIST OF CASE STUDIES

1. Fly Ash for Building Material
   - Central Building Research Institute, Roorkee.

2. Cocoa Butter Substitute
   - Hindustan Lever Ltd., Bombay.

3. Diesel Engines for Light Commercial Vehicles
   - Automotive Research Association of India, Pune.

4. Diesel Engines for Light Commercial Vehicles
   - Tata Engineering and Locomotive Company Ltd., Pune.

5. Sponge Iron Process
   - SAIL, Ranchi; NML, Jamshedpur; TISCO, Jamshedpur; SIIL, Hyderabad.

6. Soft Drink Concentrate
   - Central Food Technology Research Institute, Mysore.

7. Rifampicin
   - Themis Labs, Hyderabad.

8. Pyridoxin Hydrochloride
   - National Metallurgical Laboratory, Pune.

9. Chlorosilanes
   - National Mettalurgical Laboratory, Pune.

10. Monocrotophos
    - Regional Research Lab, Hyderabad.

11. Electronic PABX System
    - Centre for Development of Telematics, New Delhi.
ANNEXURE III

INDICATIVE QUESTIONNAIRES

Three indicative questionnaires have been developed, corresponding to the three major stages in the transfer of technology from the lab to the industry, these are:

A. Questionnaire for laboratory/research institution

B. Questionnaire for agency transferring technology from the laboratory to industry

C. Questionnaire for industrial user

The questionnaire are indicative, to be used as a checklist for collecting information on areas of concern. They are not intended to be filled up by the respondents.

A. QUESTIONNAIRE FOR LABORATORY/RESEARCH INSTITUTION

I. General information

1. Nature and affiliations of the organization

2. Principal activities

3. Organisation structure (staff structure, reporting and control, committees etc.)

4. Project initiation, approval, evaluation and monitoring procedures

5. Details of the research team involved in the R&D of the product/process in question

6. Level of involvement of the respondent in the R&D project

II Conceptualization/idea generation

1. Origin/conceptualization of idea/project

   (a) Initiator
   (b) user need
   (c) Inputs
   (d) Motivations
(e) Information availability

2. Aims and objectives of the proposed project/idea.

3. Work conducted before initiation of the R&D project (exploratory research etc.)

4. R&D project proposal:
   (a) Aims and objectives
   (b) Methodology
   (c) Expected output
   (d) Cost estimates
   (e) Time duration
   (f) Industry involvement envisaged
   (g) Inputs in preparation

5. Details of formal project launched
   (a) Date of commencement
   (b) Funds committed
   (c) Source of funding
   (d) Research team
   (e) Key individuals involved
   (f) Approval process
   (g) Involvement of industry/other organizations

6. Perceptions of key individuals on the need, applicability, usefulness and justification of the expected output from the proposed project.

III Research Activity

1. Actual duration of the project

2. Causes for delay if any

3. Project Monitoring:
   (a) Frequency
   (b) Monitoring agency/individual
   (c) Procedure
   (d) Corrective measures

4. Blueprint:
   (a) Time taken from design to blueprint stage
   (b) Difficulties encountered
   (c) Actual output
   (d) Internal evaluation of output
   (e) Parameters for evaluation

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(f) Deviations from proposed output
(g) Implications of the deviation
(h) Techno-economic feasibility and market research:

(i) Undertaken or not
(ii) Agency/individual undertaking it
(iii) parameters for the feasibility study
(iv) Results

(i) Feedback of the results to the laboratory for further research
(j) Mechanism for feedback
(k) Alternations/changes/modifications in the blueprint in view of the feedback of feasibility/market research report.

5. Output of the research activity

6. The major events in research work

(a) Breakthroughs
(b) Problems
(c) Bottlenecks
(d) Others

IV. Development Activity:

1. Team/individual developing the prototype/setting up the pilot plant, commonalities with the laboratory researcher/team

2. Frequency, mode and level of communication/interaction with the laboratory.

3. Time duration for the activity

4. Problems in translation of blueprint into prototype/pilot plant in terms of:

   (a) Scaling up
   (b) Raw materials
   (c) Manufacturing capabilities
   (d) Rated output
   (e) Quality
   (f) Costs

5. Involvement/interaction with the industry and its input in developing the prototype/pilot plant.

   (a) For sponsored research
(b) For non-sponsored research

6. Evaluation of the output:
   (a) Techno-economic feasibility
   (b) Market research
   (c) Parameters for evaluation
   (d) Evaluating agency/individual
   (e) Deviations of the actual output from the proposed/expected.

7. Feedbacks from laboratory and industry; its usefulness in undertaking modifications/alterations in the prototype/pilot plant.

8. Shortcomings/special features of the prototype/pilot plant.


10. Perceptions of the key individuals regarding the final output.

11. The attitudes of those outside the laboratory; their influence and impact.

12. Factors and variables to be avoided and added-on if the research were to be conducted again.

13. Possibilities and ways of doing the same research and development work in a shorter span of time.

14. Contact point in the industry for sponsored research, level and mode of communication.

15. Means, frequency and inclination for communication with the industry in case of non-sponsored research.

16. Degree of difficulty encountered in:
   (a) Research
   (b) Prototype/pilot plant development
   (c) Dealing with research/development team, industry, sponsors management of the lab
   (d) Finance
   (e) Marketing

V Commercialisation of Output

1. Level of commitment/input provided through ideas,
skill and time for transfer of R&D output in terms of:

(a) Identification/evaluation of potential users' skills, resources, technical capabilities and suitability
(b) Selection of potential users.
(c) Demonstration of the capabilities of the prototype/pilot plant

2. Part played in ensuring smooth and mutually beneficial transfer agreement/arrangement.

3. Communication/interaction with the agency entrusted with the transfer arrangements, difficulties encountered; communication gaps.

4. Perceptions regarding short-comings/strong points of the transfer arrangements.

5. Assistance to the industrial user in acquiring technical competence through training programmes.

6. Assistance to the industrial user for modifications in the product/process to suit his need at the construction of production facilities and commercial operations stages.

7. Contact point in the industry at the production stage; problems in communication; inter-personal relationships; information flows and retrieval logistics; frequency of meetings with the industry.

8. Time duration for which active association with the industrial user was maintained.

9. Attitudes of those outside the laboratory regarding interaction with the industry.

10. Perceptions about the role of the intermediate agency in bringing about lab-industry interaction.

11. Motivations for assisting in transfer of product/process.

12. Instances and situations under which specific problems have been referred back from the production and marketing stages; solutions provided; outcome.

13. Perceptions and expectations regarding utilization of know-how by the industrial user in terms of:
(a) Cost control
(b) Technology management
(c) Quality maintenance
(d) Marketing strategy

B. QUESTIONNAIRE FOR AGENCY TRANSFERRING TECHNOLOGY FROM THE LAB TO INDUSTRY

I. General information

1. Nature and affiliations of the organization

2. Principal activities

3. Organization structure (staff structure, reporting and control mechanisms, committees etc.)

4. Process and procedure for acquisition of technology from labs.

5. Key individuals involved in the acquisition, processing and transfer of technology in question from the lab to the industry

6. Involvement of the respondent in the process.

II. Acquisition of technology from the lab

1. Source and channel of information about the product/process developed in the lab.

2. Initial contact with the lab for obtaining the know-how:

   (a) communication with the lab
   (b) contact point in the lab
   (c) key individuals involved

3. Evaluation of the product/process being taken up for commercialization:

   (a) Techno-economic feasibility
   (b) Market-research
   (c) parameters for evaluation
   (d) Evaluating agency/individual
   (e) Involvement of lab researcher/s

4. Interpretation of the feasibility study and market research results; feedback to the lab.
5. Perceptions regarding the commercial and technical viability of the product/process being taken up for commercialization (in light of the evaluation report); expectations from the lab.

6. Work undertaken to redesign/modify the product/process in view of the perceived user needs; inputs from and feedback/communication with the lab in undertaking modifications.

7. Familiarization with the technical and commercial aspects of the product/process.

8. Instances when problems have been referred back to the lab for solution; outcome; solutions provided.

9. Form in which output was obtained from the lab, e.g. blueprint, prototype, pilot plant etc.

III. Identification/Selection of Potential Users; Demonstration of prototype/pilot plant

1. Significant characteristics of the product/process from the user's point of view.

2. Translation of a list of applications into a list of users; comprehensivity of survey; involvement of government agencies/industry associations.

3. Evaluation of users' capability/capacity to assimilate the technology in terms of his:
   (a) Size type (pvt., public sector etc.) of the industrial unit.
   (b) Line of business and its compatibility
   (c) Need of the user for the product/process with the product/process being provided.
   (d) Previous experience with utilization of indigenous technology.
   (e) Availability of skills, manpower, technical competence, financial resources, infrastructure and inhouse R&D facilities.
   (f) Managerial outlook and perceptions regarding risk, industrial efficiency, competitiveness and long term strategy.

4. Arrangements and provisions for demonstration of the prototype/pilot plant.

5. Evaluation of potential users' reaction to the
demonstration of the prototype/pilot plant.

6. Involvement of laboratory researcher in the demonstration process; feedback of users' evaluation to the laboratory and solution of problems.

7. Selection of user/s to whom the R&D output was transferred; criteria and considerations for selection.

8. Perceptions regarding suitability of the selected user/s for utilisation of R&D output.

9. Contact point in the industry; frequency and mode of communication.

IV. Transfer Agreement/Arrangements

1. Guidelines for transfer of R&D output to industrial users.

2. Users to whom the output was transferred (number of users, line of business, technical competence, infrastructure, resources etc.)

3. Details of the transfer agreement:
   (a) Type of agreement (patent-transfer, license)
   (b) Transfer fee and charges
   (c) Key individuals involved
   (d) Provisions for ensuring proper use of the technology transferred
   (e) Built in checks for follow-up action
   (f) Provisions for providing training and assistance in setting up production facilities
   (g) Provisions for ensuring utilisation of technology by the user.

4. Arrangements for interaction of lab and industry.

5. Technical managerial and financial assistance to the industrial user.

6. Time duration from the acquisition of technology from the lab to its transfer to the industry.

7. Major events in the process; problems; bottlenecks
C. QUESTIONNAIRE FOR INDUSTRIAL USER

I. General Information

1. Details about the firm
   (a) Size (assets, turnover, manpower etc.)
   (b) Type of firm (pvt. Ltd., public Ltd., partnership etc.)
   (c) Major line of business
   (d) R&D facilities available
   (e) Major markets (domestic/international)

2. Organisation structure (staff structure, reporting and control mechanisms, communication links between divisions and departments etc.)

3. Previous experience with utilisation of innovations.

4. Motivations/reasons for acquiring new technology; problems with the present product/process.

5. Expectations from the new product/process being acquired regarding
   (a) long term objectives of the firm
   (b) Profitability and growth prospects
   (c) Competitive strengths

6. Outlook and attitude of the management regarding the new product/process.

II. Involvement during Research and Development stages

1. Need for indigenous R&D for specific product/process

2. Communication of needs and requirements to the lab
   (a) Communication channels
   (b) Key individuals
   (c) Meetings, Seminars etc.
   (d) Contact point

3. Sponsorship of R&D activity (Yes/No):
   (a) Financial support
   (b) Infrastructure support
   (c) Information support
   (d) Technical support

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III Manpower training and Development

1. Training requirements for utilization for product/process know-how
   (a) Available skills
   (b) Special requirements

2. Acquisition of technical competence:
   (a) Hiring of skilled personnel
   (b) Training of existing staff

3. Key individuals in the training programme

4. Reaction/response of existing staff to:
   (a) Acquisition of new product/process
   (b) Training programme
   (c) New recruitment
   (d) Conflict resolution

5. Assistance of lab researchers and intermediate agency in training and development of manpower:
   (a) Duration of the training
   (b) Level of training provided
   (c) Provisions for training and development in the transfer agreement
   (d) Commitment of lab/scientist in training the firms employees.

6. Views regarding shortcomings in the training programme.

IV. Construction of Production facilities and Commercial Operation

1. Requirements for additional/new production facilities
   (a) Available facilities
   (b) Additional requirements

2. Resources committed for constructing new plant and machinery
   (a) Financial
   (b) Managerial
   (c) Infrastructural
   (d) Technical
3. Difficulties encountered in setting up plant and machinery

(a) Communication of problem to the lab
(b) Feedback from lab; mode, frequency, channels, problem solution, communication gap
(c) Interaction with/involvement of scientist
(d) Attitudes of Scientist/firms management
(e) Key individuals
(f) Time lapse, causes for delay

4. Problems in productionising the product/process in terms of:

(a) Scaling up, realization of scale economies
(b) Raw materials
(c) Technical defects
(d) Cost control
(e) Quality maintenance and standardization
(f) Time lapse in commercial production, causes for delay.

5. Communication of problems of productionization to the lab and feedback of solutions; channels, mode, frequency of communication.

6. Internal evaluation of output, techno-economic feasibility, parameters for evaluation, modifications in the product/process.

7. Management's expectations from the new product/process, perceptions of its need and suitability in line with the firms strategic options and long term goals.

V. Test marketing

1. Preparation and implementation of Marketing plan.
2. Identification of sample segment
3. Consumers' expectation/reaction to the new/changed product
4. Evaluation of consumer reaction
5. Feedback to Production and Lab.
6. Resolution of the problem; involvement of the lab in problem solution.
7. Improvements/changes in the product/process
ANNEXURE IV

FLOWCHART FOR THE 'TECHNOLOGY TRANSFER PROCESS'

RESEARCH

IDEA GENERATION

RESEARCH DESIGN

LABORATORY RESEARCH

ENGINEERING DESIGN

DEVELOPMENT

PROTOTYPE DEVELOPMENT AND TESTING

PILOT PLANT

TRANSFER OF R & D

IDENTIFICATION/SELECTION OF POTENTIAL USERS

DEMONSTRATION/USER'S EVALUATION OF R&D OUTPUT

TRANSFER AGREEMENT/ARRANGEMENTS

MANPOWER TRAINING AND DEVELOPMENT

PRODUCTION

CONSTRN./MODIFICATION OF PRODUCTION FACILITIES

COMMERCIAL OPERATION

MEETING CONSUMER NEEDS

CONSUMER REACTION

TEST MARKETING

PRODUCT LAUNCH

FEEDBACK

IMPROVEMENTS

BUSINESS STABILISATION
NOTES:

1. The flows are neither unidirectional nor sequential. There is much level jumping.

2. The turning points stand out.

3. The critical decision making could be at any of the turning points.

4. Most decision making neglects group dynamics, rather treats it as an exercise of hierarchical authority.

5. Time which also subsumes cost is an important indicator of success or failure.
CHAPTER - II

BUILDING MATERIALS INDUSTRY

CASE STUDY ON FLY ASH UTILISATION
CASE STUDY ON FLY ASH UTILISATION

I. INTRODUCTION

Fly ash is a finely divided residue resulting from the combustion of ground or powdered bituminous coal or sub-bituminous coal (lignite) and transported by the flue gases of boilers fired by pulverised coal or lignite. It is thrown out in large quantities as a waste material at the thermal power plants using pulverised coal for raising steam in the boilers. Fly ash is carried away from the boilers by flue gases and is extracted from them by mechanical collectors or electrostatic precipitators or a combination of both.

Disposal of fly ash has been a long standing problem faced by most of the thermal power plants around the world. Fly ash produced at these plants is normally discharged either by the 'wet system' and is collected in settling ponds or dumping areas in the form of a wet mass or slurry; or by the 'dry system' where it is deposited in storage bunkers as a dry powder.

Literature reveals that traditionally fly ash has been used for building of roads and embankments, reclamation of low-lying waste land and refuse dumps, filling of mines, treatment of polluted waters and unsuitable soils for agriculture etc. Since the 1940's
fly ash has also been used, albeit in small amounts, in the building industry around the world, as a part replacement of cement in mortars and concretes at the construction site.

Available literature on the subject suggests that the R&D for utilisation of fly ash was carried out during 1940-60 period in USA, Japan, New Zealand, UK and other European countries. As early as 1938 the American Society of Mechanical Engineers discussed the possibilities for utilisation of fly ash and extensive research on utilisation of pulverised fly ash was carried out in USA at the American Institute of Mining, Metallurgical and Petroleum Engineers, Highway Research Board, Coal Research Institute and Engineering Experiment Station etc. At the Institute of fuel (UK) research was carried out during the 1940's for using fly ash in the building and civil engineering industries.

Much before research on fly ash was initiated in India, it was being commercially used for various applications in Europe and North America. Mixtures of portland cement, fly ash and certain admixtures were successfully used by the Halliburton Co. in cementing oil wells in USA, Canada and Europe. The sintered fly ash aggregate was produced commercially in these countries.
under different trade names such as 'Terlite' and 'Lytag' and was widely used in the building and road construction industries. For more than two decades now, fly ash has been extensively and successfully used in the construction of concrete dams and for other applications in the U.S.A.

In India the Bokaro thermal power plant was the first to throw up fly ash as residue. In the mid-1950's this was tested and utilised for the first time in the country, though for a very limited application. As the know how and technology for utilisation of fly ash was well documented in specialised international journals on building, mining and civil engineering research, the Bokaro experiment used these for utilising its fly ash.

With the rapid industrialisation of India during the sixties and seventies a number of thermal power plants came up all over the country. The total annual fly ash production which stood at 1 1/2 million tonnes in 1963 increased to 7.1 million tonnes in 1978 and 9.0 million tonnes in 1981. The emission of such huge quantities of fly ash, its consequences on the environment and its potential for the building industry led to an increased research and development activity in the country on utilisation and disposal of this material. Since the 1950's various research institutes and other organisations have undertaken systematic research and development work.
on the production of Indian fly ashes. Important among these are the Central Building Research Institute, Roorkee; Central Road Research Institute, New Delhi; Cement Research Institute of India, Ballabgarh; Central Fuel Research Institute, Jealgora; Central Soil Mechanics Research Station, New Delhi; Tamil Nadu Highway Research Station, Madras; and Neyveli Lignite Corporation Ltd., Neyveli.

Other major developments during the two decades include adoption by the Indian Standards Institute of specifications and guidelines for disposal, sampling and standardisation of fly ash and building materials produced from it; and occasional efforts to commercially utilise fly ash for the construction industry.

II. R & D AT CBRI

Research on Indian fly ashes was initiated at the Central Building Research Institute, Roorkee, right after its inception. The Bokaro experiment of the mid-fifties provided the initial impetus to the CBRI to look into possibilities of using fly ash for building and construction work. Research and development work on various uses of the fly ash in Europe and North America was already well documented. The CBRI conducted its own R&D to adapt these technologies to the Indian conditions.
Some of the important uses of fly ash on which research has been undertaken at CBRI and other research laboratories in India are:

1. Portland fly ash cement
2. Ready-mixed fly ash concrete
3. Precast fly ash concrete building units
4. Sintered fly ash lightweight aggregate for concrete
5. Lime-fly ash cellular concrete
6. Fly ash building bricks
7. Portland cement clinker
8. Fly ash stabilised high magnesia cement
9. Oil well cementing compositions
10. Hydraulic binders

In the present case study an attempt has been made to conduct a detailed enquiry into the commercialisation of R&D on one of the above building materials produced from fly ash. This is the sintered fly ash lightweight aggregate for concrete. Pioneering work in India on this applications of fly ash was done at the CBRI.

II.1 Sintered Flyash Lightweight Aggregate

Fly ash contains a large proportion of minute spherical glassy particles which when heated at 1100-1200°C, soften and cohere to form Vitrified structure. The process of causing this cohesion is termed 'sintering' and the sintered agglomerates are called sintered fly ash aggregate (SFLA). The aggregate can be used in the
production of structural lightweight concrete and precast lightweight concrete building units, such as roof and floor slabs.

Investigations at CBRI to produce sintered fly ash aggregate were undertaken in 1959. At the time, the technology for its production was well developed in U.S.A., Europe, Japan and New Zealand where it was being produced commercially under different trade names. The available literature on the subject gave a detailed description of the know-how and technology for producing the aggregate from fly ash.

The CBRI R&D effort was therefore an attempt to adapt an established technology to the Indian conditions. The research was undertaken by a team of three CBRI Scientists, headed by a senior scientific officer. It was sponsored by the CBRI itself along with R&D on other applications of flyash, having been identified as a thrust area in the overall research program of the institute. The research output was expected to provide the building and construction industry with alternative source of building material and to simultaneously solve the growing problems of disposal of fly ash at the thermal power plants. The initiation of the R&D process was definitely not in response to any requirement or demand of the industry which at the time, as even at present, relied
almost totally on the traditional building materials like cement, mortar, clay bricks, lime and sand. Consequently there was practically no voluntary involvement of the industry either at the initiation stage or during the entire duration of the R&D process.

Research undertaken at CBRI initially concentrated on testing the physical and chemical properties of Indian fly ashes. Laboratory tests indicated that the fly ash produced by the Indian thermal power plants were both physically and chemically different from those produced in other countries. Apart from being coarser the Indian fly ashes contained a relatively higher amounts of SiO₂, A/2O₃ and unburnt fuel and lower amounts of Fe₂O₃ and S0₃. Since the available technology related to the use of flyash produced at the thermal power plants in either Europe, USA or Japan the establish parameters for the production of sintered fly ash aggregate were inappropriate for production of the aggregate in India. Probably of the most important contribution of research at CBRI was the re-specification of these parameters to suit the Indian conditions.

Investigations to develop the appropriate parameters for production of the aggregates were conducted using two different processes:
(a) Continuous process using moving grate sintering strand; and

(b) Batch process using stationary grate sintering hearth.

(a) Continuous process using Moving grate sintering strand:

For the continuous production of lightweight aggregates a pilot moving grate sintering strand was imported from U.K. in 1961. The pilot plant was one of the first to utilise fly ashes from different thermal power plants in India to produce sintered fly ash aggregate. The aggregates produced were tested for their bulk density, water absorption capacity, strength and staining index value etc. and requisite changes were made in the mix proportions to obtain suitable aggregates. The purpose of the imported pilot plant was more to establish the parameters for production of lightweight aggregate from Indian fly ashes and to acquire a deeper understanding of the technology for fly ash utilisation than to develop a process to be offered for use in India. The techno-economic feasibility of the process was however determined and it was offered for commercial use during the initial stages of the R&D process. Though most of the Indian fly ash samples examined, contained comparatively high content of unburnt fuel, samples from a couple of
thermal power plants contained only 7 to 8 percent of unburnt fuel and were hence unsuitable for sintering on the moving grate sintering strand. Moreover, the feasibility studies indicated that the commercial production of the aggregate by the continuous process required a very high capital outlay.

(b) Batch process using stationary grate sintering hearth:

The problems encountered in producing lightweight aggregates by the moving grate sintering strand from fly ashes having low unburnt fuel content, motivated the scientists at CBRI to experiment with the batch process for manufacture of these aggregates. A pilot stationary grate sintering hearth based on the concept of a stationary grate sinter pot developed and successfully used in Poland, was designed at the Institute. The hearth was fabricated by a local engineering firm under the supervision of the scientists and trial runs were conducted on it. The success of the initial pilot plant trials and the advantages of a stationary hearth in terms of lower capital costs made the production of lightweight aggregate using this process, a comparatively more viable and attractive proposition than with the moving rate strand. The focus of the R&D efforts at the Institute therefore shifted to perfecting the batch process. The
initial experiments used the suction principle for igniting the charge in the hearth for combustion of fly ash. The process was later modified as less fuel was required when combustion was done by blowing air through the charge. Fly ashes from different thermal power plants in India were sintered in the stationary grate hearth during experimentation, to lay down specific parameters for production of the lightweight aggregate for each of these.

The design and use of the stationary grate hearth for sintering of fly ash marked the complete indigenisation and adaptation of the process for production of the lightweight aggregate. The process and equipment technology which was imported in 1961 from U.K. was worked upon and experimented over a period of two years at CBRI and finally indigenised and adapted in 1963 with the design and development of the stationary grate sintering hearth. Along with the testing of physical and chemical properties of Indian fly ashes this was another major contribution of the R&D efforts at the institute for the manufacture of sintered fly ash lightweight aggregate. During the next 10 years the CBRI directed its efforts at perfecting the technology for fly ash utilisation and conducting feasibility surveys for different states.
III. EFFORTS AT COMMERCIALISATION

The know how for production of sintered fly ash aggregate was ready for commercialisation by the middle of 1963. The technology offered for commercial application made use of the moving grate sintering strand of a capacity of 1,50,000 cu.m. per annum. The total cost of the project as estimated by the scientists at CBRI was about Rs. 50 lakhs.

Initial efforts to promote utilisation of fly ash were directed towards the Government Departments, thermal power plants and housing development agencies. The know how for fly ash aggregate was, however, not offered in isolation but was promoted along with the other applications of fly ash developed by the institute.

During the ten years, from 1963 to 1973, there were no takers of the processes developed for fly ash utilisation. When the matter was pursued with the prospective users, two major deficiencies in the materials made from fly ash were pointed out by the various construction agencies. One was that the 28-day compressive strength of concrete with fly ash was lower than that of corresponding concrete without fly ash. To find a solution to this problem laboratory tests were conducted for two years and with some changes in the fly
ash concrete mix proportions, equal 28-day compressive strength was obtained. The other deficiency pointed out was that the use of fly ash in concrete causes enhanced corrosion of steel reinforcement due to the presence of unburnt carbon and reduction in alkalinity by pozzolanic reactions. To test this out experiments were conducted both in the field and in lab. The exposure tests in highly corrosive conditions, industrial environments and normal conditions for 10 years showed that apprehensions regarding enhanced corrosion of steel reinforcement in fly ash concrete are ill-founded and there is no enhanced corrosion of steel reinforcement under normal exposure conditions. The incidence of corrosion of steel reinforcement in fly ash concrete is, however, higher than that in the corresponding plain cement concrete under highly corrosive conditions and industrial environments.

Realising that the capital outlay for setting up a commercial plant for manufacture of sintered aggregate was rather high, efforts were made to develop a process that made use of the stationary grate sintering hearth which was less expensive than the moving grate strand and could also be manufactured indigenously.

The first direct effort to commercialise the process of producing sintered fly ash aggregate using the stationary hearth process was made in 1974. This was in
response to an enquiry by a Lucknow based firm M/s. Concrete Fabricators, for setting up a plant to utilise fly ash produced at Panki, Kanpur. The enquiry was passed on by the NRDC to the CBRI which took upon itself to offer the technology and help in setting up manufacturing facilities without any charges. The CBRI offered to first demonstrate the process at a site selected by the firm. The demonstration plant was set up in February 1974 at the site between Lucknow and Kanpur. The hearth was fabricated by the firm with the design and supervision provided by the R&D team of CBRI. The cost of fabricating the hearth and other inputs was borne by the firm while the noduliser was brought from the CBRI. The demonstration, according to the CBRI scientists was a success, but the firm wanting to commercialise the process was not impressed. The deal fell through and the demonstration hearth was dismantled while the noduliser was brought back to CBRI. One of the opinions expressed is that the firm did not consider the project to be a viable commercial venture and therefore gave up the idea of setting up the plant.

IV. PROSPECTS OF FLY ASH UTILISATION

During the late 1950's it was realised that the disposal of flyash produced at the Thermal Power plants
was going to become a national problem in the foreseeable future. The CBRI was established and it took upon itself the responsibility of finding a solution. By then, the technology of utilising fly ash in the building and construction industry was well established in UK, USA, Canada, West Germany and other developed nations. Moreover, materials made from fly ash were being widely used for construction of roads, dams and buildings etc. The industry was thriving on the advantages of such materials. Also, literature was available in plenty on the knowhow of manufacturing aggregates, concrete, bricks etc. from fly ash.

Scientists at CBRI realised the potential of the technology and decided to develop indigenous capability for manufacturing building materials from fly ash. The fact that the boom in the construction industry in the developed countries and soil conservation efforts had contributed a great deal in making the fly ash (products) industry a success in these countries was ignored in the national interest. Another argument was that if the products could be successfully used by them then why not by us. Moreover, the housing problem in the country was to be solved apart from the problem of disposal of fly ash. It was assumed that once the product was available indigenously, there would be many users for it. The
result of the efforts to commercialise the indigenous technology are before us.

The conditions in our country presently have not been in favour of this industry. Many factors have contributed to this state of affairs. However, it should be realised that the fly ash materials industry is an industry of the future in our country. With growing problems of availability of top soil as a substitute building material in the urban areas and the need for a lighter material which could speed up the construction process, the fly ash industry is bound to take off.

Among the important reasons for the non-utilisation of the research results of the CBRI conducted research products have been:

(a) There is no organised building and construction sector in the country.

(b) The transportation costs of carrying the fly ash from the source (thermal power plants located in remote areas mostly) to the building site are very high. This makes the use of traditional substitutes much cheaper.

(c) Initial investment in setting up a unit utilising fly ash are fairly high. This again gives a price advantage to the substitutes.
(d) It is always difficult to replace an established technology, specially when the alternative is equally or more expensive.

(e) Fly ash is a hazardous material and no tangible benefits are there to use it when a seemingly better option is available.

(f) Inspite of the solutions it would provide to some of our pressing problems, there is no concerted effort by the government to promote the industry through incentives, use in government construction etc.
ANNEXURE - I

PROCESS FOR MANUFACTURE OF SINTERED FLY ASH LIGHTWEIGHT aggregate

The manufacture of sintered fly ash lightweight aggregate involves the following two main operations:

i) Pelletization or nodulization of fly ash;
ii) Sintering of fly ash pellets or nodules at 1100C to 1200C

The pelletization or nodulization of fly ash is done either in a rotary drum or a titled rotary pan known as pelletizer. The experiments at CBRI used an improvised pelletizer consisting of a shallow pan 4 ft. 3 in. in diameter and capable of making 20 revolutions per minute. In order to make the fly ash particles cohere to form nodules, small amounts of dry powered shales or clay is added and thoroughly mixed in fly ash before pelletization. The mixture is fed into the pelletizer and is made to roll on the pan under a fine spray of water. The rotary motion of the pan causes the material to cascade and the particles of fly ash-clay mixture adhere to each other to form nodules. As the spherical pellets roll on the pan, these grow not only in size but also become strong enough to withstand subsequent handling.

The process of sintering comprises of heating the pellets to 100C to 1200 C to ignite the unburnt carbon in
the fly ash. This causes the minute spherical glassy particles of the fly ash to soften, cohere and agglomerate to form vitrified structure. The sintered agglomerates are called sintered fly ash aggregate. Sintering of fly ash can be done either by the continuous process or by the batch process. The former uses the moving grate sintering strand and has been tried on an experimental basis at CBRI with the imported pilot plant. The latter makes use of a stationary sintering hearth designed indigenously during the development stage of the project.

The sintering hearth process is the one that constitutes a part of the effective output of the R&D process and is offered for commercial application. The thermal efficiency of the sintering hearth is better than that of the moving grate sintering strand. It can be used to sinter fly ash containing 5 to 8 percent unburnt carbon. The process involves filling up the sintering hearth with the fly ash pellets and igniting wood and charcoal in the combustion chamber below. Air is blown by pumps which heats up in passing through the burning fuel and fires. The carbon in the fly ash as it moves up. When the entire batch is ignited, the hearth is emptied and made ready for the next batch. In fly ashes containing less than 5 percent carbon, more carbon is added before the pelletization stage. The sintered
material is rolled over a 5 mm. screen to remove fines and the agglomerated bigger lumps are picked out. These are fed to a jaw crusher to get sintered fly ash aggregate of 12 mm. and less.
NOTES

1. For definition of fly ash see IS: 3812-1966; Specification for fly ash.


3. Weinheimer, C.M. Evaluating importance of the physical & chemical properties of fly ash in creating commercial outlets for the material. Transactions; American Society of M.E., Vol. 66, August


7. Little John, C.E. The Utilisation of Fly Ash. Engineering Experiment Station, Clemson A and M College (USA), Bulletin No. 6, 1954.


12. Presently there are over 50 thermal power plants in India, producing about 19 million tonnes of flyash every year. With further addition in capacity of the existing power plants and commissioning of some super thermal power plants, the annual production of fly ash is estimated to reach about 37 million tonnes by the year 1989-90.


14. See for instance:

(i) Orchard, D.F. Concrete Technology; Contractors Record Limited; Vol. I, 1954


(iii) Kinniburgh, W. "Lightweight aggregate from pulverised aggregate", Concrete and Constructional Engineering, Vol. 51, No. 12, p. 571.

15. For details of the process see Annexure 1.


18. For description of the moving grate sintering strand process see Annexure 1.
CHAPTER III

CHEMICAL INDUSTRY

1. CASE STUDY ON CHLOROSILANES
2. CASE STUDY ON MONOCROTOPHOS
1. CASE STUDY ON CHLOROSILANES

1.0 SUMMARY

1.1 This case is about the development and transfer of technology for the manufacture of Chlorosilanes, a product used for making silicones. This technology was developed in the National Chemical Laboratory (NCL), Pune through a collaboration with M/s HICO Products Limited, Bombay. The technology was developed during late seventies and early eighties through various stages of laboratory investigations and pilot plants. Then HICO established a commercial unit having a capacity of about 1000 tonnes of Chlorosilanes per annum. The Plant came into production in November 1982. About Rs. 8 crores were spent on pilot plants and the commercial units. The R&D institution as well as HICO received ICMA Awards for their efforts in successfully developing a sophisticated technology and its use entirely through indigenous efforts. However, soon after it came into production, the Plant due to high cost of inputs became a victim of competition from imported products. Due to this, the factory is now closed for more than 18 months resulting in heavy losses to HICO. This is a case where development of indigenous technology and its use resulted in a serious loss to the entrepreneur. The Company has suggested
various methods by which the Plant could be revived, including restricted imports of Chlorosilanes and/or properly priced raw material inputs. This case illustrates how technology development and transfer in India is not backed up by a well thought out policy guidelines for identifying items for which indigenous technologies are to be developed and how they should be supported.
2.0 BACKGROUND

2.1 The problem of development of indigenous technology and its transfer to industry has been receiving close attention in all developing countries for the past three decades or more. For example, after Independence in 1947, the whole structure of the National Laboratories under the Council of Scientific and Industrial Research (CSIR) was established only to develop indigenous technologies. The National Research and Development Corporation of India (NRDC), a Government of India enterprise, was established in 1951, as a non-profit making public enterprise, specifically to promote transfer of locally developed technologies to industry.

2.2 In order to assess what has been achieved in this direction, several studies have been made in many countries and the U.N. System on the whole process of development of indigenous technology and its commercialisation.

2.3 Recently, the International Development Research Centre, (IDRC), New Delhi embarked on a project to study "Utilisation of Indigenous R&D Output", covering six areas: food, building materials, metallurgical and engineering, chemicals, drugs and pharmaceuticals and electronics. As a part of this Study, two chemical
processes were selected: (i) manufacture of dimethyldichlorosilanes (DMDCS) technology for which was developed in the national Chemical Laboratory (NCL), Pune and (ii) Manufacture of Monocrotophos, a pesticide, for which technology was developed in the Regional Research Laboratory, Hyderabad (RALH).

2.4 Both the laboratories belong to the CSIR family.

3.0 CHOICE OF THE PROJECT BY NCL

3.1 Chlorosilanes have been imported into the country for quite some time. Out of them dimethyldichlorosilanes (DMDCS), is the main raw material used in the indigenous silicones industry.

3.2 Chlorosilanes find use in the manufacture of silicone oils, resins, emulsions, greases, silicone rubbers, and many special products. They are used in diverse industries, chemicals and allied products, construction, electronics and electricals, food and related items, leather, mining, paper, coal, petroleum, rubber, textiles, printing and many more.

3.3 Even in the fifties, NCL was interested in the reactions of silicone and chlorine. The work on Chlorosilanes is a result of this earlier work. After Dr.
B.D. Tilak became the Director of NCL in 1966, there was greater emphasis on the development of indigenous technologies, essentially an attempt in import substitution. One such technology was for the manufacture of Chlorosilanes. Strong incentive in NCL for the development of technology for the manufacture of Chlorosilanes was due to two reasons: (1) Chlorosilanes were a 100% imported item. (2) Being a monopoly of multinational companies, no one abroad was willing to give this technology to Indian entrepreneurs.

3.4 Development of this technology was therefore a good effort in import substitution of a product and a process. Therefore, NCL mounted a programme through their Inorganic and Chemical Engineering Divisions to develop an indigenous technology for the manufacture Chlorosilanes. Work at bench level as well as at a small pilot plant level (capacity 5 kgs per batch) was done around 1976. NCL spent about Rs. 10 lakhs on the development of this technology.

3.5 At this stage, M/s HICO Products Limited, Bombay were brought into the picture. HICO was already formulating silicone products with imported DMDCS. The Company was a strong believer in the utilisation of indigenous technologies. Earlier they had taken technologies from the NCL and the Regional Research
Laboratory, Jorhat for a number of Chemicals - ethyleneoxide condensates, chloroacetic acid and dilapan from NCL and oil well chemicals from RRL - Jorhat. Therefore when there was a possibility of import substitution of raw materials needed for their own internal consumption, HICO became interested in the NCL technology for the manufacture of chlorosilanes. The Company had good leadership in Dr. G.M. Abhyankar, Managing Director who had experience of working with Dr. Tilak. Discussions between NCL, HICO and NRDC resulted in a collaboration for further development of the technology for the manufacture of chlorosilanes. This agreement was entered into in 1977.

4.0 WORK IN HICO

4.1 HICO in collaboration with NCL proceeded in a systematic manner for upscaling of the technology for the manufacture of Chlorosilanes. In order to upscale the operations, a small pilot plant with about 60 tonnes per annum capacity was first established in HICO factory in Thane Belapur, outside Bombay. Operations at this level encouraged HICO to put up a larger pilot plant having an capacity of about one tonne per day. HICO spent about Rs. 60-70 lakhs for the pilot plant investigations of this process. They also employed the consulting engineering
firm, M/s Humphreys and Glasgow to help them in their work. Besides this, they also employed competent chemical engineers in their own Company to help in the establishment of the pilot plant and the upscaling of the process. Investigations at the pilot plant stage gave encouragement for the establishment of a full-fledged commercial unit having a capacity of about 1000 tonnes of chlorosilanes per annum. The plant was put up at KHARSUNDI, RAIGAD DIST., Maharashtra State. Continuous improvement in the technology was made until this technology is contemporary with any available from abroad, in terms of raw material consumption, yields and quality of the product. Rs. 7 crores was invested in the commercial sized plant. This Plant came into operation in November 1982. It was fully indigenous - process, design and equipment. Only one INCONEL reactor of indigenous design was manufactured abroad to save time.

4.2 HICO received INDIAN CHEMICAL MANUFACTURERS ASSOCIATION (ICMA) Award for 1983 for the "Forward Development of Technology". This Award was presented to HICO in April 1984. NCL also received ICMA Award during the same year for their contribution to the development of chlorosilanes technology. The citations are:

HICO: HICO Product Limited, Bombay, have achieved
yet another success in a difficult and closely guarded area of the manufacture of Chlorosilanes/Silicones. The process technology for Chlorosilanes/Silicones, involving sophisticated chemical engineering, was developed by the National Chemical Laboratory, Pune. The pilot-plant developmental work was carried out by Messrs. HICO Products Limited at their works and the process design and engineering of this complicated plant on a commercial scale was successfully carried out completely indigenously. This is the only plant of its kind in India today and there are only very few such plants in the world.

In recognition of the forward looking entrepreneurship shown by Messrs. HICO Products Limited and their own significant contributions to the successful transfer of this high-risk technology, the Indian Chemical Manufacturers Association is happy to confer the I.C.M.A. Award for Forward Development of Technology for 1983 on Messrs. HICO Products Ltd., Bombay.

NCL: National Chemical Laboratory (NCL), Pune have demonstrated in an imaginative way their expertise in dealing with complicated chemical engineering oriented technology for the manufacture of silicones by Messrs. HICO Products Limited.

The Indian Chemical Manufacturers Association
recognizes the NCL's contribution in the development and successful transfer of technology in a very demanding and challenging area and deeply appreciates this fruitful cooperation between a national laboratory and an industrial unit.

5.0 FURTHER DEVELOPMENTS

5.1 While HICO and NCL received encomiums for developing a complex technology not available to Indian entrepreneurs, further developments in HICO for the commercial exploitation of this technology were not happy. At the time of the establishment of the HICO commercial plant, the studies made by the consulting engineering firm, Humphreys & Glasgow were very positive as to the commercial viability of the Plant. But soon things changed. During the years 1986 and 1985, the total production of chlorosilanes in the HICO factory was only 588 tonnes, around 25% of rated capacity. Out of this, the Company itself consumed 301 tonnes. Outside sales were only 112 tonnes. This is when the internal demand for chlorosilanes was of the order of 1500 tonnes per annum. The reasons are obvious why HICO plant was not able to function at its rated capacity and sell the same to consumers in India, who are mainly formulators who imported chlorosilanes and converted them into silicone.
products. The price of indigenous product was very high compared to that of imported material.

5.2 The main raw materials required for the manufacture of DMDCS are silicone metal, methyl alcohol and chlorine. When the Plant was established, cost of the raw materials were as follows:

Silicon metal....Rs. 12/- per kg.
Methanol..........Rs. 3/- per kg.

5.3 However, by 1985 the prices of these essential raw materials shot up to Rs. 45/- per kg. of silicon metal and Rs. 7/- to 8/- per kg. of methanol. The price of chlorine during this period was competitive with international prices.

5.4 Due to steep rise in the cost of inputs, the production costs of DMDCS increased substantially. The sale price shown in the Annual Reports of HICO Products Limited was Rs. 52/- per kg. in 1985 and Rs. 70/- per kg. in 1986. The imported price inclusive of import duty of 100% is around Rs. 50/- per kg. At present there is thus a difference of about Rs. 20/- per kg. between the price of imported product and the indigenously manufactured product. Therefore, the formulators were reluctant to lift DMDCS manufactured by HICO. Due to this reason the Plant has not been working during the last eighteen
months. As a matter of fact HICO themselves, who are formulators of silicone products, now import DMDCS. A very intriguing situation indeed. An unit which received a prestigious Award for establishing an industry based upon sophisticated indigenously developed technology had to be shut down, almost immediately after the receipt of the Award, because commercially the product cannot stand competition with imported product.

6.0 FURTHER EFFORTS OF HICO TO OPERATE THE PLANT

6.1 HICO have been making numerous representations to the Ministries and Departments of Government of India to help them from this predicament of closing down a factory in which an investment of about Rs. 8 crores was made and the product is needed in the country even today. Directly as a result of this unproductive investment the company which was having a good reputation in the market for profitability and whose equity shares were selling around Rs. 40/- earlier suffered grievously. The price of HICO share has come down to Rs. 13/- (Report in ECONOMIC TIMES of July 8, 1987). It is said that the company incurs a loss of approximately Rs. 2.5 crores every year due to this unproductive investment. While this is so, the country continues to import DMDCS.
7.0 OTHER PROBLEMS

7.1 There are some other problems which result in the uneconomic operation of the HICO Plant.

7.2 Originally the conversion efficiency of the technology developed in the NCL was about 65 to 70 percent for the main product, DMDCS. The rest were other products namely, trimethyl chlorosilane, methyl trichlorosilane and methyl hydrogen chlorosilane. Only DMDCS, is used by formulators of silicone products in India. The other products are not in much demand in the country because technologies for their use are said to be not fully developed. However, discussions with HICO indicated that this problem is being overcome.

7.3 Due to some process changes in the manufacture of silicon metal in India, silicon metal of the required quality for the manufacture of DMDCS is not locally available at present. This would involve again import of the silicon metal. Of course imported silicon metal is very much cheaper than indigenously produced metal - Rs.12/- against Rs. 45/- per kg.

7.4 The formulators raised the point that quality of DMDCS manufactured by HICO was not upto the mark. HICO claimed that the product marketed by them is upto international standards. This matter was considered in
the DGTD. After several discussions at the government level and in various forums, DGTD requested NCL to collect samples from the HICO plant and imported DMDCS and conduct their analysis in order to see whether DMDCS manufactured by HICO comes up to international standards.

7.5 Accordingly during March 1987, samples were collected and analysis done by NCL.

7.6 However, there was controversy between HICO and some silicone formulators, the users of DMDCS, regarding the procedure for the collection of samples. This matter could not be resolved and some of the formulators disassociated themselves with the whole matter. Inspite of this, NCL went ahead with the collection of samples and analysis. Their results show that DMDCS manufactured by HICO is upto international standards, as is revealed by the following results given by NCL.

<table>
<thead>
<tr>
<th>Sample</th>
<th>DMDCS Purity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Rohone Pulenc (French)</td>
<td>99.8%</td>
</tr>
<tr>
<td>2. Wacker Chemie (German)</td>
<td>99.82%</td>
</tr>
<tr>
<td>3. HICO Products</td>
<td>99.95%</td>
</tr>
</tbody>
</table>

7.7 How to manufacture DMDCS at a competitive price and how to persuade Indian formulators to use their product are the two important questions that are facing HICO.
7.8 The manufacture of chlorosilanes is made only in a few developed countries - the USA, Germany, Japan, UK and some European countries. The size of plants in the USA are quite large, up to 200,000 tonnes per annum. In Germany such units have a capacity ranging from 40,000 tonnes to 70,000 tonnes per annum. In Japan, the size of the units is relatively small, 25,000 tonnes per annum. Compared to these sizes, the capacity of the HICO unit is tiny - 1000 tonnes per annum. Perhaps this could not be helped because the local market for DMDCS is only around 1500 tonnes even today. HICO Plant was essentially an import substitution effort. This is also an important factor that needs to be considered while extending assistance to HICO to revive their Plant.

8.0 ROLE OF NRDC

8.1 The role of NRDC in the development and commercialisation of technology for the manufacture of diethyldichlorosilanes was related to the following areas:

1. NRDC participated in the discussions that were held before NCL and HICO signed an agreement for the development of this technology. NRDC offered financial assistance in the development of this technology.
However, perhaps in the light of financial incentives available at that time for the development of indigenous technology and its own resources, HICO did not find it necessary to seek NRDC assistance.

2. NRDC took over this technology from HICO after getting it assessed by Engineers India Limited for purposes of horizontal transfer. NRDC found that the technology developed by NCL-HICO collaboration was contemporary and there was no need to import this technology into India. This technology is now available to any entrepreneur in India or abroad.

9.0 DISCUSSIONS

9.1 The development of indigenous technology for the manufacture of chlorosilanes and the utilization of this technology have brought about very clearly the contradictory situation and conditions that prevail in India for the attainment of technological self reliance. Here is a situation in which a complex technology was developed and large investments were made in the establishment of industry based on this technology. NCL which developed the technology and HICO which used the technology received public praise for this excellent effort. No sooner these encomiums were received, the
Plant itself became sick because it cannot manufacture the product at a competitive price under prevailing market conditions in India. Not only this, a reputable Company had to face serious financial losses in their manufacturing and trading activities. This came about essentially through circumstances on which neither the Company, nor the R&D institution had any control. The problem was entirely due to steep rise in the price of the raw materials and adjustments in taxation and import duties. Several suggestions essentially restricted import of the product and competitive prices for raw material inputs, made by the Company to help them operate this Plant have not yet found favourable response in the Government. Each one of the suggestions similar to those made by the Company has been implemented in the country in some case or the other. There could be problems why these suggestions could not be implemented in the case of DMDCS. The suggestions are essentially the following:

1. Restricted imports of DMDCS.
2. Duty hike on imported DMDCS.
3. Making available raw materials at international prices.

9.2 It is a fact that giving too much protection to inefficient indigenous industry against imports will end up in the country having a high cost economy and costly
goods and services to the consumer. If this factor is the guiding principle for the establishment and running of industry in India, at present many industrial units will find no place in this country. That is why a judicious policy of support to industries against international competition is being given. Chlorosilanes is an item which is required in relatively small quantities by many industries. Rise in the price of chlorosilanes is not likely to make serious impact in the ultimate price the consumer has to pay for the goods and services, which involve use of silicones. Under these circumstances, a decision based upon technological self reliance is more appropriate in this case.

10.0 LESSONS

10.1 There are many lesson that could be learnt from the experience gained in the development and utilisation of indigenous technology for the manufacture of chlorosilanes.

10.2 It is not enough if a technology is indigenously developed and an user found for the technology. Even successful technologies can come to grief when operated on a commercial basis due to circumstances beyond the control of the industry and the R&D Institutions. The business
and commercial environment is very important.

10.3 Indigenous technology cannot play a useful role in development of technological reliance unless it is backed by right policies and programmes of the government.

10.4 Close attention has to be bestowed even while deciding on a work programme to develop indigenous technologies. It could be that some technologies already developed need not have been developed if all the national concerns are taken into consideration while some that needed to be developed are not developed. But, once a decision is taken, there is need for extending full support for its development and use, including policies on taxes, duties, and other financial incentives, restricted imports, pricing of inputs etc.

10.5 Indigenous development of technology can receive good impetus through a collaboration of competent R&D institutions, NRDC, industry and capable design engineering firm.

10.6 Institutions like NRDC can clearly play an important role in taking care of the interests of indigenous technologies and giving the required support including financial support as required.
11.0 CONCLUSION

11.1 Experience of HICO and NCL in the development of indigenous technology for the manufacture of chlorosilanes and use of the technology can really act as a damper in the development of future indigenous technologies. The case reveals that there is no unified approach to the attainment of technological self-reliance in the country.
2. CASE STUDY ON MONOCROTOPHOS

1.0 SUMMARY

1.1 The development and transfer of technology for the manufacture of the pesticide, Monocrotophos, is described. The Regional Research Laboratory, Hyderabad (RRL-H) is a part of a team formed in 1977 by the Council of Scientific and Industrial Research (CSIR) to develop technologies for the manufacture of pesticides needed in the country. RRL-H developed this technology through laboratory and pilot plant levels. The laboratory also developed the capability to offer to entrepreneurs a basic design package or a detailed design package as needed. Their collaboration with National Organic Chemical Industries Limited (NOCIL) was very fruitful. NOCIL not only spent around Rs. 21 lakhs to establish a pilot unit of a size in which they had the confidence for purposes of upscaling but also established a good manufacturing plant to produce about 700 tonnes per annum of Monocrotophos. M/s. Sudarshan Chemical Industries Ltd., also took this process to manufacture around 200 tonnes per annum. However, they took a detailed design package from RRL-H. Four more parties also took this process. All the six signed agreements with the National Research and Development Corporation of India (NRDC).
1.2 Development of this technology is a good example for the attainment of success in technology development and technology transfer. It had a demand pull, competent R&D institution, market for the product and a good collaboration from design engineers and commercial organisation. More than all these, the project had needed policy support from the government. A number of lessons can be learnt from this case for successful development of indigenous technology and its use.
2.0 BACKGROUND

2.1 The problem of development of indigenous technologies and their transfer to industry has been receiving much attention in all developing countries. This has been one of the endeavours of developing countries towards the attainment of self reliance. India has done a great deal in this direction. The establishment of a large infrastructure in the shape of R&D institutions, universities, higher technological institutions and special agencies is for the attainment of technological self reliance.

2.2 The Council of Scientific & Industrial Research (CSIR) which established a large number of National Laboratories was intended to develop industrial technologies, needed in the country. The national Research & Development Corporation of India (NRDC) established in 1951 was for promoting the transfer of indigenous technologies from R and D institutions to the users of technologies. There are many problems in the successful development and transfer of indigenous technologies. A number of studies exist. However, the problem needs further study.

2.3 Recently, the International Development Research Centre (IDRC) embarked on a Project to study "Utilisation
of Indigenous R&D Output" covering six areas viz., food building materials, metallurgical and engineering, chemicals, drugs and pharmaceuticals, and electronics. As a part of this study, technologies for the manufacture of two chemicals were chosen. They are, Chlorosilanes, essentially dimethyl dichlorosilane (DMDCS) & Monocrotophos. The technology for the manufacture of DMDCS was developed in the National Chemical Laboratory (NCL), Pune and that for the manufacture of Monocrotophos in the Regional Research Laboratory, Hyderabad (RRL-H). Both the Laboratories belong to the CSIR.

3.0 CHOICE OF THE PROJECT BY RRL-H

3.1 Monocrotophos is an organo phosphorus pesticide. It belongs to a group with an anticholinesterase activity. It is a systemic as well as contact poison and can be applied to the soil in the vicinity of the growing plant to be protected. It can also be applied directly to the plant where it is distributed and translocated through the plant tissue.

3.2 Monocrotophos plays an important role in pest management of economically important crops like cotton, sugarcane, groundnut and tobacco. It is found effective against insects like ball worms, ball weevil, white flies
of the cotton, sugarcane shoot borers, tobacco ball worms and horn worms, potato beetles and leaf hoppers, for controlling of aphids or mites in groundnuts, mango shoot gall maker and pests of some ornamental plants.

3.3 The use of monocrotophos does not present any hazard of residual toxicity.

3.4 Monocrotophos (Technical Grade) has an ISI specification - IS-8025-9026. The product developed by RRL-H, technical and formulation have been registered with the Central Insecticides Board, which is the approving body for the introduction of pesticides into the country.

3.5 Earlier to the development of indigenous technologies for the manufacture of pesticides, all pesticides were being imparted. None were being manufactured in the country. Therefore, during 1976-77 the Government of India in the Ministry of Chemicals appointed a Committee with Dr. B.D. Tilak, at that time, Director of the National Chemical Laboratory, Pune to produce a report for the encouragement of the development of indigenous technologies for the manufacture of bulk pesticides which were then being imported. Based on the Tilak Committee Report, a special programme for development of technologies for the manufacture of pesticides was mounted in the Regional Research
Laboratory, Hyderabad, national Chemical Laboratory, Pune and the Regional Research Laboratory, Jorhat. Technology for the manufacture of monocrotophos was one of them.

3.6 Thus, the development of an indigenous technology for the manufacture of monocrotophos is the result of demand pull. There was need for this product in the country. The technology was not available and therefore it was necessary to develop a local technology. The Council of Scientific Industrial Research mounted a joint programme involving three of their laboratories mentioned earlier. The RRL, Hyderabad quickly developed a process for the manufacture of monocrotophos, starting the work in 1978.

4.0 THE PROCESS

4.1 The raw materials required for the manufacture of monocrotophos are the following:

<table>
<thead>
<tr>
<th>Specifications/Assay%</th>
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<tbody>
<tr>
<td>i) N-methyl acetoacetamide 49-52%</td>
</tr>
<tr>
<td>ii) Chloral IS:646-1970</td>
</tr>
<tr>
<td>iii) Trimethyl phosphite 98%</td>
</tr>
<tr>
<td>iv) Solvents</td>
</tr>
</tbody>
</table>

All the raw materials are available in the country.
4.2 The RRL-H also offers separately process know-how for the manufacture of trimethyl phosphite. It also has a technology for the formulation of pesticides using monocrotophos.

4.3 The dehydrated N-methyl acetoacetamide (MMA) is reacted with chloral. The adduct formed is chlorinated. Chlorinated product is dissociated and 2-chlor-N-methyl acetoacetamide is dissolved in a solvent and condensed with tri-methyl phosphite. The reaction mixture is distilled to recover the solvent. The residual monocrotophos is concentrated, cooled and collected.

4.4 Currently, the laboratory has licensed this process through NRDC to six companies as listed in Table 1*. Currently, two companies, National Organic Chemical Industries Limited (NOCIL) and Sudarshan Chemical Industries Limited are in production. In 1986, NOCIL produced around 600 tonnes of monocrotophos. The company is now extending its capacity to around 1085 tonnes per annum. Sudarshan Chemicals is producing around 200 tonnes per annum. Apart from these two companies, monocrotophos is also being produced by Ciba-Geigy using an imported technology.
5.0 WORK IN RRL-H & NOCIL

5.1 The technology for the manufacture of monocrotophos was given to NOCIL through the National Research & Development Corporation of India. NOCIL went about in a very systematic manner for the establishment of this pesticides unit. Earlier, RRL-H established the process on a 5 kilogram scale. While RRL-H was confident that this technology could be upscaled to commercial level for NOCIL unit, the Company wanted to establish a pilot plant such that the scale up factor for the commercial plant is not more than 1.20 or even 1.16. Therefore, NOCIL said that they would like to establish, in RRL-H, a pilot plant for this purpose. During 1978-80 a pilot plant was established in RRL with an expenditure of Rs. 21 lakhs, all met by NOCIL. Later the pilot plant was shifted to the factory site. After this the commercial plant having a capacity of 600 tonnes per annum was established by NOCIL at Lote Parshuram in Maharashtra.

5.2 In the case of Sudarshan Chemicals who wanted to manufacture around 200 tonnes of monocrotophos per annum, no pilot plant was established by them.

6.0 LINKAGES

6.1 The whole project for the development of
pesticides was an effort by three R&D institutions, viz., RRL, Hyderabad, National monitored in the CSIR Head Quarters, Delhi and also by the Ministry of Chemicals, who wanted periodical reports be sent to them on the development of the indigenous technologies for the manufacture of pesticides. RRL, Hyderabad, which is the lead institution in this effort, established a sound system for the development of technologies and their transfer. RRL-H provided guarantees with regard to three items, (1) quality, (2) raw materials consumption and (3) capacity. However, these guarantees will apply only if the party takes basic design package from RRL. As a matter of fact, RRL-H would not agree to transfer any technology for the manufacture of pesticides without the basic engineering package. The Laboratory also is willing to give guarantees with regard to consumption of utilities provided the detailed design engineering also is given by RRL-H. R.L. Dalal Consultants did the detailed engineering for the NOCIL plant. However, Sudarshan Chemicals had the detailed engineering done by RRL-H.

6.2 The choice of the technology package is that of the buyer of the technology. Four levels of technology packages are available from RRL.

6.3 One special matter which needs attention in the case of monocrotophos is with regard to the technology
itself. Monocrotophos is a product already being manufactured elsewhere. Shell makes this product. They also have their own technology. However, the contribution of RRL-H with regard to a development of this technology is to adapt it to conditions in India. Shell technology requires relatively low temperatures which may be difficult and expensive to obtain in India. Therefore, RRL-H developed a technology which can be used at a relatively high temperatures with raw materials mostly made in this country. The import content of raw materials for the manufacture of monocrotophos is nil. Only a few items of equipment need to be imported. The process flow sheet is at fig. 1.

7.0 FURTHER ACTIVITIES IN THE DEVELOPMENT OF PESTICIDES

7.1 Table 1 gives technologies for the manufacture of pesticides already developed by RRL-H and licensed to various industrial establishments. Thus technologies were developed for the manufacture of seven pesticides viz., monocrotophos, quinolphos, MBC, DDVP, diazinon, chiorpyrphos, butachlor were developed in RRL-H. The Laboratory has also a programme for development on new agro chemicals. They are given in Table 2.
9.0 DISCUSSIONS

8.1 The development of a technology for the manufacture of monocrotophos and its transfer to industry is a textbook case where everything worked well and in time. The whole development was based upon a clear identification of the pesticides required in the country. A group of CSIR laboratories was entrusted with this task. The progress of work was monitored. Very little time was wasted in the development of the technology. A project started in 1977 produced some good results by 1978. There was in-house capability in RRL-H for giving a design package either at the basic level or at the detailed level. The Laboratory also had the capability to assist the recipients of the technology for the establishment of the factory, start up and operation of the unit. The Laboratory and the NRDC were able to secure collaboration with a good industrial concern who were willing to do their best for the development of the technology. They had the necessary licences for the manufacture of the product and the resources to immediately establish the unit. They had the resources for establishment of a pilot plant which was fairly expensive. They also had the necessary marketing capability. The collaboration of the industry also ensured a design which took care of all safety matters.
9.0 LESSONS

9.1 The study of technology development and technology transfer in the case of the pesticide, monocrotophos, has many lessons for the successful development and transfer of indigenous technologies. For the successful development of technology and its successful transfer the following seems to be essential:

9.2 Demand pull: There must be a felt need for the technology and an entrepreneur who is willing to collaborate in its development. In the case of monocrotophos the chemical was already being imported and certainly the agricultural development programme of the country made certain that this product had a future market. The policies of the government made it possible for the entrepreneurs to use the indigenous technology which meant that technology developed had a ready user.

9.3 Choice of the party to whom technology is transferred is a very important matter for the successful transfer of technology. It was a good thing that NOCIL, a well established chemical company in the country with needed resources was the partner of RRL-H in this case. NOCIL had a well thought out procedures for the development of technology and its use. They would not like to have a scale up factor of more than 1:20. When
they saw that the work done in RRL-H was at the level of 5 kilograms batch, they wanted to pilot plant to be established so that the commercial plant will not have a scale up factor of more than 1:20. For the establishment of the pilot plant NOCIL was willing to spend the needed resources. They spent about Rs. 21 lakhs for establishing the pilot plant in RRL-H and later this pilot plant was shifted to their site.

9.4 Monitoring at the Government of India level the development of an identified technology is a contributing factor in the success of technology development and transfer in this case. The monitoring ensured that no time was wasted in the development of technology. If the development of technology takes very much time, many other factors come into play which could result in non-utilisation of the developed technology.

9.5 The Regional Research Laboratory at Hyderabad not only had good scientific capability but it also had a good pilot plant set up in their chemical engineering division. It also had a design group. All the three groups, viz., Organic Chemistry, Chemical Engineering and the Design Group were give the task of development of the technology through all its stages including giving guarantees to the licences. Therefore, it is necessary for the successful development and transfer of technology
to involve design engineering groups and chemical engineering groups from the very early stages of the development of technology.

9.6 NRDC can play a catalytic role in the development of this technology. It played a role in the formulation of a project for the development of technologies for the manufacture of pesticides. It acted as the licensor for those technologies and took care of their interest at the government level.

9.7 Once, a successful collaboration is established it increases the confidence of the entrepreneur in the capabilities of the laboratories. In the case of NOCIL and Sudarshan Chemicals, they have taken technology for the manufacture of DDVP (Dichlorovas). Not only this, many other companies have taken technologies for the manufacture of different pesticides from RRL, Hyderabad, vide Table. 1.

10.0 SUGGESTIONS FOR FURTHER PROMOTION OF SUCH ACTIVITIES

10.1 The whole project for the development of technologies for the manufacture of pesticides was carried out in RRL-H with the resources already allocated to them. No special grant or funds were specifically given for the development of these technologies. The resources
available to RRL-H were redeployed to give thrust for the development of pesticide technologies. The Organic Chemistry group in 1978 had about 30 people. They essentially developed technology for the manufacture of the pesticides. The total expenditure for 10 years of this activity in RRL-H from 1977 to 1987 might not have exceeded Rs. 2 crores. However, the quantity of pesticides being manufactured by RRL-H technology is 2000 tonnes per annum with a value of Rs. 20 crores in 1987. The capacity under implementation is around 2600 tonnes per annum valued at Rs. 40 crores. The capital investments in existing units is Rs. 10 crores and the projected investment is of the order of Rs. 22.5 crores. RRL-H already earned about Rs. 1.5 crores by way of premia and consultancy charges. More amounts will be earned as royalty. However, if additional resources could have been made available to RRL-H and the others involved in this special effort probably work could have been even faster.

One of the things that could have been done with these additional resources would be to modernize the equipment available to RRL-H and other institutions.

10.2 RRL-H already has facilities for testing pesticides. The data produced are acceptable to Central Insecticides Board. Earlier, RRL-H had been going to other institutions in the country for carrying out some
tests, facilities for which are not available in the RRL-H. It is time that in view of the very successful effort by RRL-H for the development of pesticides technologies, facilities available in RRL-N are augmented.

10.3 The import duty structure and the quantities that are allowed to be imported into the country have to be constantly monitored such that the indigenous technology and the users of this technology are not adversely affected.

10.4 There is need for proper pricing of the inputs. If they are not priced properly indigenous technologies cannot get rooted in the country.
### Table 1

**Technologies Developed by RRL-H for Manufacture of Pesticides**

<table>
<thead>
<tr>
<th>Pesticide</th>
<th>Licensee</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monocrotophos</td>
<td>1. Sudarshan Chemical Industries Ltd.</td>
</tr>
<tr>
<td></td>
<td>3. National Insecticides and Chemicals Ltd.</td>
</tr>
<tr>
<td></td>
<td>4. Crop Health Products Private Ltd.</td>
</tr>
<tr>
<td></td>
<td>5. Vantech Pesticides Ltd.</td>
</tr>
<tr>
<td></td>
<td>6. Hindustan Insecticides Ltd.</td>
</tr>
<tr>
<td>Quinolphos</td>
<td>1. Sudarshan Chemical Industries Ltd.</td>
</tr>
<tr>
<td>MBC</td>
<td>1. JKBM Ltd.</td>
</tr>
<tr>
<td>DDVP</td>
<td>1. Sudarshan Chemical Industries Ltd.</td>
</tr>
<tr>
<td>Diazinon</td>
<td>1. Sudarshan Chemical Industries Ltd.</td>
</tr>
<tr>
<td>Chlor Pyrithos</td>
<td>1. Vantech Pesticides Ltd.</td>
</tr>
<tr>
<td>Butachlor</td>
<td>1. Montari Industries Ltd.</td>
</tr>
<tr>
<td></td>
<td>2. JKBM Ltd.</td>
</tr>
<tr>
<td></td>
<td>3. National Insecticides and Chemicals Ltd.</td>
</tr>
<tr>
<td></td>
<td>4. Crop Health Products Private Ltd.</td>
</tr>
<tr>
<td></td>
<td>5. Vantech Pesticides Ltd.</td>
</tr>
<tr>
<td></td>
<td>6. Hindustan Insecticides Ltd.</td>
</tr>
</tbody>
</table>

Note:
1. Capacity in Production - 2000 tpa
2. Capacity under Implementation - 2600 tpa

### Table 2

**Agro Chemical Development Programme at RRL-H**

(To be released by 1990)

<table>
<thead>
<tr>
<th>Type</th>
<th>Agro Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insecticides</td>
<td>1. Flucythrinate</td>
</tr>
<tr>
<td></td>
<td>--- Cotton</td>
</tr>
<tr>
<td></td>
<td>2. Cartap</td>
</tr>
<tr>
<td></td>
<td>--- Rice</td>
</tr>
<tr>
<td></td>
<td>3. Acephate</td>
</tr>
<tr>
<td></td>
<td>--- Rice, Tobacco, Cotton</td>
</tr>
<tr>
<td></td>
<td>4. Neem</td>
</tr>
<tr>
<td></td>
<td>--- Cereals, Commercial Crops</td>
</tr>
<tr>
<td>Herbicides</td>
<td>1. Chlorosulfuron</td>
</tr>
<tr>
<td></td>
<td>--- Wheat, Weeds</td>
</tr>
<tr>
<td></td>
<td>2. Bentazone</td>
</tr>
<tr>
<td></td>
<td>--- Soyabean, Rice, Ground nut</td>
</tr>
<tr>
<td></td>
<td>3. Isoproturon</td>
</tr>
<tr>
<td></td>
<td>--- Wheat, Weeds</td>
</tr>
<tr>
<td>Fungicides</td>
<td>1. Thiophanate</td>
</tr>
<tr>
<td></td>
<td>--- Rice, Vegetables, Fruits</td>
</tr>
<tr>
<td></td>
<td>2. Edifenphos</td>
</tr>
<tr>
<td></td>
<td>--- Rice</td>
</tr>
<tr>
<td>Plant Growth Promoters</td>
<td>1. Glyphosine</td>
</tr>
<tr>
<td></td>
<td>--- Sugarcane</td>
</tr>
<tr>
<td></td>
<td>2. Naphthyl Acetic Acid</td>
</tr>
<tr>
<td></td>
<td>--- Fruits</td>
</tr>
<tr>
<td></td>
<td>3. Fatty Alcohols</td>
</tr>
<tr>
<td></td>
<td>--- Cereals</td>
</tr>
</tbody>
</table>
DRUGS AND PHARMACEUTICALS INDUSTRY

1. CASE STUDY ON RIFAMPICIN
2. CASE STUDY ON PYRIDOXIN HYDROCHLORIDE
I. CASE STUDY ON RIFAMPICIN

I. INTRODUCTION

The case of Rifampicin is a unique one in many ways. The product involved is a bulk drug which is used in the treatment of Tuberculosis and Leprosy - diseases which are widespread in India. Research was done 'in house' by medium sized private industry and the problems of successful technology revolve round remunerative market prices to the user of research who also happens to be its originator.

Drug prices in India are controlled by government and some essential drugs like Rifampicin are imported without any duty to ensure reasonable prices to the consumer.

The issues in technology transfer in this case transcended the intra-company and market conflicts to wider national policy. Whose interests should the State policy protect in the short run? That of the ultimate consumer, or the entrepreneur who takes risk in undertaking research for 'import substitution'.

If one were to say that the priority is the consumer, and that, he should not pay more than world prices - what
is a 'fair' international price in a world market where powerful multinational corporations use discriminating pricing as a strategic weapon in retaining market share, profits? The price charged at the moment? Or something else?

The conflict faced by policy makers is not easy of solution. Indiscriminate import substitution can give rise to 'high cost' industrial structures which make indigenous production uncompetitive - internationally, and impose a burden on the domestic consumer.

But it is not always that international markets are 'free'. Dumping for short or long term is not unknown, especially if the exporter is also the owner of technology which he would like to exploit. At some stage in the technology product life cycle, it pays to export product rather than knowledge.

In the face of such business realities what could be institutional solutions in a technology transfer impasse - where product research has been successful but the business has failed - and would become viable if State policy becomes sensitive.
II. INDIAN DRUGS AND PHARMACEUTICAL INDUSTRY

Indian domestic production of drugs has increased from Rs. 10 crores, four decades ago to Rs.1156 crores in 1985-86.

There are over 2500 drug units. They vary in size, ownership pattern, product mix and main line of business (Bulk drugs or formulations).

The production pattern in 1977 was as follows:

EXHIBIT - 1

(Rs. in crores)

<table>
<thead>
<tr>
<th></th>
<th>Bulk</th>
<th>Formulations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public sector</td>
<td>48</td>
<td>47</td>
</tr>
<tr>
<td>Foreign ownership</td>
<td>63</td>
<td>292</td>
</tr>
<tr>
<td>Indigenous industry</td>
<td>39</td>
<td>361</td>
</tr>
<tr>
<td>including small scale</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>150</td>
<td>700</td>
</tr>
</tbody>
</table>

Besides local production there is a growing import which was Rs. 47 crores in 1977 and Rs. 200 crores in 1985-86. Indian industry is also a consistent exporter of both bulk drugs and formulations.
III. BROAD OBJECTIVES OF THE NEW DRUG POLICY

The broad principles and objectives which Indian Government have kept in view in formulating the new Drugs Policy are as follows:

(i) To develop self-reliance in drug technology;
(ii) To provide a leadership role to the public sector;
(iii) To aim at quick self-sufficiency in the output of drugs with a view to reduce the quantum of imports;
(iv) To foster and encourage the growth of the Indian sector;
(v) To ensure that the drugs are available in abundance in the country to meet the health needs of our people;
(vi) To make drugs available at reasonable prices;
(vii) To keep a careful watch on the quality of production and prevent adulteration and malpractices;
(viii) To offer special incentives to firms which are engaged in Research and Development; and
(ix) To provide other parameters to control, regulate and rejuvenate this industry as a whole, with particular reference to containing and channelizing the activity of foreign companies in accordance with national objectives and priorities.

These apparently seem to be consistent, but a close scrutiny would highlight conflicts between the development of indigenous technology and fair prices to consumers.
Among Indian industry, drug and pharmaceutical industry is most regulated and government policy support is critical for success of an enterprise. Hence the specific mention of import policy of technology is closely scrutinised by government and there are compulsions on foreign drug firms to spend minimum stipulated sums on in-house R&D.

Indian firms on the other hand have been encouraged to set up research facilities and promote import substitution. Policy encourages such effort. But sometimes circumstances make it difficult to realise policy goals.

IV. ABOUT RIFAMPICIN

Tuberculosis (T.B.) is a common Indian disease. According to the Tuberculosis Association of India there are 10 million active cases of T.B. A national survey indicates that half the country's population is infected and would be prone to the disease when the body is weakened. The victims of the disease are mostly the poor.

The treatment of T.B. has undergone many changes. Till about 30 years age, change of climate and sanatorium rest were chief forms of treatment. Streptomycin, Para-
Amino-Salicylic Acid (1945), Isoniazid (1952) and Pyvarinamide have all been used in T.B. treatment.

Rifampicin is the generic name of an antibiotic isolated from streptomycin meditegranei, researched by Lepelit and Ciba (research agreement in 1963) and introduced in 1967. The drug is effective against Mycobacterium tuberculosis and Mycobacterium Lepras.

To quote Sensi:

"The short course chemotherapy of Tuberculosis where rifampicin plays a primary role, appears a very good answer in terms of cost-benefit ratio for a rational treatment of the disease and should be used in developing countries with the necessary adjustments of the proposed regimens taking account the socio-economic epidemiological and medical situation in each country".

Rifampicin has a cure rate of almost 100% for T.B. Another significant benefit is reduction of the duration of Therapy from conventional 18 to 24 months to a 6 to 9 months regimen. Today Rifampicin is the latest, powerful and effective drug for T.B. and Leprosy.

To quote Sensi again:

"Rifampicin is now and will remain in the near future one of the most expensive anti-tubercular drugs because of its complicated technology involved in its production -
V. TECHNOLOGY FOR RIFAMPICIN PRODUCTION

The technology for manufacture of this drug has been a closely guarded secret and is held by six companies in the world:

EXHIBIT - 2

<table>
<thead>
<tr>
<th>Company</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lepetiv &amp; CIBA</td>
<td>Italy</td>
</tr>
<tr>
<td>Pharachem</td>
<td>Bulgaria</td>
</tr>
<tr>
<td>Leich</td>
<td>Poland</td>
</tr>
<tr>
<td>CKD &amp; Yuhan</td>
<td>South Korea</td>
</tr>
</tbody>
</table>

There have been many attempts in the past to bring this technology into the country.

Around 1976 IDL chemicals where DOW Chemicals of USA had an interest (they seemed to have a tie up with CIBA) made a proposal for technology transfer. Rifampicin technology as stated earlier consists of the steps: (i) fermentation of basic drug, and (ii) formulation, consisting of several chemical steps. IDL proposed that they would bring in the latter (perhaps to start with).

This partial transfer of technology (apparently a less critical part) was not acceptable to Government, who on the advice of the Central Drug Research Institute
(CDRI) insisted on a total transfer including basic fermentation knowledge necessary for production. This was not acceptable to IDL (DOW) and they withdrew.

It is also understood that Minister Ganesh felt at that time that in view of its importance to the health of the poor, the research and development of this drug should be done in the public sector. IDPL was requested to initiate steps.

CIBA, one of the originators of the product also expressed interest in bringing in technology but nothing concrete seems to have emerged.

Simultaneously Government permitted 7 Indian companies to produce the drug - the licenses ranging from 1 to 20 tons. Four of these have also been permitted to enter collaboration agreements - the total lumpsum payment amounting to Rs. 60 to 100 lakhs plus royalty.

Till date nothing concrete seemed to have emerged in Indian efforts to buy Rifampicin technology from abroad.

It is understood that a number of offers have been made by intermediate agencies for sale of know-how but none from the original six (quoted earlier) with the result that import of Rifampicin continued, and has grown as the following table will show:
**EXHIBIT - 3**

<table>
<thead>
<tr>
<th>Year</th>
<th>Qty. (tons)</th>
<th>Value (Rs. Lakhs)</th>
<th>Price/kg.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980-81</td>
<td>11.26</td>
<td>577</td>
<td>5126</td>
</tr>
<tr>
<td>1981-82</td>
<td>16.07</td>
<td>663</td>
<td>4137</td>
</tr>
<tr>
<td>1982-83</td>
<td>36.90</td>
<td>1286</td>
<td>3485</td>
</tr>
<tr>
<td>1983-84</td>
<td>75.77</td>
<td>1596</td>
<td>2113</td>
</tr>
<tr>
<td>1984-85</td>
<td>100.00*</td>
<td>2000*</td>
<td>2000*</td>
</tr>
</tbody>
</table>

* Estimated

Rifampicin imports account for 10% of the total bulk drug imports and the proportion is increasing showing increasing demand and limited local production.

VI. THEMIS CHEMICAL: RIFAMPICIN PROJECT EFFORTS

Themis Chemicals is a medium sized, private enterprise, relatively a new entrant to the business. There are older companies in this field but Themis has a strong product development base.

Their product range includes Vitamin B12 (a fermentation process product) Ethambutol (T.B. drug) and Phenylbutazone.

They saw in increasing Rifampicin imports, an area of opportunity. They were conscious of the problems involved
in biosynthesising the drug - the large investments involved and the near impossibility of getting technology from existing owners.

To quote:

"Operation Rifampicin took off in the late 70s. What followed was a series of innovative experiments, repeated trials, frequent back tracking, exploring new leads, adoption of diverse methodologies, frustration, fulfillments, constant reassessing and cross-checking - seven long years sustained only by a dedication to produce results which others had declared impossible. Part of the ground work included obtaining a specimen strain from Central Bureau Voor Schimmecultures Holland, liasoning with the foremost scientists in India's premier research institutes like Central Drug Research Institute, Lucknow, Regional Research Laboratory Hyderabad and the Institute of Microbial Technology, Chandigarh".

VII. PILOT PLANT AND COMMERCIAL PRODUCTION

While laboratory research was done in Themis further product development was taken up at a new company. Themis Chemicals acquired Andhra Citrates Limited, Hyderabad.
This was a 'sick' company with an investment of Rs. 5 crores set up to produce citric acid based on technology provided by Regional Research Laboratory, Jammu.

The technology transfer for citric acid was not successful, due to technical difficulties and escalating cost of intermediates. There were also managerial problems. Consequently, the project was abandoned and the Financial Institutions which had advanced large sums of money were looking for a new entrepreneur who could take over the company.

The unit was equipped with a modern Fermentation Unit with six fermentors of 33,000 litres capacity each, along with all necessary utilities. Themis took over the sick unit in early 1984; brought in Rs. 1 crores as its own contribution; discarded the manufacture of citric acid; and, brought in their inhouse technology for the manufacture of two antibiotics, Rifampicin and Gentamycin.

The upscaling and preliminary pilot plant trials were done successfully at the Hyderabad plant.
VIII. TECHNOLOGICAL EVALUATION

The erstwhile Director of the CDRI had evaluated the technology developed by Themis and felt that, to quote:

"its (....rifampicin) production involves fermentation step to manufacture an intermediate Rifampicin Bors which is then converted by synthetic manipulation to Rifampicin".

"Its production technology is highly protected and guarded particularly the microbial organism used in fermentation step and is not easily available".

"May Indian firms have been issued letters of intent and given... permission to import technical knowhow. But none have been successful".

"....I can say with reasonable confidence that the technology developed by Andhra Synthetics and Antibiotics (the new name of Themis at Hyderabad) is comparable to international standards".

"...For example they have achieved an efficiency of 8000 units per milli litre compared to the world standard of 14,000".

Themis successfully scaled up the lab process and produced small quantity commercially.
IX. UNREMUNERATIVE PRICING

While the technical capability of producing on some scale (admittedly small) of the drug was developed, in the regulated ambience of the Indian Drug and Pharma scene, the marketing of the drug became a losing proportion.

When Themis identified Rifampicin as a possible business opportunity, it was imported at around $ 700/kg. or Rs. 7000/kg. Themis took this as a benchmark for its costing.

In the decade between the conception of the R&D project and commercial production, international prices sharply declined to $ 150/kg. and later improved to $ 270/kg. Price reduction is nothing unusual in the international market - reflecting the desire or strategy of the owner of the technology process to share some of the gains with the consumer. The R&D venture of Themis was classified as a mis-adventure.

Themis alleges (and this is confirmed by others in the field) that the sharp fall in the international process is due to an aggressive strategy adopted by the international cartel of 7 who have technology for the drug and are also exporters of product to India.

It is said that the cartel acted as a discriminating
monopolist charging different prices in different markets - they particularly brought down prices of exports to India to prevent commercialization of the research done at Themis.

The exhibit supports some of the allegations. A sharp (commercially unexplainable) drop in international prices would have somehow been cushioned by import duties.

While all antibiotics and bulk drugs enjoy the tariff protection of a 75% import duty. Rifampicin is imported free of duty which has made it a very sensitive issue.

A combination of circumstances, international price fall and duty free imports made the imported rifampicin cost around Rs. 3000/kg. while the tentative cost of Themis was around Rs. 5400/kg.

X. POSSIBLE SOLUTIONS

There seem to be two possible ways to resurrect the research effort:

1. To impose an import duty to bridge the gap between world prices and Themis cost of production.
2. To pool the imported and local price and sell the drug to the consumer at an average price.

These suggestions have been made by the erstwhile director of CDRI, the Chairman of the Industrial Finance Corporation (State owned) which has a financial stake in the future of Andhra Synthetics (Hyderabad operation of Themis).

XI. POSSIBLE DILEMMA OF POLICY MAKERS

The suggestions made are logical from the point of view of Themis who rightly look to the State for protection and encouragement of indigenous research.

But policy makers have another obligation - to supply an essential drug like rifampicin at the lowest possible price. Could they in all fairness put the burden on the consumers (more so when there is a valid criticism that Indian industry is not internationally competitive)?

There is thus a conflict between the short and long term interest of consumers and the protection for indigenous research.

Then, there is also a possibly valid allegation that the current prices charged by the importers are dumping prices.
The dilemma brings into focus the crucial importance of State policy in successful commercialization of indigenous research. Technical viability does not seem to be enough.

XII. WHY ARE THE COSTS OF THEMIS HIGH

There seem to be a number of reasons why Themis cannot produce rifampicin at the current international prices. Among these:

- the state of the fermentation industry
- high cost of inputs
- the firm being at the starting point of learning curve

There are nine plants using fermentation technology in the country - 2 in public sector; 3 multinationals (not CIBA and Lepelit); and, four private sector units.

Most of the Indian plants are of 1960 vintage and compare unfavourably in terms of investment costs with the world industry, which is much older. This is particularly aggravating for the plants of Themis which are less than 5 year old.

In addition to high costs of investment, local prices of inputs are substantially higher than world costs. For
rifampicin, 10 input materials (78% of total cost) are 3 times more expensive in India. High costs seem universal in the field of drugs produced locally and using fermentation technology, as the following table will show:

EXHIBIT - 4

<table>
<thead>
<tr>
<th>Name of the drug</th>
<th>Price in US $</th>
<th>Equivalent in Rs. per kg.</th>
<th>Govt. declared price per kg. Rs.</th>
<th>Ratio of imported to indigenous</th>
<th>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Penicillin Standard</td>
<td>16</td>
<td>195</td>
<td>760.00</td>
<td>1: 3.8</td>
<td>IDPL</td>
</tr>
<tr>
<td>Gentamycin</td>
<td>230</td>
<td>2,806</td>
<td>26,000.00</td>
<td>1: 9.2</td>
<td>HAL</td>
</tr>
<tr>
<td>Tetracycline</td>
<td>25</td>
<td>305</td>
<td>819.30</td>
<td>1: 2.7</td>
<td>IDPL, Pfizer Sarabhai</td>
</tr>
<tr>
<td>Oxytetracycline</td>
<td>22</td>
<td>268</td>
<td>847.30</td>
<td>1: 3.0</td>
<td>- do -</td>
</tr>
<tr>
<td>Doxycycline</td>
<td>155</td>
<td>1,937</td>
<td>5,980.00</td>
<td>1: 3.0</td>
<td>Ranbaxy, IDPL</td>
</tr>
<tr>
<td>Ampicillin</td>
<td>65</td>
<td>793</td>
<td>1,677.00</td>
<td>1: 2.1</td>
<td>- do -</td>
</tr>
<tr>
<td>Amoxycillin</td>
<td>70</td>
<td>854</td>
<td>2,229.00</td>
<td>1: 2.6</td>
<td>- do -</td>
</tr>
<tr>
<td>Vitamin B12 1.5/gm</td>
<td>55</td>
<td>124.37</td>
<td></td>
<td>1: 2.2</td>
<td>Merind, TCL</td>
</tr>
<tr>
<td>Erythromycin Est.</td>
<td>73</td>
<td>890</td>
<td>1,992.50</td>
<td>1: 2.2</td>
<td>Alembic</td>
</tr>
<tr>
<td>Rifampicin</td>
<td>280</td>
<td>3,500</td>
<td>6,000.00</td>
<td>1: 2.7</td>
<td>Themis Chemicals Ltd.</td>
</tr>
</tbody>
</table>

The wide gap between imported and local prices has made the rifampicin local product research unviable. The
company is not in a position to use its successful research (in a limited technological sense).

EXHIBIT - 5

LICENCES ISSUED FOR RIFAMPICIN

<table>
<thead>
<tr>
<th>YEAR</th>
<th>FIRM</th>
<th>LICENCED CAPACITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980</td>
<td>i) Themis Pharmaceutical, Vapi</td>
<td>1 T</td>
</tr>
<tr>
<td></td>
<td>ii) P.C. Mehta Pharmaceutical, Amritsar</td>
<td>72 T</td>
</tr>
<tr>
<td>1981</td>
<td>i) NIL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ii) CADILA LABS, AHMEDABAD</td>
<td>10 T</td>
</tr>
<tr>
<td></td>
<td>iii) Rajasthan State Industrial Development Corporation, Jaipur</td>
<td>200 T</td>
</tr>
<tr>
<td>1983</td>
<td>i) Curewell (I), Faridabad</td>
<td>10 T</td>
</tr>
<tr>
<td></td>
<td>ii) Ciba-Geigy, Bombay</td>
<td>12 T</td>
</tr>
<tr>
<td>1984</td>
<td>i) Wander Ltd., Bombay</td>
<td>75 kg.</td>
</tr>
<tr>
<td></td>
<td>ii) Alembic Chemical Works, Baroda</td>
<td>20 T</td>
</tr>
<tr>
<td>1985</td>
<td>i) Hindustan Antibiotics, Pune</td>
<td>15 T</td>
</tr>
<tr>
<td></td>
<td>ii) Arun K. Mittal, New Delhi</td>
<td>15 T</td>
</tr>
<tr>
<td>1986 (Oct.)</td>
<td>NIL</td>
<td></td>
</tr>
</tbody>
</table>

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EXHIBIT 6

COST OF MAJOR RAW MATERIAL IN INDIA
AND INTERNATIONAL MARKET

<table>
<thead>
<tr>
<th>Raw Material</th>
<th>Qty. reqd. per year at max capacity utilisation</th>
<th>International price Rs./kg</th>
<th>Total value Rs.lakhs</th>
<th>Indian price Rs.lakhs</th>
<th>Total value Rs.lakhs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tetrahydrofuran</td>
<td>51275</td>
<td>32.00</td>
<td>16.41</td>
<td>80.50</td>
<td>41.28</td>
</tr>
<tr>
<td>Tertiary Butylamine</td>
<td>15400</td>
<td>66.00</td>
<td>10.16</td>
<td>140.00</td>
<td>21.56</td>
</tr>
<tr>
<td>Barbituric Acid</td>
<td>7548</td>
<td>105.00</td>
<td>7.93</td>
<td>450.00</td>
<td>33.97</td>
</tr>
<tr>
<td>Dextrose</td>
<td>488400</td>
<td>4.00</td>
<td>19.54</td>
<td>12.00</td>
<td>58.61</td>
</tr>
<tr>
<td>Chloroform</td>
<td>481160</td>
<td>6.00</td>
<td>28.87</td>
<td>26.00</td>
<td>125.10</td>
</tr>
<tr>
<td>Methanol</td>
<td>614381</td>
<td>3.00</td>
<td>18.43</td>
<td>7.50</td>
<td>46.07</td>
</tr>
<tr>
<td>Vitamin C</td>
<td>21741</td>
<td>80.0</td>
<td>17.39</td>
<td>207.00</td>
<td>45.00</td>
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<td><strong>TOTAL</strong></td>
<td></td>
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<td>136.23</td>
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<td>422.93</td>
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</table>

**NOTE :**

(A) % of above ten items to total raw material consumption as per Form I.........78.75%

(B) Ratio of total value at International price to total value at Indian price.........1 : 3.11
1. INTRODUCTION

Vitamin B6 (Pyridoxine hydrochloride) is an important and irreplaceable member of the Vitamin B complex family. It is used for certain types of anemia, nausea and nervous disorders. The drug serves an important role in metabolism, as a nutrition factor (Enzyme cofactor) in conjunction with other vitamins of B-group, for a wide variety of metabolic transformations of amino acids.

The synthesized existence of Vitamin B6 can be traced back to the early fifties, when scientists experimenting in the laboratories of Hoffmann La Roche, the Swiss pharmaceutical giant, were able to produce it for the first time. Since then only one other company, the German multinational Merck, Sharp and Dohme has been able to successfully master the technology for synthesis and manufacture of this drug.

Research and development for manufacture of Vitamin B6 in India dates back to the early 1960's. Scientists at the National Chemical Laboratory, Pune have sporadically worked towards developing a suitable and efficient process through, both, known and new routes. The latest effort has led to the development of an indigenous process, which
is being tried out for commercial production. Claims have been made of the technology being the latest and most efficient; and, that indigenous production is expected to, not only substitute the imports but also provide enough surplus for exports.

The manufacturing process of this Vitamin has been subjected to an extremely high rate of technological obsolescence. So rapid has been the pace of change that even Merck has been left behind, thereby ensuring world monopoly of Vitamin B6 to Roche.

- Is the new NCL technology the state-of-art?
- Can indigenous R&D efforts keep pace with those of the MNC?
- Will the local manufacturer be able to withstand the aggressive marketing strategy of a successful MNC?
- Will the utilization effort turn out to be a successful venture?

Though, this case of indigenously developed Vitamin B6 presents a picture of smooth transfer of technology from the laboratory to the industry, the answers to the above questions will determine the extent to which the potential of the indigenous R&D effort will eventually be exploited.

These in turn bring to the fore the issues in technology transfer in this case. Whatever the level of
success at the Research and Development stages, the successful commercialization of this manufacturing process will be determined ultimately at the market place. The interest of the final consumer, the pricing policy of the MNC's and the need to foster indigenous R&D and import substitution are issues that may require active government intervention.

The prospects of indigenously produced Vitamin B6 replacing its imported counterpart in the Indian market look very good. For lack of government support, however, it is very much possible that even this state-of-art and efficient technology may end up in a situation similar to that of Rifampicin and Chlorosilanes. Excessive protection on the other hand may lead to obsolescence which would be a pity, specially in an area where the indigenous technology seems to have finally come up to the international standards. The solution to the dilemma faced by policy makers may spell the difference between success and failure of the indigenous effort.

2. CHOICE OF THE PROJECT BY NCL

In India a major portion of the prevailing diseases can be sourced to nutritional deficiency. In this respect Vitamin B6 has an important role to play. It is used for building up resistance to infection which in turn lowers
mortality risk, for speeding up convalescence in the aftermath of debilitating ailments, and for the treatment of certain types of anemia and nervous disorders.

Until 1986, Vitamin B6 was not being manufactured in India. The country's total requirement of the drug was being met through imports which averaged between 25 to 30 tonnes per annum. The demand for the drug in 1989-90 is estimated at 80 tonnes.

During the early 1960's scientists in the Department of Organic Chemistry at the National Chemical Laboratory, Pune started experimenting with the well known oxazole chemistry for making pyridine derivative. This being the basis of practically all the processes for Vitamin B6 manufacture. The aim was to develop indigenous technology for manufacture of the drug. As in most of the other CSIR laboratories during the period, the emphasis on development of indigenous technology was essentially an attempt in import substitution.

3. R&D AT THE NATIONAL CHEMICAL LABORATORY

The initial research efforts at NCL during the early 1960's aimed at replicating the known processes for manufacture of Vitamin B6. The chemistry of the process was based on a key Diels-Alder reaction and was well known
and documented. However, by the time the manufacturing process was stabilized in the laboratory, a better and a more efficient process had been commercialized by the Swiss multinational Hoffmann La Roche. As has been mentioned earlier, the evolutionary process of this Vitamin was subject to a very high rate of technological obsolescence. Research efforts at NCL were subsequently given up.

Work was re-initiated on indigenisation of the technology in 1970. The chemistry of the process was well known and most of the laboratory work was therefore of developmental nature. The aim was to stabilize the 'known' method of Vitamin B6 production and accurately determine the parameters of the manufacturing process. The outcome of this second effort was a manufacturing process based on the conventional method of Vitamin B6 production. Around 1972 this knowhow was passed on to the public sector monolith, the Indian Drugs and Pharmaceuticals Ltd. (IDPL). The company set up a plant to manufacture the drug but production was never stabilized, and nothing ever came out of the IDPL Vitamin B6 project. Though IDPL continued to make efforts for commercial production, work at NCL on the conventional route was given up after this setback.
During 1980 a group of ten scientists renewed efforts to develop an economically viable process for the production of Vitamin B6. As different from the earlier efforts, work was initiated on new and alternate routes for manufacture of Vitamin B6. Instead of confining themselves to developmental work by trying to specify the parameters of a process based on known and established chemical reactions, the scientists began by laboratory experiments on the chemistry part of the process itself. The efforts were directed at finding alternatives to certain operations which necessitated working with expensive equipment or those which were not manufactured in India. Also, the experiments conducted were aimed at making maximum use of locally produced raw materials. For instance, the use of Butenediol, a common pesticide intermediate easily available in India.

As the group leader Dr. T. Ravindranathan himself notes:

"The test lies in the method adopted, since economy of cost and self-reliance are the crucial criteria. Therefore, to make the entire project viable, we had to think of a way which would be simple enough to be inexpensive".

In this particular R&D effort at the NCL the
scientists of the group seem to have had a fairly clear perception, not only of the objectives of the project but also of the needs, requirements and specifications of the process that was expected to be optimized at the laboratory level.

The laboratory work was completed within two years and the process details and the chemistry was passed on to NRDC in 1982 for commercialization.

The process involved more than six steps of reactions with critical control of process parameters and use of essentially indigenous raw materials. Though the Vitamin B6 technology developed by NCL followed the well known oxazole chemistry route for making pyridine derivative, the process itself was based on Ethylacetoacetate, unlike the conventional process which was based on Alanine.

Following are some of the highlights of the new NCL process:

- Readily available raw material
- Import constituents negligible
- Successful use of P205, which normally poses scale-up problems
- Diene component: stable and easy to handle giving high yields in key diels alder reaction
- Diels alder reaction is at atmospheric pressure
- Higher overall conversion to Vitamin B6
4. EFFORTS AT COMMERCIALIZING VITAMIN B6 TECHNOLOGY

The first attempt to commercialize the Vitamin B6 manufacturing process was made by NCL, directly in collaboration with IDPL. R&D initiated at NCL in 1970 had made use of the conventional method to stabilize a manufacturing process at the laboratory level. The know-how was essentially imported and the process had merely been replicated in the NCL laboratory. No attempts had been made to, either change it or adapt it to the Indian raw material and equipment specifications.

The process parameters were passed on to IDPL around 1972 for commercial application. By all accounts very little or no interaction seems to have taken place between NCL and IDPL after the technology was passed on to the latter.

An approximate Rs. 3 to 4 crores was spent by IDPL in setting up a plant for manufacture of Vitamin B6. Though some amount of Vitamin B6 was produced, commercial production at the plant could not be stabilized. IDPL is still continuing its efforts to get into commercial production but its endeavors are yet to see the light of day.

Various reasons have been assigned for the failure of this venture. The fact that there was practically no
interaction between the laboratory and the industry during the scaling up process seems to have played a significant role in the outcome of the venture. The technology used by IDPL was not as adapted to Indian conditions as the one later developed by NCL. It was based on the older conventional method of Vitamin B6 production. It is, however, opined that a close interaction with the laboratory could have solved many of the problems faced by IDPL in scaling up. IDPL did not think it necessary to approach the scientists at NCL even once, for a feedback on the problems encountered, relying for most part on its own staff to find solutions to them. For all practical purposes the scientists at NCL had no involvement in the development and commercialization of the technology, once the process details had been passed on to IDPL.

The question is: Would the commercialization effort have succeeded had NCL been involved - post-transfer of technical knowhow - for trouble shooting? Scientists at NCL felt that it would have, at least partially. IDPL seems to think otherwise.

The second attempt to commercialize the production technology for Vitamin B6 made use of the alternate manufacturing process based on Ethylacetoacetate, developed by the NCL. The process was optimized at the
laboratory level and given to NRDC in 1982 for patenting and commercialization.

In 1983, the NRDC licensed this new technology for manufacture of Vitamin B6 to two private sector firms: (1) Themis Chemicals, Hyderabad; and (ii) Lupin Laboratories Pvt. Ltd., Bombay.

Lupin Laboratories undertook further development work to commercialize production of the Vitamin. Themis Chemicals, on the other hand, gave up the idea after acquiring the technical know-how.

Further work on scaling-up, development and commercial application of the NCL process for Vitamin B6 production was jointly undertaken by Lupin and NCL.

5. SELECTION OF LUPIN LABORATORIES

Lupin Laboratories was set up in 1968 with an initial investment of Rs. 5,000 only. During the seventies and early eighties the company showed a phenomenal growth rate. Its sales turnover in the current year is expected to cross the Rs. 75 crore mark. The company is headed by Dr. D.B. Gupta, a one-time professor of Chemistry at Birla Institute of Technology and Science, Pilani. By 1983, at the time when NCL technology for Vitamin B6 manufacture was passed on to NRDC, Lupin Laboratories had already
emerged as major formulators of Vitamin B6 in India. They had also developed the capability and resources for implementing sophisticated technology projects. Once the manufacturing process was patented by the NRDC, scientists at NCL were keen to see its implementation through commercial application. Lupin approached them with an offer to do so.

The timing of the Lupin offer, coupled with the fact that it was a high growth company, possessing the requisite expertise and very much familiar with the Vitamin B6 technology, presented an attractive opportunity to the NCL for commercializing its Vitamin B6 manufacturing process. NCL strongly recommended to the NRDC to license the technology to Lupin.

6. NCL-LUPIN COLLABORATION FOR DEVELOPMENT AND COMMERCIAL PRODUCTION

The development of the technology from the laboratory process to the commercial plant level was through joint efforts of NCL and Lupin. The former worked out the Chemistry part of the process and specified the process parameters whereas the latter provided engineering inputs and investments.

The development work started with the Lupin setting
up a pilot plant at Aurangabad in 1984. As mentioned earlier, the Vitamin B6 manufacturing process involved six steps of chemical reactions with critical control of process parameters at various steps. The pilot plants were not set up for all the six stages of the process. Only those stages which required critical control were tried out at the pilot plant level. Extensive experimentation was undertaken at the pilot plant level for a period of nearly 18 months.

After achieving success at the pilot plant level, Lupin decided to set up a commercial plant at Ankleshwar, Gujarat. Work on this plant started around the beginning of 1985 and trial runs on it were conducted in November 1986. The plant was commissioned in April 1987 and till reports last came in the plant has produced more than 2 tonnes of Vitamin B6 valued at around Rs. 24 lakhs.

The scaling-up and development of the manufacturing process was marked by a close interaction between the scientists at NCL and the engineering staff of Lupin. Periodic meetings, normally once a month, were held between the NCL and Lupin staff working on the project. The problems that cropped up during scaling-up were related not only to the design and engineering aspects but were sometimes of the nature which required alterations in the chemical reactions and processes. In such cases the
The problem was referred back to the laboratory of NCL for solution. The problems of scaling-up and design were solved at the plant site, frequently in consultation with the NCL scientists.

Evidence of the close cooperation between NCL and Lupin during development can be seen from the manner in which two major problems in scaling-up were tackled.

To quote:

"During one particular stage in the process of evolution, a toxic gas is released. The scientists, comfortable in their knowledge of laboratory experience, expected that in a scale-up too, the gas, on passing through a condenser, would be absorbed and detoxified. But this did not happen. To being with, beyond a certain scale, the concentrate of toxic gas becomes very high, and secondly, in a plant, the condenser is cooled to degrees far exceeding its counterpart in the laboratory. With these new parameters in force, the gas, because of intense cooling, instead of being detoxified, turned to liquid". The problem was countered by the scientists conducting further experiments to respecify the condenser temperature.

In another case, one of the intermediates being
produced at the plant was found to be unstable. The scientists at NCL were promptly informed of this. After fresh experiment in the laboratory the scientists suggested the use of a catalyst. This increased the stability of the intermediate.

According to sources at NCL, a close interaction of this kind was one of the main causes for the smooth transfer of technology from the NCL to Lupin Laboratories.

To quote Dr. D.B. Gupta, Chairman, Lupin Laboratories:

"We approached NCL to allow us to participate in this challenging project, and after the process of Vitamin B6 had been developed in the laboratory, we provided the engineering inputs".

7. COMMERCIALIZATION OF VITAMIN B6 TECHNOLOGY : SUCCESS OR FAILURE ?

With the commissioning of the 50 tonnes per annum Lupin plant at Ankleshwar, the NCL process for manufacture of Vitamin B6 has been effectively commercialized. This has been possible through a process of smooth transfer of technology from the laboratory (NCL) to the industry (Lupin). The plant operating at full capacity is expected to fully meet the country's current demand by producing
Vitamin B6 valued at around Rs. 6 crores per annum. This will effect an annual saving of Rs. 2.5 crores in foreign exchange.

The above is based on the assumption that the indigenously produced Vitamin B6 will be able to capture the domestic market and replace its imported counterpart.

To be able to do this, however, the indigenous product has to be internationally competitive both in terms of price and quality.

Lupin Laboratories have agreed to market Vitamin B6 at Rs. 1200 per kg. for a period of two years. The imported price of the Vitamin is around Rs. 900-1000 per kg. According to Lupin this is because the prices of raw materials in India are very high - steeper than those prevailing in the international markets.

There is a strong lobby for either banning imports or imposing restrictive tariffs on imports of Vitamin B6. Lupin has already sent its formal request to the Government to this effect.

It is expected that initial protection to the industry in the form of ban on imports will not only preempt the multinationals from resorting to their discriminatory pricing strategies but will also help the
domestic firm to establish itself in the market and stabilize production.

As for the competition from the subsidiaries of the MNC's within the country, Lupin does not foresee any threat from them. To quote Dr. Gupta:

"Most of them (MNC's) do not bring their best technology to India and have no intention of doing so. Consequently, Roche India is not structured like Roche Switzerland and that is the reason why they do not possess similar capabilities or capacity. Thus even if Roche India had ever thought of indigenising the Vitamin B6 process, it would have been an extremely difficult proposition for them".

The issue in successful commercialization of this technology therefore centers around the Government policy to provide protection to this industry.

Impact of a tariff protection is bound to be felt by the ultimate consumer in the form of higher prices of the final drug. No protection on the other hand will pitch the local firm against the all prevailing MNC and the indigenous effort can very well peter out like other similar efforts.

Another factor that may influence the survival of the
domestic industry is the number of local units to whom the technology is finally licensed.

Currently, only Lupin has set up plant for Vitamin B6 production. Its installed capacity is enough to meet the country's demand. There are, however, four more local entrepreneurs who have shown interest in entering the field. Their initial enquiries are being seriously evaluated for licensing. Can the domestic industry already threatened by the MNC's, survive increased local competition in a limited market? On the other hand, will the present installed capacity in the country be able to meet the projected demands of the next 5-10 years.

Though the Vitamin B6 technology developed indigenously has been successfully passed on to the industry, the commercial viability of the industry will depend ultimately on the Policy decisions of the Government.
CHAPTER - V

PROCESSED FOODS INDUSTRY

1. CASE STUDY ON COCOA BUTTER SUBSTITUTE
2. CASE STUDY ON SOFT DRINK CONCENTRATE
In the early 1960’s HLL’s soap business (its most profitable line) was threatened by a shortage of soapery fats, particularly of hard fats; government legislation prohibited the use of groundnut oil because it was edible; hardening capacity was getting scarce and tallow an import was uncertain (this was decades before tallow was banned for import for non-commercial reasons). The company was on the lookout for a substitute. Literature survey indicated that Shorea Robusta was a tree which yielded a seed, which would yield a fat hard in its natural state (so needed no hardening), was plentiful because the tree was grown for its timber.

The early potential calculations showed that it could run into millions of tons and provide an answer to the company’s prayer.

The research unit did a literature survey; established the antiquity of the tree (mentioned in the epics of Mahabharat and Ramayana); and reported that Sal Seed unlike the other oil bearing types was a winged seed which nature had provided for easy propagation when hot winds of the summer carried it far in the forests. A
typical potential calculation (done by HBTI, Kanpur) read as follows:

**Area of Sal forest in India** : 27.5 million acres  
**Anticipated yield of Sal fruit** : 400 kg. per acre  
**Yield of Kernels** : 200 kg. per acre  
**Gross potential** : $27.5 \times 10^6 \times 200$ kg/10$^3$  
= 5.5 million tons  
**Equivalent oil (at 13% yield)** : 715,000 tons

This seemed a large source and the company set its buying department to start procuring the seed.

Very soon the target looked difficult to achieve because of its short season (6 to 8 weeks), due to the onset of monsoon; and difficulties of collection. The potential of over five million tons was slashed to a million.

To most companies this would have meant an end of a new project: promising but beset with practical difficulties.

But at HLL this was the beginning of a new high technology business.

* The search was industry wide. The case reports HLL efforts.
II. THE UNIQUE CHARACTERISTICS OF SAL FAT

Analysis of commercial samples of sal fat indicated that its fatty acid composition was similar to that of Ilipe also belonging to the Shorea family.

Around mid-1960's while the demand for chocolates increased dramatically, the production of cocoa beans remained stagnant and the prices of cocoa butter rose sharply. Chocolate manufacturers in Europe were looking for a cheaper and technically accepted substitute. Unilever, especially its business interests in Holland were on the look out for a promising product.

Cocoa butter equivalent (CBE) were of three kinds:

- Lauries
- Hydrogenated fat fractions
- Fats with symmetrical disaturated mono-unsaturated glycerides

The first two are not compatible with cocoa butter, their use restricted to cheaper version of coatings containing chocolate. The last CBE, to use a generic term, was totally compatible with cocoa butter and could be mixed with it in any preparation without affecting its physical characteristics.

The origin and development of CBEs could be traced to
the work of Unilever in the late 1950's.

In non-technical terms, the important characteristic of a CBE was remaining hard and brittle at 30°C and yet melt fully and completely at 35°C (temperature on the tongue) and leave no oily after-taste.

Sal fat had these characteristics by virtue of having 69% symmetrical glycerides.

Its competitors were products based on Ilipe and Shea, both small crops grown in Malaysia and Africa (Ivory coast and upper Volta).

HLL researchers saw a product possibility and their colleagues both in Unilever and Bombay agreed with them.

A new business was thus born in the mid sixties.

III. RESEARCH ORGANISATION AT HLL

The research centre of HLL is one of the nine research centres of Unilever located all over the world. There is a constant and active interaction between the scientists in the various centres.

Research activity in Unilever goes back to the late forties (Colworth House) and by the end of 1960's a separate research division was established.
Research unit at Andheri was established in the early sixties which worked both on problems of HLL as also other Unilever companies.

It had 27 scientists in 1972 and over a hundred currently, about half of them with doctorates.

R&D expenditure at HLL has fluctuated between 0.5 to 0.95% of sales turnover. The small size of HLL research has attracted adverse comment. But that does not directly concern us here.

Suffice to say that it has organisational linkages with HLL and also Unilever: a part of a world wide net work of information exchange.

IV. MULTIPLE PRODUCT AND MARKET OPERATION

Today cocoa butter equivalent business (CBE) is not one product but many:

- Raw Sal fat
- Neutralised sal fat
- Pressed sal fat
- Purified fractionated oil
- Full substitute
The price range of the products varies from Rs.18,000 tons for raw oil to Rs.35,000 for the purified fractionated oil. The full substitute is yet to be marketed.

The range of technology varies from relatively low technology of raw fat to the high tech full substitute.

The preference of countries varies depending on processing facilities, food laws and economics.

CBE marketing seem to have a distinct structure of its own with a closed shop cocoa club in which Unilever also participates.

Hindustan Lever is not the only exporter of sal fat products from India and neither is Unilever the sole buyer. The business is spread from UK, EEC to Japan and USSR.

V. MARKETING - RESEARCH COORDINATION

CBE is a research 'discovered' product and would have remained a 'find' if the company dynamics did not pick it up to make it a substantial export business.

The problem solving process seems to be a constant dialogue between the business, called 'profit centre' and
the research group.

In the case of sal fat product group research has contributed to product up-gradation at each level.

The most significant is the purification of sal fat and dealing with the P&Q factors which made untreated sal fat behave sub-optimally in storage.

An extract from Research Units handout makes interesting reading.

"Trace impurities in sal fat continued to cause significant variations in the characteristics of the end product. This has been found through deterioration of the quality of sal fat in terms of stearing content and dilatation value. Some extensive studies over the period of three years have enabled to identify the organic polar impurities. A process was developed to produce a suitable adsorbent (silica-alumina) known as SAREX, for the removal of these impurities and produce a high value stearine product. The process for the production of 200 tonnes per annum of SAREX was designed by Research based on pilot scale data. The detailed engineering design and commissioning of this 200 tonnes per annum plant at one of our factories at Taloja was carried out by the Research team."
The process design to produce 5,000 tonnes per annum of upgraded sal fat was prepared by Research in 1980. Based on the process design, M/s Dalai Engineering Consultants were assigned to carry out the detailed engineering design and equipment specification. Emphasis was laid on energy conservation and heat recovery. Research liaised with Dalai Engineering to carry out the final plant design.

The process involves a series of batch operations. To make it a commercially feasible system, a three-stage counter-current operation using seven adsorption towers in a sequential order was proposed. The adsorbent was regenerated and reused at least for 30 operations. The operation of 140 control valves and about 30 electric motors (pumps and stirrers) was made possible by the use of a microprocessor control system.

The microprocessor hardware was specially designed and developed by Tata Electric Co's R&D, for this process. The software package was developed by our own Research team. It is worth noting that the plant is unique in India in that it is the only unit that uses chromatographic separation principle on an industrial scale, the whole operation being controlled by a microprocessor. With this process, even poor quality sal
oil with high FFA can be SAREX-treated to produce a high value material. The adsorbent SAREX is also developed in-house. The export market for this product is of the order of $15 million.

VI. CONFLICT RESOLUTION IN PRODUCT DEVELOPMENT

Product development in HLL has not always been a 'conflict-free-process'. The perceptions of the researcher, the production man and the marketeer have differed, sometimes radically. As in all organisations there has been differences of opinion.

But the company provides a forum for conflict resolution. The profit centre approves a research budget and sets its priorities of actions. It is quite possible that both the programme and financial allocation would not be acceptable to research. After discussions and trade-off at various levels an annual research budget is mutually agreed upon. But this is only 70% of the total budget research spending.

There is a 30% which is approved by the Research Board, that consists of four Board members including the Chairman, which tries to strike a balance between what is immediate corporate necessity and what excites the
research team.

This is not all. There are also conflicts between the priorities of Unilever and HLL which are more 'sensitive' and get settled at a 'higher' level of corporate hierarchy.

VII. RESEARCH PHILOSOPHY

Producing research answers for day to day business problems could be dull business. Dr K.K. Menon articulated an interesting point of view:

"In any research enterprise, it is useful to have a certain amount of carefully chosen seemingly irrelevant research. Many businesses usually consider research support strictly in areas of present interest, from the point of view of present requirements of research support, without heeding the need in terms of the logic of science to experiment a little 'between and beyond' the demands of the market place. These types of research stand uniquely at the interface between what is known and what is unknown - between today and tomorrow, research that can alter future possibilities. Thus a research, planned exclusively by analysis of the present, will advance into the future facing backwards, with too much visceral thinking in fact.

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A good scientist should create new opportunities in addition to responding to needs. Therefore, the concept of relevance must be treated with caution when applied to scientific activity and used as a criterion for support. 'Relevant' generally means a refinement of what already exists. This is not to say that refinement is a lowly activity. It is an essential activity and necessary consolidation. There is nothing wrong with market need as a guide to research as long as it is recognised for what it is, i.e. a response to an assumption that the future is like the present, only more so.

Where planning is the essence of Research, is when the fruits of experimentation are converted to real products of economic value with a market potential. A history of science, written with all the panoramic advantage of hindsight and distance from the scene may appear to be inevitably advancing logically in a facile manner. Nothing can be farther from the truth. The discovery of insulin or penicillin or phonograph or polyethylene or tungsten filament lamps or transistors or reverse transcriptase was not planned; however, the production of all these, required painstaking planning and engineering inputs to make the scientific inventions available to the public. However, 'the basic developments which change the direction of whole technologies are rare
and cannot be planned. They spring up when and where least expected but invariably arise in prepared minds where unique juxtapositions of thought occur. They are the product of long preoccupation and deep reflection. The 'eureka' image has no place in reality and yet the image persists because people perceive only the externals of scientific activity' (J.D Birchall).

To be successful, the scientist in industry has to be as close to the frontiers of his field as his academic colleague and in addition he must possess the Edisonian ability to recognise technical possibility. Recognition and translation are rate determining steps in the successful utilisation of scientific results. Some of our work such as the use of niacinamide for lightening the colour of the skin (Fair and Lovely), use of long chain alcohols and their derivatives to increase photosynthetic efficiency in plants (Mixtalol, Probutol), use of branched chain fatty acids to inhibit methanogenesis and increase milk production in cattle, have taken too long to journey from the laboratory to the market place. Part of the difficulty has been the relative lack of effective communication which involves elements of argument since only an argument can ultimately persuade and convince, only an argument can construct creativity". 
VIII. DISCUSSION

What is the chemistry which makes research 'find' and 'promote' a product as in this case?

- Corporate culture
- Needs of business
- A structure for conflict resolution
- An accepted philosophy of research
- A responsive international network of information

The case of cocoa butter equivalent gives some insights. But are these replicable?
2. CASE STUDY ON SOFT DRINK CONCENTRATE

1. INTRODUCTION

Indian soft drink industry has many years of history. Hot weather, growth of urbanization and acceptance of carbonated drinks has opened up a growing market. And hence, it is not unusual that in many towns during summer there is a scarcity of bottled soft drinks.

Traditionally bottled drink business was a regional and local business. The big consumption centers were metropolitan towns and each town had a preferred brand like Spencers, Brandons, Vimto etc. Some of them looked beyond local market and got an acceptance.

The national soft drinks market in many ways developed after Coca Cola started marketing its brand all over the country. They had the advantage of size, a product image, organizational strength and financial resources.

Starting from 1951 over a period of a decade or so, Coca Cola became an accepted product enjoying national distribution and consumer loyalty. Gradually the regional brands started fading out - leaving Coca Cola as the market leader.
Soft drinks come in a number of flavours, some of them are entirely or partly fruit based. The fruit based drinks are more expensive and limited by the supply of fruit pulp at economic prices. The flavoured drinks on the other hand are artificially coloured and flavoured. The largest share of the market in non-fruit segment is Cola drinks (60%) followed by orange (25%) followed by Lime/Lemon (15%).

The success of Coca Cola brought with it, its own problems, the entry of competitors and a commercial rivalry which went beyond business and market share considerations.

The violent passions that soft drink marketing generates, seem to be universal. For example, the traditional (much written about) rivalry between Coca Cola and Pepsi Cola.

Coca Cola's style of operations - its refusal to disclose the ingredients of the flavour it uses (claimed to contain and undisclosed ingredient which gives the product its perceived uniqueness) and even more crucially its non-acceptance of diluting foreign equity which became mandatory for all multinational operators in the country by mid 1970s.

Coca Cola had its ardent supporters and
uncompromising adversaries. Among them, the Indian Venture Capital wanting to wrest a market share from it, in what was considered a growing and profitable market.

From time to time Indian Government tried to make Coca Cola fall in line with their general policy of indigenising multinational companies, both, in management and equity capital. The Coca Cola was amenable to bringing in Indian managers but drew a line at equity participation.

Over a period, both sides found acceptable solutions, but the truce was temporary. The foreign exchange earnings of Coca Cola (India) were acceptable for some time but the demand for greater compliance with general Government Policy continued.

Apart from policy makers, the Indian Parliament also took keen interest in the affairs of Coca Cola - somehow the Company acquiring the status of being a symbol of American imperialism (This again is not an Indian phenomenon and seems universal).

Every time the renewal of licenses came up for decision making, the pro and anti lobbies worked and some more concessions were proposed to the company.

Finally, in 1966-77 after a long battle, Coca Cola
was finally asked to close its operations in India and move out. Today India is one of the countries where Coca Cola does not operate. Its arch rival Pepsi Cola also has no presence here (there is a proposal for its entry as a promoter of fruit products; final government decision is still to be taken).

The case of Cola Drink '77' deals with the technology transfer of product know-how from the Central Food Technology Research Institute (a national laboratory of international repute; a part of the string of research laboratories under the Central Ministry of Revenue) to Modern Food Industries Ltd. (a Public Enterprise under the Ministry of Food) which is in the bakery business. It was set up through an Australian grant to popularise the use of wheat in non-wheat consuming areas, under the Colombo Plan in mid 1960s.

The technology transfer was completed in 1977 and the product has been in the market since the last decade, with ups and downs in profitability and market share.

This case has some unique features:
- there have been strong political factors influencing decisions
- it throws light on Public Enterprise problems in technology adoption in competitive consumer food industries

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- the role played by the distribution system; and
- the role of 'marketing' in successful technology transfer.

2. MATCHING BARGAINING STRENGTH

All through the 1970s there was a battle of wits between the Coca Cola company and the Government of India. The Government, trying to 'discipline' the company, asked for disclosures - wanting Coca Cola to dilute equity. Coca Cola on its part, buying time by pleading commercial considerations for non-disclosures on the plea that it was earning foreign exchange through export of flavours to neighboring countries.

When things took a serious turn, in one of the meetings, the Government suggested that CFTRI, the National Food Laboratory should be asked to do research and product development and come up with an indigenously formulated cola drink. It is possible that the suggestion was made genuinely to promote local research, equally with a view to postpone decision making on the future of Coca Cola operations. While the research was on, the decisions could be pended.

In another meeting (there were many in this period) the bottlers (21 of them), who were franchised by Coca
Cola to produce the product, raised a demand that if the Government wanted Coca Cola to close its operations in India, they (the bottlers) should be given an alternate product so that they could survive. With this pressures on decision makers, it was decided to ask CFTRI, Mysore to start work on producing an acceptable cola flavour.

When CFTRI got this suggestion, they found it unusual (normally they work on a budget for a customer) and sent a budget covering the proposed work for approval and sanction. The Ministry of Industry sent it to CSIR (the coordinator of National Laboratories) for action. CSIR on its part suggested that CFTRI should not ask for extra budgetary support and reallocate its own existing funds. It also suggested that inspite of no new allocation of funds, CFTRI should take the request as a priority because the Ministry of Industry was seriously concerned with the problems of producing a new product.

Some months later, CFTRI was asked by the Ministry to send a report on the progress of the product. CFTRI sent them a progress report dealing with soft drinks in general, not the Cola drink specifically. They seem to have felt that the interest expressed could be a passing interest, and were not keen to commit time and money for its product development, unless they received a clear mandate.
The Joint Secretary concerned expressed a specific desire to be sent samples of Cola drink as soon as possible. Assured of some interest, CFTRI set to work - produced bottled Coca Cola look alike (using its own formulation); filled it in original Coca Cola bottles; and sent it to the Ministry for evaluation. An in-house (within the Ministry) product test was done and the product was found satisfactory by the impromptu panel - indistinguishable from Coca Cola (it was packed in original Coca Cola bottles). Some found it even better.

The matter rested there for some time. CFTRI went back to other research and the Ministry to its administrative tasks. The successful product formulation remained a memory with a few who tasted it.

In the meantime, the country went through a major change in its political leadership. Mrs. Gandhi's Congress was replaced by a coalition (Janata).

The new Cabinet happened to have a socialist Minister - George Fernandes, who became interested in the Coca Cola controversy which he had inherited from the previous regime. Perhaps he saw in the Coca Cola issue, the possibility of obtaining political approbation if he could successfully deal with a giant multinational.
Someone in the Ministry (perhaps the Joint Secretary who reoriented the earlier product development work) briefed the Minister about the earlier CFTRI work. The Minister wanted a couple of thousand bottles of the new product sent to him so that he could take the opinion of Parliament Members on the product, and decide on the future course of action.

The request (or directive) was passed on to CFTRI which found itself ill-equipped to deal with the problem of producing couple of thousand bottles for use in Delhi. They were successful in producing the flavour but did not have bottling facilities. They therefore, moved the flavour to Delhi and sought the help of Coca Cola’s competitor, Parles, to help them bottle the new product. Parle obliged (or their bottler) and a few trucks of the new product was sent to the Minister for product trial.

The product trials at the Parliament House were successful and the political pressures mounted to throw out Coca Cola - now that a satisfactory substitute flavour was found by a national laboratory.

The stridency of the anti Coca Cola had increased. And with an acceptable Cola flavour in hand, Government gave an ultimatum to Coca Cola to comply with their terms.
Coca-Cola decided to quit. This was not the only case when a large multinational was sent packing by the new Government. IBM also moved out when they were asked to dilute their equity in their Indian operations.

The tough action against the two giant MNCs which were not ready to compromise their policy, was seen as a proper display of strength by the Government of India.

The only comparable event in the history of Government-MNC relations was the exist of Ford and General Motors from the Indian market in 1950s when another powerful Minister T.T. Krishnamachari forced the pace.

Government decided to launch a substitute to Coca-Cola, using the new CFTRI formula. Suggestions were invited for an appropriate brand name. The acceptable suggestion was to receive a cash reward.

Interestingly, the acceptable suggestion came from a veteran Parliamentarian, H.V. Kamath who suggested that the new soft drink should commemorate the historic change in government - from Congress to Janata of 1977. He suggested that the new introduction be called '77'. Thus was born '77' - a Coca Cola look alike.
3. LOOKING FOR A PRODUCTION BASE

Upto this stage, product decisions were taken at the level of Parliament - Minister George Fernandes and the civil service. But the product commercialization needed an enterprise to carry on the political thrust. CFTRI could only produce the flavour, even get some small quantities bottled outside, but they could not launch the product.

The search for a likely partner was on. There were many who were interested. Among them was Parle Products, Coca Cola’s major competitor and one of the large bottlers in the North (the key area for Cola drinks). But the choice fell on Modern Bakeries Ltd. a public enterprise in the bread making business. They were seen to have distribution strengths as they had bazaar contacts with trade, and operated in a daily purchase consumer goods market. They had bread making units in a number of States and their Managing Director was a civil servant who had done some good marketing effort in frozen food business (as head of Maharashtra’s State Government owned public sector unit) and had also worked earlier in the Indian subsidiary of Unilever.

There were suggestions that, as Modern Bakeries may not be fully conversant with the marketing of soft drinks,
a Joint sector company should be floated - perhaps in partnership with Parle.

But nothing came of the alternatives, possibly because of philosophical convictions, the performance of Modern Bakeries, or, a desire to introduce a new entrant into the soft drinks market.

4. TECHNOLOGY ISSUES

One thing that stands out in the technology transfer is the ease with which CFTRI could replicate the Coca Cola formula. Coca Cola as a product has a "mysterious aura" about it - some thing unique - giving the impression that the formulation would not be easy and might need a long search for suitable ingredients.

For example, it was always assumed that there was Cola nut extract in Coca Cola. Was it necessary for the formulation (apart from questions of claims in communication strategy)? May be it needed sophisticated equipment for analysis.

But in practice it turned out to be the simplest of all the technological issues. By trial and error a reasonably satisfactory formulation was obtained in the laboratory. The recipes were published, and with a little
ingenuity, the first batch of samples were readied within a few months.

There were problems, but these were in laying down specifications for materials and choosing sources of supply. Some old suppliers of Coca Cola helped. The criticality was specifications suitable for soft drinks. With some experimentation, it was possible to standardize inputs.

All the ingredients which went into the formulation were indigenous except cinnamon oil from Sri Lanka.

Perhaps one advantage CFTRI enjoyed was that it had the process to produce turpene free lime and lemon oil which prevented rancidity and gave the product stability.

Could one say that the CFTRI technologists have broken the myth surrounding Coca Cola? Is it possible that what was significant, was not the product itself, but the aura that was built around it? The image being taller than reality.

Even if replication was easy, a decision of some importance was to maintain confidentiality of formulations. Modern Bakeries (Food Industries) felt that it would be better if production of flavour was done at Mysore. It was less accessible, had a research culture
and the staff turnover was less, compared to its own operations.

5. CFTRI AS A PRODUCTION UNIT

Thus the product formulator, CFTRI became the producer of the '77' flavour. In some ways it was unusual because production falls outside their mandate - this was neither product development nor a pilot plant but regular commercial production.

After the first phase, Modern Food Industries produced the caramel but the acid is still produced at Mysore (1987).

It is interesting to note that in this technology transfer, the laboratory doubled as a producer and continues to do so. This is unusual and was perhaps due to special relationship between the two organisations, or maybe, the apparent simplicity of product formulation.

6. PRODUCT QUALITY

In a food product the final decider of product acceptance is the palate. Except for a minority of opinion, it seems to be generally agreed that as a product '77' is equal to or better than Coca Cola, as an Indian
consumer sees it.

A number of blind tests seem to support the contention, both, done in the laboratory of Modern Bakeries and the market.

There were no capacity limitations and equipment bottlenecks. If the market wanted, the volumes could be supplied.

7. MARKET PERFORMANCE

Exhibit-I gives the sales of '77' in the last 8 years. There has been a decline in sales of the soft drink from Rs 61.18 lakhs in 1980 to Rs.38.94 in 1986.

Apart from decline in sales, Modern bakeries report that their bread business had to subsidise the soft drink business and it is only now (1987) that the trend is a little more healthy. One does not see the product '77' in large metropolitan towns, neither has it any presence in the media.

In some regions (U.P.), smaller towns do sell '77' - its total share is estimated to be 18% of the cola which itself is more than half of the flavour market.
Currently, there are plans to push the product harder, possibly benefit by past experience - but results have yet to come.

By any marketing indicator, '77' is not a resounding success today - whatever might have been its promise and perceived potential when Coca Cola moved out. To put it briefly '77' is a product that failed.

8. POST MORTEM : WHAT MIGHT HAVE GONE WRONG

In 1977, with no Coca Cola it looked an ideal opportunity for a new entrant into the cola flavoured soft drink market. The erstwhile Coca Cola bottlers were unorganised; Parle's strengths were not in the Cola segment; and it looked as though with good production help from CFTRI, and visible Government support, the way was clear for '77' to be the market leader and fulfill the political prophecy of replacing a multinational giant.

It is not the purpose of this study to do an analysis of marketing failure of the product in the last ten years (it would be informative if it is done), but to raise issues regarding the success or failure of technology transfer between CFTRI and Modern Food Industries.
If one were to put down possible reasons which were raised during discussions with management for market failure of '77', they read as:

- lack of political push after the new government came into power (1979)
- inability of Modern bakeries as to muster bottler support
- the lack of profitability of the business and hence limited promotional support for the product
- flavour drinks not being a priority concern to the company compared to fruit based drinks
- absence of soft drink marketing culture
- absence of organisational interest
- changing top management and hence corporate priorities
- was not a natural extension of the bread business
- at some levels seen as additional work.

It is possible that the reasons mentioned had contributed to market failure. Maybe, there are others.

But two issues stand out: managing the bottlers, and the perceptions of Modern Bakeries role in production of '77'. In some ways both the issues are inter-related.
9. PRODUCTION RESPONSIBILITY OF MODERN BAKERIES

Once the flavour was accepted and exclusive rights were assigned to Modern Food Industries, CFTRI felt that it had completed the assignment successfully. It was available on 'tap'- for advice, training and such help as the company people needed.

From time to time, the scientists were called upon to solve problem of quality - like the product going flat, which they did. But formally, CFTRI was not associated with the soft drinks part of Modern Food Industries. There was neither a Board representation nor were there any advisory groups.

From the start Modern Bakeries looked upon themselves as successors to Coca Cola operations, cast themselves in their mould, and set out to franchise the existing 21 bottlers for '77'. They did not consider themselves as independent 'manufacturers'.

It is possible that this perception was 'handed down' to them by Government, as it was concerned about bottlers problems after the exist of Coca Cola. Typical concerns were: the disposal of old Coca Cola bottles, compensation, supply of new bottles, their design, cost, etc.
Thus Modern Bakeries pursued the single option of getting as many bottlers as possible into their franchise arrangement. Unfortunately, they did not succeed in enlisting the support of many Metro town bottlers who controlled major markets. The reasons could be many. For instance:

- the alternatives, North Indian bottlers had in launching their own product e.g. Campa Cola.
- the negotiating ambience and style
- discomfort of bottlers with public enterprise procedures
- inexperience
- successful competitor's bid to lure away influential bottlers from '77'. This seemed to have happened twice. Once in late 1970 and later in 1982-83 when McDowell launched a new product under Kisan Mehta's guidance.
- intense government interest at one time and later apathy.

Once '77' lost influential bottler support, it automatically became a small town moffusil product with limited market reach and product image.

Of the many 'ifs' in this case, one possibility was of Modern Bakeries setting up their own bottling plant in Delhi - the key market for Cola drinks. The investments would have been large compared to the bread business but certainly small compared to normal Public Enterprise practice.
10. MANAGING BOTTLER RELATIONSHIPS

Public Enterprises have problems in dealing with distribution organisations (there are exceptions). The style and culture does not permit long term mutually beneficial relationships.

The mutual perceptions of Public Enterprise and distributors are that of those who are competing to share the same surplus. Distributor commissions are seen as excessive and direct distribution more satisfactory - perhaps a hang over of scarcity marketing.

For the bottlers, used to a commercial culture of a Multinational, it was uncomfortable. There has been much mutual dissatisfaction in handling this relationship.

But in soft drink marketing, bottlers are a crucial part in maintaining quality and distribution. Not so much the retailers - where Modern Bakeries perhaps had some strengths.

CFTRI feels, perhaps rightly, that if Modern Bakeries were more successful in managing bottler relationships, the quality problem would have been less, leave alone the distribution logistics.
11. THE CULTURE OF PRODUCT PROMOTION

If appreciation of marketing is limited in Public Enterprise (most of them handle products in short supply) the understanding of advertising and product promotion is even less. In the soft drink industry, where product cost is a small part of consumer price, communications are crucial. Modern Bakeries did hire a well known advertising agency for product success - Hindustan Thompson - but its effectiveness needed a two way traffic between Product Managers and the Agency people, which was missing.

Added to this was the losses made by the operations. This made advertising budgets small which in turn affected the product image.

Perhaps it is no surprise that '77' was preferred in a blind product test but failed in impressing customers in the market. Because unique selling proposition of a soft drink is the product image - like what Coca Cola cultivated consistently, and well, like what '77' did not in the first decade of its introduction.

12. POST SCRIPT

Someone at Modern Food Industries made an interesting
remark that they were not the only ones who failed to launch a Cola soft drink successfully. The new entrants into the field Mcdowels (82/83) and Double Cola (1986) are yet to make a mark and in the process have made some substantial losses.

13. SUCCESS OR FAILURE OF TECHNOLOGY TRANSFER: MULTIPLE PERCEPTIONS

The following table presents differing perceptions of the actors in the Cola drink '77' case:

<table>
<thead>
<tr>
<th>ACTOR</th>
<th>PERCEPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Government</td>
<td>- Promoted a Coca Cola look like</td>
</tr>
<tr>
<td></td>
<td>- Settle scores with Coca Cola</td>
</tr>
<tr>
<td>2. CFTRI</td>
<td>- Have successfully done product formulation</td>
</tr>
<tr>
<td></td>
<td>- Have gone beyond the brief and acted as a concentrate factory Modern bakeries</td>
</tr>
<tr>
<td>3. Bottlers</td>
<td>- Unsatisfactory service</td>
</tr>
<tr>
<td></td>
<td>- Poor product image</td>
</tr>
<tr>
<td></td>
<td>- Not very profitable business</td>
</tr>
<tr>
<td></td>
<td>- Cumbersome dealings with a Public Enterprise franchiser</td>
</tr>
<tr>
<td>4. Modern Bakeries</td>
<td>- Losing profit made in the main business</td>
</tr>
<tr>
<td></td>
<td>- Not in own line of activity</td>
</tr>
</tbody>
</table>

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- Needs a different managerial culture: high spending on advertising and promotion
- Not priority compared to fruit based products

5. Consumers Metro/Large Towns
- Have not seen the product for some time - may be it is withdrawn

6. Consumers Smaller Towns
- We do see it from time to time
- Not a bad product

One wonders if the technology transfer from CFTRI was a success or a failure? Perhaps it is both.
CHAPTER VI

METALLURGICAL AND ENGINEERING INDUSTRY

1. CASE STUDY ON DIESEL ENGINE RESEARCH AT THE AUTOMOTIVE RESEARCH ASSOCIATION IF INDIA

2. CASE STUDY ON DIESEL ENGINE RESEARCH AT THE TATA ENGINEERING AND LOCOMOTIVE COMPANY LTD.

3. CASE STUDY ON SPONGE IRON PROCESS
I. THE AUTOMOTIVE RESEARCH ASSOCIATION OF INDIA

The Automotive Research Association of India (ARAI) is an autonomous Research Association set up by the Automotive Industry and assisted through aid by the Ministry of Industry, Government of India.

The objective of ARAI is to provide service to the industry in the fields of applied research in automotive engineering, product design and development, evaluation of automotive equipment and ancillaries, standardisation, and technical information.

Funding for ARAI is mainly from the following four sources:

(i) Own earnings
(ii) Membership subscription
(iii) Allocation from the Government, and
(iv) A cess fund on the automobile industry

In the past nine years, since the ARAI started functioning effectively, the trend has been to become more reliant on its own earnings. These constitute the earnings from projects funded, by the corporate sector of the
An extensive range of facilities for evaluation, design and development of automotive components has been set up at ARAI. Among these include laboratories for vehicle evaluation, power plant and engine development, components, materials, metrology, instrumentation and emission. There is also a technical information services division, for an effective system of communications of technical information.

The ARAI undertakes four types of work:

(i) Sponsored projects of specific nature from the industry and the Government.

(ii) ARAI projects, initiated on their own of national/industry interest.

(iii) Testing and evaluation work.

(iv) Special projects

II. BACKGROUND

R&D on diesel engines for commercial vehicle started at the ARAI during 1979. A major part of the work was part of sponsored projects financed and commissioned by the private sector automobile firms. Till 1982 the Power Units Development and Design Group, working on the engines, conducted R & D mainly on the large 6-cylinder engines for commercial vehicles. During this period of three to four
years; test data on these engines was collected and analysed. The engine team developed competence and expertise to conduct a high level of R&D work on the engines. Since the designs and concepts in both indirect injection engines and direct injection engines were well established and in use by the leading automobile manufacturers in UK, USA, West Germany and Japan, most of the work conducted at ARAI was developmental and adaptive.

The first commissioned R&D project for LCV engines was taken up by ARAI in 1982. Since then the Association has conducted more than half a dozen LCV engine projects commissioned by the industry. Most of this work related to either converting the inefficient pre-combustion engine to a direct injection engine, improving the fuel efficiency of the existing engines or turbo-charging them.

III. THE R&D PROCESS AT ARAI

The process of initiating and executing a commissioned R&D project provides a very interesting insight into the R&D process at ARAI. The process essentially involves the following stages:

A. The formulation of a project proposal begins with an enquiry from an automobile manufacturing firm interested in solving a specific problem. If the enquiring firm is
interested in commissioning a project related to the engine, for instance, the query is passed on to the engine team of the ARAI, which consists of the following: One Deputy Director (Project Leader), One Assistant Director, one Senior Engineer and two Project Engineers. The two senior most members of the team interact with the firm very closely to get a detailed specification from it, regarding its problems and requirements. The specifications are normally very detailed and exhaustive. These are then translated into a project proposal which also contains the time scheduling and the budget for the project.

The time taken to finalise the proposal after an enquiry is received is approximately 2-3 months. The proposal is then formally sent to the firm for approval and finalisation of the project contract.

The proposal formulation stage is very critical in the entire process of R&D at ARAI. It requires that: the firm commissioning the project has a very clear perception of its requirements which also mesh into its overall corporate plans; the requirements are clearly and explicitly conveyed to the research team; a very close interaction takes place between the sponsors and the scientists to assess the suitability, feasibility and applicability of the project to be undertaken; the parameters for research are clearly defined; and the negotiations regarding the expenditure
etc. on the project are successful. A problem in any of these aspects could not only lead to the abandonment of the project in the initial stage itself but could also spell the difference between success or failure in the completion of the project; between a positive and meaningful research output as against an output which may not be very useful or have any commercial applicability. Also, as it happens very often, the interaction of various viewpoints in generating the proposal may change the focus and direction of the proposed research thereby leading to an output which is very different from one which was conceived of by the sponsors. If this happens, it may or may not match with the corporate plan of the sponsoring firm which may have to change its perceptions regarding the future directions and strategy. The proposed output could also turnout to be unsuitable or its expected end use may not match with the capabilities or resources and infrastructural facilities available with the firm. It is imperative therefore, that the individuals involved at this stage not only try to develop a clear understanding of each other’s views and requirements but also have a wider vision regarding the purpose and applicability of the research effort. The successful formulation of an appropriate research proposal could go a long way in ensuring the success of both the research process and the final output.
B. Once the project is approved and commissioned the process is initiated with a meeting of the team members to discuss the details of the R&D work to be undertaken. Each of the team members is a specialist in some aspect of the engine development. The work responsibility of the project is divided among them on the basis of their experience and expertise. Normally, of the 5 scientists working on the engine team, 2 are assigned the job of preparing the engineering design according to the specifications. One scientist each works on vendor development, tooling and alterations in the engine and testing. At the end of the project 3 members of the team get together to conduct the analysis of the final output.

During the course of the research and development work, the facilities and expertise available at the various laboratories of ARAI are made use of and the team members frequently interact with the lab personnel. Interaction and contact with the sponsoring firm is limited to the monthly review reports submitted to them by the research team. This precludes the possibility of an active and close involvement of the firm in research and development thus alienating the Production, Machine Tools, Sales, Service and Quality Control department of the firm from the R&D process. The specifications provided at the initiation stage together with inputs given at the monthly review
meetings to the scientists serve as guidelines and indicators of requirements and capabilities of the various departments of the firm.

However, the third party suppliers of critical components are involved in the development process and interact with the research team right from the design engineering stage. The feedbacks from the process enables the suppliers to make the necessary changes in their production facilities. Though, to a certain extent, this does serve the purpose of keeping the suppliers of the sponsor, abreast of the expected changes in the design of the engine and its components, the very concept of vendor development by the R&D organisation, in commissioned research, needs to be questioned. Not only could the geographical location of the small component suppliers of the sponsor make it difficult for the scientists to consult and communicate with them as frequently and as closely as required but also it is impractical to expect the ARAI team to replicate the functional relationship that exists between the sponsor and his suppliers. The success of the scientists in developing such a relationship contributes greatly in final outcome of the process of commercialisation. But again the degree of success could vary from one project to another thus becoming a critical factor in the commercialisation process. Moreover, it may
be mentioned that quite a few components are subcontracted not to the suppliers of the sponsoring firm but to local contractors who are provided designs by the engine team to undertake fabrication, forging and casting work etc. The final machining of the material is done at ARAI. This would imply that at the time of commercialisation of the output this job will have to be performed by those who have had no previous experience in doing it. The success of the effort will then depend upon the efficiency and clarity with which the design and knowhow could be passed on.

All this not to say, either, that these aspects could become problematic or that if they do, they cannot be overcome, but that in commissioned research it is essential to recognise these critical factors for what they are and take the required measures to ensure a smooth translation of the research output into commercial application.

C. The development of the prototypes is undertaken after the engineering designs have been prepared. At the time of the initiation of the project, normally five engines are provided to the ARAI by the firm. The prototypes are developed from these engines which are modified as per the specifications and designs. A rigorous testing of the prototypes is undertaken in coordination with Testing
Laboratory. In case of defects the scientists either make minor modifications in the engine itself or go back to the drawing table for further modifications in the design. The prototypes are retested after every alteration till a satisfactory output conforming to the specifications is obtained. The process followed in the development of a new engines further confirms the observation made in case of the Telco R&D that a large part of the R&D process for engine development in India relate to development and adaption of already established and commercialised concepts, processes and ideas.

D. The final output of the R&D process at ARAI is provided to the sponsoring firm in the form of a report which consists of two parts: (a) drawings and engineering design of the new component; and (b) Analysis of the old and new designs.

Along with the final report 5 prototypes developed from the old engines are also given to the firm. The working of these are, however, first demonstrated to the engineers from the firm, both at the test beds and after putting it in the vehicle.

With the delivery of the final report and the prototypes the formal responsibility of the ARAI ends towards its sponsors. Nevertheless, it has been observed
that occasionally further problems crop up at the stage of productionisation. In such cases the project scientists visit the plants to solve them, and also to assist and advise the firm on various aspects like quality control, vendor development retooling, precautions etc. In Telco's project to develop Light commercial vehicle, both the R&D and production were in-house processes and hence these functions were conducted simultaneously with the designing and development of the vehicle. In commissioned research of the kind undertaken at ARAI the traditional linear method of working is followed where the output of one stage provides the input for the next.

IV. LCV ENGINE PROJECT AT ARAI

The first R&D project on LCV engines was commissioned to ARAI in early 1982. Since then more than half a dozen major projects have been conducted by the Association for the Automobile industry. A review of three of these is undertaken in the following paragraphs.

(i) Case 1:

During the early 1980's, M/s Mahindra and Mahindra Limited started exploring the possibility of manufacturing a light commercial vehicle using a direct injection engine. Their existing line of vehicles were fitted with the
precombustion engines which were outdated and inefficient. To undertake the R&D for converting the indirect injection engine to a direct injection engine they approached the ARAI.

After initial negotiations, a proposal was submitted by ARAI in 1982. The duration of the proposed project was 26 months. The project was formally initiated in early 1983 and it involved a total design change from the existing engine. Review of work done was conducted every month in joint meetings of the scientists and engineers from the sponsoring firms. The concepts and designs of a direct injection engine had been developed and standardised much earlier by Japanese and West German LCV manufacturers, but this was the first time the ARAI was undertaking a R&D project for developing a DI engine. The concepts and technical information on the state of art engines was obtained from technical literature available, brochures and specifications of leading engine manufacturers of Japan, West Germany, UK and USA, and inspection of the imported engines and their components. But since the available literature on the subject did not specify very detailed information on designs, the research team at ARAI had to conduct its own experiments to develop and adapt the existing knowhow and concepts within the specified parameters.
The project was completed in 1985, within 26 months of its initiation. The output in the form of a final report together with prototypes of the redesigned engine were handed over to the Mahindras. The unique feature of the prototype engines developed was that their power to weight ratio and torque were such that they could be used, both, for tractors and the smaller LCV's. The design of the developed engine was significantly different from one that was being used by the firm. Hence major changes in the machining line and tooling were required for manufacturing the new direct injection engines.

The Mahindras were not in favour of undertaking major changes in their production line and were therefore hesitant in implementing the changes suggested by the research team. Moreover, they wanted a reconfirmation of the research results before investing for alterations in the existing production line. The firm therefore negotiated with one of the world's leading engine design consultants AVL, Vienna for evaluating and scrutinising the design developed by the ARAI. The AVL confirmed the design changes suggested by the ARAI scientists with minor alterations.

M/s Mahindra and Mahindra now propose to manufacture this redesigned engine but use it for a tractor for the
domestic market. The production of these tractors is expected to commence during late 1987.

In the overall execution of this R&D project a few points need mentioning. One, inspite of the fact that the Mahindras were not keen on undertaking major tooling and production line changes a project was negotiated with the ARAI which proposed a complete design change and hence a corresponding alteration in the production line. In case, the firm was not aware of the proposed changes, it only goes on to show that either the parameters for the R&D process were not very well specified in the project proposal or there was a communication gap between the scientific team and the sponsoring firm at the proposal formulation stage. However, it may be possible that the impending changes were not even conceived of by the research team, at the beginning of the project.

Secondly, the suitability of the final output for the proposed application was not worked out properly. A project which started with the objective of developing a direct injection engine for an LCV ended up with an output which was finally used for powering a tractor. Thirdly, there was a lack of faith, in each other’s ability, between the two parties. This led to the Mahindras approaching the foreign consultants for reconfirmation of the research and development results.
(ii) Case 2:

In 1984, the Standard Motor Products of India Ltd. approached the ARAI to conduct R & D for improving the fuel efficiency of their existing LCV engine. This engine was an indirect injection having a relatively high specific fuel consumption. The domestic market, with the influx of Japanese firms through collaborations, was becoming selective when it came to the operational efficiency of a light commercial vehicle. It was felt that offering a fuel efficient LCV to the market, without delay, was essential.

The scientists at ARAI tested and evaluated the existing engine and submitted two proposals for the firm’s consideration. The first was for a 12 month duration project which aimed at maximising the short term benefits of the firm, by suggesting minor modifications in the design of the engine which would improve its fuel efficiency. The second proposal was for a 18 month project which would aim at maximising the longer term benefits of the firm. This was proposed to be undertaken by changing the indirect injection engine into a direct injection engine, and would require major alterations in the tooling and production facilities of the firm.

The time taken to finalise the proposals was approximately 3 months from the date of enquiry from the
During this time there was a very close interaction between the scientists of ARAI and engineers from Standard Motors.

Both these proposals were accepted by the sponsors and R & D work on both the projects started simultaneously. What began, therefore, as an effort by Standard Motors to improve the competitive strength of their product in the domestic market, was translated into two R & D projects which were to suggest ways to do so, both, in the short run as well as in the long term. There seems to have occurred a change in perceptions of the firm regarding their requirements. From wanting an improvement in the specific fuel consumption of their existing indirect injection engine through minor modifications, they also went in for total design change for development of a direct injection engine. This would not only take more time in implementation but would also require a larger capital outlay, thus necessitating a change in their strategy to fulfill a current requirement of the domestic market. The change in the perception seems to have resulted from their interaction with the research team which had its own views and opinions regarding the requirements of the firm and the market. These may or may not have been taken into account in the strategic plans of the firm when it initially decided to go in for R & D on its existing engine.
(a) The short-term R & D project:

The objective was to make minor alterations in the existing engine design to improve its fuel efficiency. By minor alterations it was implied that no major retooling or change in the production line would be required for implementing these design changes. The engine would remain an indirect injection engine, but with an improved specific fuel consumption.

The project was of one year duration, during which the designing and development was to be completed. Five engines were provided by the firm for modifications and development of the prototypes.

An additional Project Engineer was included in the engine team to undertake 80% of the developmental work for this project. The others assisted at the design and evaluation stages only. Would the work distribution have remained the same if the longer term project was not commissioned and this was the only work sponsored by the Standard Motors? It seems that a low profile was given to the R & D work on this project and efforts were concentrated in development work for the larger project.

The project was completed in scheduled time and the final report, together with the 5 redesigned engines, handed over to the firm, after their demonstration. During
the monthly reviews were done by a joint team of Standard Motors' engineers and ARAI scientists.

(b) The long term R & D project:

The objective of this project was to change the existing engine of the Standard Motors from indirect injection system to direct injection system. This called for a major change in the design of the engine, and therefore, in the tooling and production facilities of the firm. It was expected that the redesigned engine would be the state of engine and would result in a competitive edge to the firm in the domestic market, over a relatively longer term.

The concepts and knowhow to be applied for redesigning the engine were totally different from those used for making minor changes in the short term project. These were taken from international literature on engine technology and the state of art engines available for inspection, to the scientists of the engine team.

The forging, casting and tooling jobs required for the project were locally sub-contracted. The machining of components, however, was done at ARAI.

The project was completed in 18 months time and the
output handed over to the sponsors in the form of a final report and 5 prototypes.

IV. COMMERCIAL APPLICATION OF THE R&D OUTPUTS

At the time when the results of the short-term project were communicated to the firm, the long-term R & D project was more than half way through. Preliminary results of this had already started coming in, of which the firm was aware through the monthly review meetings. These results were encouraging.

It was decided by the Standard Motors that they would wait for the output of the long-term project before taking a decision on the utilisation of the short-term project output. It seems that, since, for the utilisation of the output of the former, major design changes were expected in the production facilities of the firm, it decided not to invest in making alterations for improving the short term fuel efficiency of the engine. The firm possibly thought that once the results of the major project were available, within the next six months, the production line changes would have to be made anyway. The decision to make minor modifications in the existing engine was therefore deferred.

The report of the long term-project recommended major
design changes and was made available to the firm in September 1986. The formal responsibility of the ARAI finished with the acceptance of this report by the firm. Standard Motors plans to soon start manufacturing a new range of LCV's using this output. The scientists of ARAI engine team continue to assist in the vendor development process of the firm.

It is doubtful, however, that the firm will be able to stabilise its production of the direct injection engines very soon. This is not only because the time consuming process of vendor development started only after the design and prototypes were formally handed over to the firm (as different from Telco's case, where each department was functioning simultaneously for the development and commercialisation of the Tata 407), but also because every problem that crops up during productionisation will have to be referred back to the scientists who will have to visit the firm's plant site to solve them. It may be mentioned that after completion of the R & D project the ARAI no longer has any formal commitment to provide its services to the firm. Moreover, the delay might also occur since the engine will be used in a vehicle together with other vital components like the gear box, transmission system, axle etc. The matching of these with each other, so essential for a successful and efficient vehicle, will be more or less an entire R & D process in itself.
2. CASE STUDY ON DIESEL ENGINE RESEARCH AT THE TATA ENGINEERING AND LOCOMOTIVE COMPANY LIMITED

I. CHRONOLOGY OF IMPORTANT EVENTS

1965  - Project launched to set up 2nd Telco plant at Pune

1966  - R & D taken up as a coordinated activity at Telco

Jan'1968 - 'Engineering Research Centre' (Telco's R & D Division) set up at Telco, Pune

1969  - End of collaboration with M/S Daimler Benz A.G, West Germany

1972  - Fuel crisis: R & D undertaken to change the indirect injection engine of Tata trucks into a direct injection engine.

1980  - Introduction of the first indigenously developed truck - the Tata 1516

Apr'1984 - Project Jupiter conceived (To develop Tata's first LCV)

Jul'1984 - Project Jupiter launched

Feb'1986 - Tata's first LCV - "Tata 407" introduced in the market

Feb'1987 - A new truck "Tata 608" introduced

1988  - Proposal to introduce a new 2 ton pickup

II. The Engineering Research Centre

Functions of the centre:

(a) To improve existing products to adapt/suit the environmental conditions.
(b) To develop new products conforming to the perceived needs and preferences of the market

(c) To ensure consumer satisfaction

(d) to provide a technological edge to Telco in the domestic market

The Engineering Research Centre is the Research and Development division of Telco. It employs over 750 highly skilled technicians, engineers and scientists, all of whom are engaged in design and development of a wide range of automobile, mainly commercial vehicle, products. In the last 21 years of its existence more than Rs.100 crores have been spent by the centre on R & D.

The operations of the Engineering Research Centre have a pronounced market orientation to them and are geared towards bringing out output that can be commercialised.

The objective of the R & D activity at the Centre is to match the user expectations and to make efforts to develop their needs and preferences in the desired directions.

Among the major achievements of the R & D activity at Telco in the last two decades, have been the development of:
(a) Direct injection engine for the Tata trucks from the existing indirect injection engine.
(b) Syncromesh gear box
(c) Easy ride seat
(d) Power steering
(e) Dual circuit breaker
(f) Aero-dynamic body for the various models
(g) Semi-forward body
(h) Turbo-charged engine for trucks
(i) Light commercial vehicle - "Tata 407"

In Telco’s R & D efforts more than 90% is development work. The basic parameters of design and principle are well established globally. Any R & D process undertaken at Telco is therefore more of a developmental process to adapt the existing processes and products to the local conditions, than one in which basic research is undertaken.

III. THE LCV STORY AT TELCO

Development of an LCV engine at Telco constituted one part of an overall corporate plan of the organisation to develop and commercialise a light commercial vehicle for the Indian market. The development of the LCV engine was not undertaken in isolation nor visualised as a project in itself. In fact the entire R&D
process itself, to design and develop a light commercial vehicle, was only one of the constituents, though an important one, together with the inputs provided by Finance, Planning, Foundry, Production Engineering, Machine Tools Division, Growth, Construction, After Sales Service, Sales, Ancillary development, and Suppliers etc, to translate a strategic alternative, a concept, into reality.

The project to design, develop and commercialise, a light commercial vehicle - the Tata 407, was code named 'Project Jupiter'.

Telco decided to develop a light commercial vehicle because of various reasons. among these:

- Stagnation in the sales of Telco's existing range of products. Need/Desire to diversify the product range.
- Growing needs of the Indian market for a fuel efficient light commercial vehicle.
- Prospective competition from both existing manufacturers of LCV and the proposed new collaborations with Japanese firms.
- Existing infrastructure and capabilities of Telco which could enable it to diversify into LCV's without much difficulty.

For the above reasons a complete product was conceptualised to meet the objectives of Telco's Corporate
plans. The idea to design and develop an LCV engine originated out of the need for such an engine for the product to be developed.

IV. STAGES IN THE DEVELOPMENT OF TATA 407

Instead of the traditional linear method of working (each department initiating action only after the previous department completes its job) an integrated functional system was followed. All divisions of Telco were involved and they provided inputs right from the start. This not only facilitated an effective inter-functional dialogue but also ensured that the final product incorporated the features perceived by the different divisions of the organisation and that the performance requirements from each of these divisions was within their individual resources and capabilities. It also enabled work on different aspects of the project to continue simultaneously, thereby expediting the completion of the project. For instance, Auto Planning and Production were fully involved at the design stage to present their views on process angles, value engineering aspects etc. The specifications in turn were finalised in close consultation with Sales. Similarly, the production team was involved with the recruitment of manpower, planning of special facilities, shop layouts; the Engineering Research
Centre and Production jointly made batches of prototypes; Quality Assurance Division was involved with the production and testing of these with the aid from Service Department, and gave continuous feedback on the vehicle’s performance.

There were however, distinct stages in the development of the Tata-407 which can be classified as follows:

1. Conceptualisation of the new product and detailed definition of its specifications:

Factors taken into consideration were: end use of the product, the potential demand, prospective competition, existing market conditions, state of the art in both domestic and international markets, existing capabilities and infrastructure of the organisation, resource requirements, and time duration of the project etc.

Various departments of Telco which had a role to play in the execution of the project were involved in the decision making right from this stage. The target date of completion and the expected output was specified.
2. Consideration of the options/alternatives:

3-4 alternatives were selected initially on which feedback was obtained from various departments. Each alternative was reconsidered in the light of the feedback information.

3. Shortlisting of the alternatives and selection of the product.

4. Preparation of designs, drawings, mockups:

Also feasibility study of the project was undertaken. Major work during this stage was conducted by the Engineering Research Centre but in consultation with the other divisions.

5. Development of Prototypes:

The Engineering Research Centre and Production jointly made prototypes in batches which were of two types:

(a) Prototypes of components in aggregate: 6 to 8 units of each component were made.

(b) Prototypes of the product as a unit - the complete prototype of the vehicle was made.

6. Performance and endurance test of the prototypes:

Conducted by the ERC with inputs from Quality
Assurance Division, Service Department and Production.

The structural and other weaknesses in the product were brought out and the required alterations made.

The development of the prototype and its performance tests were done simultaneously after the release of the first prototype. It was an iterative process in which the output of one stage provided input for further work in the other stage and vice-versa.

7. Preparation and release of Engineering designs for production:

The engineering drawings came out of daily interaction between the drawing teams, for various components, from the ERC, and the engineering teams from the tooling department.

Much before the drawings and designs was released for production the required tooling changes were undertaken by Machine Tools Division.

Another important interaction that took place at this stage was the close coordination between the design teams of Telco and the outside component manufacturers. For instance, the fuel injection pump was developed and
designed in close consultation with its suppliers. This enabled the component suppliers to initiate changes in their production facilities and gear up to supply the component in time. This function which is termed as 'vendor development' has played an important part in the development of Tata 407, both in terms of quality and time.

The Telco considers its ability and resourcefulness for proper management of the vendor development process as an important and vital factor for the successful commercialisation of Tata 407.

8. Development and Testing of tooled up Prototypes:

A second batch of prototypes was developed and tested after the required retooling in the plant had been effected. These prototypes were evaluated against the proposed designs and parameters to determine the variations between the proposed and actual outputs.

The process of testing and development was carried out again as before and the iterations helped in the evolution of the final product. Necessary changes were incorporated at each stage and the changes were retested.
9. Commercial Production:

Once the tooled up prototypes were finally approved the Production line manufactured 50 vehicles which were re-evaluated jointly by the ERC, Service and Quality Assurance Division. These vehicles were also given field trials and customer reactions were obtained. Necessary changes, though not many in this case, were incorporated in the production line and commercial production was commenced.

Very little basic research or innovation was required for the development of Tata 407. The concepts, processes and products were well established and had been successfully commercialised by leading manufacturers of LCV's in Japan and West Germany. Project Jupiter was therefore a singularly directed effort at development and indigenisation of already established technology. The ideas and concepts for the project were obtained from:

- International literature on the design and concepts used in LCV's, especially the engine.
- Catalogues of major international brands of LCV's
- Specifications of state of art LCV engines
- Hardware components of imported LCV's
- Trade fairs and Automobile fairs around the world.
The time duration of the entire project was 18 months. Of these, the first 6 months were taken up in conceptualising and selecting the product to be developed. Within the next 12 months, simultaneous work at the other stages led to the commercialisation of the LCV. The project began in July 1984 and the first Tata 407 vehicle was launched in February 1986.

According the Engineering Research Centre, once the concept and design of a product has been developed, its successful commercialisation depends upon:

(a) Production engineering
(b) Machine tooling
(c) Management of the ancillarisation process
... and the interaction of these with each other and with the other divisions of the organisation.

V. R & D OF THE TATA 407 ENGINE

The objective of the R & D process to develop an engine for the Tata 407 was to indigenously design an engine which could be manufactured from materials available in India. Also, the production of such an engine should be able to utilise as much as the existing plant, machinery, knowhow and infrastructure of the organisation as possible. The engine to be developed was
to be a compact 4-cylinder Direct Injection Engine which would fit into the overall design of the Tata 407.

When the project was taken up, Telco was already manufacturing a 6-cylinder Direct Injection Engine for its larger models. The focus of the R & D effort was to try and design an engine which would require minimal of tooling changes in the already existing production and infrastructural facilities. Initial efforts, therefore, concentrated on changing the design of the existing engine to conform to the new specifications. The engine team at the Engineering Research Centre interacted closely with the Production and Machine Tools Division for laying down the specifications and developing the engineering design for the proposed engine. In laying down the specifications a realistic approach was taken by matching the specifications of the state of the art engines available in the world markets with the existing capabilities of the organisation. The process was again an iterative one in which parameters were specified and respecified during consultations among the various divisions. During the process, answers to some very pertinent and basic questions were sought before finalising the parameters for designs and production. For instance, Could Telco use the existing facilities and infrastructure to design and manufacture a state of art...
engine? What would be the limiting factors in doing so? What compromises would have to be made in design parameters which could reflect itself in the operating efficiency, performance, life and reliability of the engine? Would the product remain the state of art engine? What will be its short-coming? What will be the consequences?

In answering these questions it was realised that the proposed engine will have to be a little heavier than the LCV engines available in the international markets. This would have its effect on the specific fuel consumption of the engine. Moreover, a compromise will have to be made in terms of its quality and performance. However, it was concluded that given the limitations, the proposed engine will be of a fairly good quality.

It may be mentioned that there was a strong view of the experts involved in designing and developing the Tata 407 that an engine alone did not determine the quality, suitability and performances of a vehicle. This involved the perfect matching of the vital components of a vehicle like the transmission, gear box, axle etc. The compromise on the design of the engine was therefore acceptable once the proper matching of the other components were ensured.
The major features of the Tata 407 engine designed and developed were: A 4-cylinder Direct Injection Engine which had a high power to weight ratio developing 65 HP at 3200 RPM and high torque at low speeds. The engine was of 97 Bore and 120 stroke as different from those of the Tata 1615 trucks which were 6-cylinder, 97 Bore, 128 stroke, 2800 RPM engines.

An important aspect of the engine development was the management of the ancillary operations by the Telco team. Among the components of an engine that are manufactured by the outside suppliers are the fuel injection pump and the piston. The pump is supplied as per the specifications by a monopoly supplier which makes it necessary to involve him in any decision to change the design of the pump. The design specifications of the final injection pump developed for the engine were laid down in consultation with the supplier which made it possible for him to manufacture and supply it to Telco in time. A close interaction with such suppliers is not only vital but also a necessary condition for adhering to quality standards and time schedules of the project. Such a close interaction at the time of initiation of the project and during its entire duration has been one of the strong points of the Telco's efforts.
3. CASE STUDY ON THE SPONGE IRON PROCESS

1. INTRODUCTION

Based on the source of metallic iron, the iron and steelmaking industry can be broadly classified under two categories: about 70% world steel tonnage is made from ore and the rest is from steel scrap.

The dominant process for the conversion of ore to metallic iron is the blast furnace process which accounts for over 98% of the tonnage of metallic iron recovered from ore. The blast furnace produces molten iron which is refined to steel of the required composition. The accepted process for iron to steel conversion is the basic oxygen furnace. Modern steel plants based on the blast furnace and basic oxygen processes are huge complexes with capacities - in the multimillion tons per year range.

The second category is the scrap based steel making. The dominant process here is the electric arc furnace which is used to melt scrap and produce molten steel of the required composition. The scrap based electric arc furnace steel plants are viable in small capacities in range of 100,000 tons per year.

A small fraction (2%) of steel tonnage is being made
using alternate processes for extracting metallic iron from its ores. All such operating plants produce solid iron from its ore and are classified as direct reduction processes. This metallic iron is used to replace some or most of the scrap fed to electric arc furnaces.

While the blast furnaces use a specific variety of coal known as (coking coal), the direct reduction process can use hydrocarbons (mainly gas) or coal. Molten steel produced through either of these routes, is continuously cast into sections for further processing to shapes and sizes as required by customers.

The statistics on world production of direct reduced iron by process and by countries are given in Table I and Table II.

It can be noted that gas based processes account for major part of direct reduced iron making capacity as well as production. Also, production of direct reduced iron has dramatically decreased in the developed countries while it has increased in the developing countries.

Industrially and technologically, the gas based processes have become well established. The commercial success hinges on the availability of gas at economic prices.
The coal based processes are all variations of an old concept, first proposed and industrially tested by Sir William Siemens, about a hundred years ago. The process is apparently very simple as it consists of reacting coal, ore, flue and iron in a rotary kiln.

Countries where coal based DR processes are being used, the rotary kiln process has been difficult to master and continued industrial operation of these units is difficult. While the concept is old, several engineering innovations and operating excellence have been necessary for its successful implementation.

In the early 1970's, India became actively involved in the alternative route, i.e. direct reduction - electric arc furnace route (DR/EAF), for steel making. This was with the realisation that there was a resurgence of worldwide interest in methods of steelmaking that aimed to bypass the traditional blast furnace-oxygen steelmaking route which necessarily depended upon coaking coal.

The conventional iron and steelmaking route employing coke ovens, blast furnaces and oxygen steelmaking facilities continue to be the most economical method of making steel in large integrated steel plants. However, the capital costs associated with this route was high and was becoming higher with increased stress on ecological
factors; the installation of such large facilities especially in countries like India was not always possible because of paucity of funds to meet the massive capital outlay, lack of suitable raw material resources, want of adequate market to justify the installation of a commercially viable integrated steel plant, inadequacy of infrastructural facilities and dearth of necessary skills. Moreover, the conventional route relied on hot metal, with all its associated impurities, as an intermediate product.

As opposed to this, the direct reduction-electric arc furnace route was emerging as an economically attractive proposition, especially in case of relatively small units. Some of its advantages were: the time required for commissioning a DR/EF steel plant was about two years compared with five to seven years for an integrated steel works; the sponge iron could be used as a partial or total substitute for scrap which was in short supply with the rapid development of electric arc furnaces; unlike blast furnace smelting, direct reduction could be based on a wide range of non-cooking coals.

On the other hand, the record of sponge iron manufacture by direct use of non-cooking coal as a reductant had not been particularly impressive. At least two out of the five plants initially built in countries deficient in natural gas had to be closed down and the
remaining three experienced considerable difficulties in operating at rated capacities. Against this background, it was obvious that large scale plants for sponge iron manufacture could not be built without an element of risk being involved in such a venture, which developing countries like India could ill afford. The situation, therefore, demanded further work on the development of coal based direct reduction technology to suit the local needs and conditions.

In the following paragraphs we look at four different and mutually independent efforts in India, to develop and commercialise the sponge iron manufacturing technology. Though, the degree of success achieved in each of the four cases varies considerably, this is not an indication of either the suitablility or the adaptibility of a particular technology to the local conditions.

2. SPONGE IRON INDIA LIMITED (SIIL)

The history of SIIL goes back to 1964 when Andhra Pradesh Government made an effort to see if pig iron could be manufactured using non coking coal in Andhra Pradesh. This was to alleviate a shortage of pig iron.

In conducting this study it was found that a lot of work had been done in the country, and it was suggested
that to set up pig iron manufacturing facility, the support of organisations such as UNIDO, UNDP should be obtained.

A proposal was sent by Andhra Pradesh Industrial Development Corporation (APIDC) to the Government of India for UNDP support in 1969, proposing the production of pig iron indigenously. The proposal was evaluated by two UNDP Consultants. The consultants advised that it would be useful to include steel making also, in the proposal. The proposal had envisioned the use of a rotary kiln for the production of sponge iron. The Consultant pointed out that this method was not industrially successful anywhere in the world and suggested that a semi-commercial operation should be first set up and the process viability checked up. For such a semi-commercial plant, UNDP agreed to give aid and it was suggested that the size of such a plant should be 100 tonnes per day.

The recommendations of the UNDP were accepted by the Government of India in 1972. The Andhra Pradesh Government was given the 'go-ahead'. UNDP gave assistance for selection of critical equipment. It was noted that the conversion of sponge iron to steel in the electric arc furnace was a well established commercial process and UNDP would be only rendering assistance for the sponge iron plant. Andhra Pradesh Government started the work on
steel making and set up Andhra Pradesh Steel at Kathagudam.

The funds available to the Andhra Pradesh Government were used up in the steel project. Andhra Pradesh Government therefore requested the Government of India for putting up money for the sponge iron plant. The Central Government agreed to this suggestion.

For critical equipment and technical personnel etc., UNDP invited international quotations, in December 1975. The following three parties quoted:

(1) Lurgi
(2) Allis Charmis
(3) Krupp.

Krupp indicated that the capacity of the proposed plant was too low and that they were not interested in offering a small plant. They, instead, offered a larger plant.

Lurgi offered a 30,000 tonnes year plant based on the use of coal.

Allis Charmis offered a plant in which upto 20% oil could be used. The Allis Charmis plant was of a larger capacity but could only give 100 tonnes per day of production by using a heavier lining. Thus the working diameter of the kiln was reduced. After the experimental
stage the opening could be enlarged and production increased.

The quotations were evaluated and the Lurgi offer was accepted.

At this time, though NML and TISCO were also working on direct reduction technology, they were not able to offer complete plant designs for the proposed SIIL plant. Hence, it was found necessary to obtain and accept foreign quotations. It was also noted that the proposed plant would not function as a push button unit. Substantial developmental work had to be done before it could become viable. Bulk of the testing of the material required for this plant was undertaken at NML.

Although, the 100% coal process of Lurgi was selected. There was an overwhelming opinion that further work on using multi-fuels and on improving the fuel efficiency on the process should be initiated indigenously. Thus Government of India decided to entrust Steel Authority of India to set up a pilot plant for doing further work.

In October 1977, Lurgi’s quotation was accepted. In June 1978 the construction started on the SIIL plant. In March 1980, the plant was commissioned.

The first two campaigns at the plant had to be
terminated within 14-18 days.

In the original design, 100% use of the feed coal was giving very good results but it was difficult to control the temperature profile in the kiln.

A Committee was appointed to solve this problem. Among the members of the committee was a UNIDO expert, Dr. Schermer, who had worked on the Krupp plant in South Africa. SIIL and Lurgi engineers collaborated with the committee members and it was decided that feed coal should be fed from the discharge end to control the temperature profile. With this modification, as well as other modifications on the sizing of the ore and coal, the problem was overcome. The campaign life was subsequently increased beyond 120 days.

The plant has been working satisfactorily ever since.

The operation of the kiln is not without its problems. The process is highly sensitive to the raw material quality and has to be adjusted for each new set of raw materials. The process has to be monitored very closely as 'build' occurs within the kiln, checking the flow of material within a few hours. The problems of operating the kiln thus aggravates whenever the input quality of material varies. This has been one of the major problems, as consistent supply of specified
materials has not been available. For each set of materials, adjustments have to be made in the sizing of the material going into the kiln as also in the placement of the material at locations within the kiln. Moreover, adjustments have to be made on the flow of combustion air into the kiln. If proper attention is paid to all these factors, the kiln can be operated satisfactorily, as demonstrated by SIIL performance in these past years.

In 1982, it was decided to expand production at SIIL. The options for expanding production were: either to set up a duplicate plant, or set up a larger sized plant. Since the local infrastructure could be fully utilized by setting up another 30,000 tonnes plant, it was decided to go in for the second option.

The second SIIL plant was installed in October 1985.

The new plant incorporates all of the improvements and modifications made by SIIL. It started production within a week of its commissioning. Over 95% of the equipment was procured indigenously.

In this plant microprocessor controls have been installed which have been designed and built indigenously.

Based on this experience, SIIL have developed the required expertise and are willing to design and commission more sponge iron plants.
They have offered designs of up to 100,000 tonnes per year capacity. Several parties have come and bids have been made. However, not one of the proposals has materialised as coal availability for none of them could be assured.

SIIL is currently working jointly with the Karnataka Industrial Development Corporation to put up another plant. This plant with a capacity of 100,000 tonnes will be set up in the Bilari Hospet Area. It will used lignite and is expected to cost around Rs. 50 crores. The project is being reviewed by the financing authority. Several patterned applications have been made by SIIL. SIIL feels that several vendors capable of giving larger kilns are available in India. Refractories for kiln lining is also available in India and can be installed.

While SIIL has demonstrated that a sponge iron plant based on coal can be successfully operated, it has also uncovered several problems that have to be sorted out.

The quantity of waste generated is of the order of 1.4 tonnes for each tonne of sponge iron produced. Of these wastes, about 0.1 tonne of material, per tonne of sponge iron, is sponge iron fines. Alternative use for the fines has been found. These fines can be briquetted and sold as a prime product. SIIL have designed a
briquetting machine and this unit is to be commissioned in
the next few months. Fines, other than those of sponge
iron, have to be disposed off.

About 1/2 of the energy produced in the system is
carried away in the wastes gases of the kiln. SIIL is
proposing to set up a wastes heat boiler and steam turbine
to recover this.

3. RESEARCH AND DEVELOPMENT CENTRE FOR IRON AND STEEL
(RDCIS)

Pursuant to the Government of India’s decision in
1977, to set up R&D facilities for improving the
effectiveness of the rotary kiln technology for making
sponge iron, the Research and Development Centre for Iron
and Steel was asked to set up required facilities.

The goal was to undertake raw material evaluation for
the sponge iron rotary kiln process and work on improving
the basic effectiveness of the process.

A complex costing Rs. 6.7 crores was set up at
Ranchi. Testing equipment for iron ore, coal was
purchased and installed.

A coal based Rotary Kiln Sponge Iron Pilot Plant of 5
to 9 tpd capacity was set up by RDCIS, with the assistance from M/s Lurgi at Heavy Engineering Corporation (HEC), Ranchi. HEC has provided the indigenous and infrastructural facilities and consultancy for this project.

The Pilot Plant has been set-up in order to adopt and assimilate the existing rotary kiln sponge iron production technology in India and also to improve this technology through innovative engineering design development as well as research towards process improvement.

The Sponge Iron Pilot Plant of RDCIS was fully installed along with its peripheral facilities, in January, 1982.

All the Plant units underwent cold run trials for 24 hours, to test their mechanical and electrical performance. In the first six months of its operation, 4 campaigns were run on the plant. During these four campaigns the total operating time of the kiln was about 45 days (excluding heating and hold-up periods). About 200 tonnes of sponge iron was produced out of which 25 tonnes was identified as product of good metallisation, suitable for melting in Electric Arc Furnace.

The sponge iron produced was melted in an Electric Arc Furnace to make steel. Initial trials indicate that
the use of 20% sponge in metallic charge does not have any adverse effect in the steelmaking process.

The RDCIS facility is available to all designers and consultants for testing raw materials. Confidentiality is maintained and RDCIS has conducted tests for a number of users. Today this is the only pilot size facility available in India for intermediate size testing.

RDCIS has embarked on several projects to improve the performance of the kiln:

(i) Iron ore fines generated during the initial screening of the ores can be agglomerated and used. Several approaches are being tested,

(ii) The waste heat in the kiln gases can be used to protect the charge,

(iii) A rotary kiln has been developed and designed,

(iv) A pilot unit is being fabricated and is to be commissioned soon.

The injection services is being evaluated. Patents on these improvements have been applied for.

Some laboratory testing work has also been undertaken for external agencies notable among them being the
laboratory test work of raw materials for a possible Sponge Iron Plant for Associated Steel Plant (ASP), Durgapur.

Since ASP is having mainly Electric Arc Furnace Unit (which is likely to be expanded in near future), the scrap requirement is high and is likely to increase further. As per estimate after the Stage-II expansion, apart from internal generation, ASP will have to procure annually about 180,000 tonnes of scrap. If the Durgapur Steel Plant is also modernized with incorporation of continuous casting units, about one lakh tonnes of scrap would be required by it annually. Durgapur will, therefore, be a potential location for setting up of a sponge iron plant.

RDCIS is also giving consultancy services to M/s Burn Standard & Co. for setting up a Sponge Iron Plant. Whether the plant is set up as captive to ASP or run by M/s Burn Standard, it would definitely help in meeting the scrap requirement of both the plants at Durgapur.

4. NATIONAL METALLURGICAL LABORATORY (NML)

The National Metallurgical Laboratory has been actively engaged in the development of processes for the
direct reduction of iron ores - suitable under Indian conditions, for nearly three decades.

NML was the first laboratory in India to take up development work on direct reduction. Although work on Direct Reduction at NML had continued on bench scale during late Sixties, it was only in the early Seventies that the NML organised itself to give Direct Reduction technology a major thrust. Much of this enthusiasm was derived from the encouragement received from the then Cabinet Secretary, Sri B. Sivaraman followed by the then Minister for Steel, late Sri Mohan Kumaramangalam and Secretary, Sri H.C. Sarin.

A rotary kiln used for manganese ore was converted for direct reduction of iron ore. This had a production rate of 3-4 tonnes per day. Several campaigns were tried and tests were conducted for various combinations of coal ore and flux.

Based on this experience, NML felt that they had the knowledge to set up a large production sized unit. An old cement kiln at Andhra Cement Co. was modified to work as a sponge iron kiln. The expected production rate was 50 tonnes of sponge per day. The plant was in operation for about a year and barring innumerable mechanical breakdowns, the rated capacity of 50 tonnes of sponge iron day
was exceeded during extended trouble free runs. The metallisation of 90-95% was obtained by using the ore from Bellary-Hospet area and coal from Singareni Collieries.

The project was abandoned as continuous production could not be maintained. NML claims that the basic problems were to do with mechanical breakdowns but that the process was workable.

After this unsuccessful commercialisation of their know-how, NML has stopped working on the rotary kiln technology for making sponge iron.

Around the middle of 1970’s, NML scientists started working on an alternate process called the NML - Continuous Vertical Retort Direct Reduction process (NML-VRDR). A unit with a capacity of 350 kg. sponge iron per day was tried out. Sponge iron with 85.95% metallisation was produced from different grades of iron.

Based on the experience with this small unit a pilot plant with full facilities for charging, discharging, metering, was installed to produce 1-1.5 tonnes of sponge iron per day. The retort is 245 mm dia. and 4.8 metres long which fixed up in a furnace 3.5 metres high. The retort is connected with the charging arrangements from the top and is gravity fed. The exhaust gases consist of high percentage of carbon monoxide and hydrogen and the
among the entrepreneurs' minds about the capabilities of NML to provide a working technology; and concept of a small (4000 tpa) captive sponge iron plant has not yet been tried out or tested anywhere in the world - its viability being strongly questioned by many.

5. THE TATA SPONGE IRON

Chronology of Events:

1970  
Tata Steels decision to put in efforts in the field of sponge iron making

1972-73  
Laboratory experiments and commissioning of 3 1/2 tpa pilot plant

1973-74  
Design, engineering and erection of 10 tpa pilot plant

1975  
10 tpa pilot plant commissioned

1977-82  
Backup studies on cold models and mathematical modelling

1982  
Modification of pilot plant

Oct’1981  
Letter of Intent for Ipitata

Oct’1982  
Incorporation of the Company

Jan’1983  
Ground breaking at site

Oct’1985  
Cold trials of plant equipment

Dec’1985  
Hot commissioning of the plant

Jan’1986  
Start of commercial production runs

Mar’1986  
Achievement of 90% metallised product

Apr’1986  
First despatch of sponge iron from Ipitata.
During the early 1970's the sponge iron process for steel making was not of immediate relevance to the operations of the Tata Iron and Steel Company Ltd. (TISCO). The operations of the company were based on the traditional route for steel making and it successfully operated an integrated steel plant at Jamshedpur, Bihar.

The management of TISCO, however, realised that research and development in this area would not only be in the national interest but would also provide the company with a distinct competitive edge in future, were this technology to take-off and become an established and acceptable method of steel making in India.

With the intention of assessing the potential of the DR process, a group of senior TISCO managers visited several plants around the world, which were using the coal based Direct Reduction technology for making sponge iron. Among other things, they found that the process was very sensitive to raw materials.

The idea of TISCO going in for R&D on the coal based direct reduction process was pushed through by the then Director of the R&D division of the company.

In 1972, TISCO decided to install as a research and development unit, a pilot plant for the sponge iron
process. In order to obtain an idea of the process parameters involved for design purposes, it was necessary to carry out some bench scale tests in the laboratory. These were conducted in a 30 cm. long stainless steel cylindrical bomb of 5 cm. diameter.

It was realised, however, that these laboratory tests were purely for guidance and could only be used to arrive at the broad ranges of the process parameters, to be used for design purposes.

Based on the laboratory experiments, a 3 1/2 tpd pilot plant was set up. Once this was commissioned successfully, the scientists at TISCO decided to set up a larger pilot plant. Thus a 12 tpd rotary kiln based direct reduction pilot plant was commissioned in early 1975. The objective of setting up this pilot plant was to assess the suitability of the solid state direct reduction process for sponge iron manufacture with Indian raw materials. The entire plant was designed and installed by TISCO personnel and did not involve any foreign exchange expenditure.

The operations of this pilot plant began in 1975 and it was run till February 1986. In the first thirty-two months of its operation, 20 campaigns were carried out in which green pellets, fired pellets as well as lump ores of
various physio-chemical characteristics were used as the iron oxide feedstock. Non-cooking coals of various types as well as lignite were used as the reductant, either, exclusively or in combination with light diesel oil which was sprayed into the kiln through the discharge hood.

While the pilot plant was in operation, efforts were made to evaluate the results and solve various problems, based on which modifications were made in various areas. It was also felt necessary to identify simultaneously, the optimised flow conditions of the solids in the charge bed inside a rotary kiln.

Cold model studies were carried out in models of rotary kilns of varying sizes in order to predict the fundamental aspects of material flow in rotary kilns. While such work led to quantitative correlations of the process and operation parameters with several variables, a mathematical model was also developed.

The experience of running the TDR pilot plant helped in identifying certain problem areas. The experimental cold model studies on the flow of solid materials in a rotary kiln and the mathematical modelling work helped in correlating the data generated in the pilot plant with those predicted by the computer-aided mathematical model. With this background, some modifications were undertaken.
in the pilot plant. The pilot plant modification work was begun in 1982 when it was decided to dispense with the travelling grate, and increase the kiln length to 22 metres.

It was also decided to provide a rotary dryer for drying coal, to overcome the difficulties faced with screening and sizing wet coal in the rainy season.

These modifications were completed in September 1982 and experimental work was continued till February 1986.

The results obtained and the confidence generated in the pilot plant over a period of about 12 years, brought the TDR process to a stage of commercial exploitation. A new company, named IPITATA Sponge Iron Limited, was then promoted jointly by Tata Steel and IPICOL (Industrial Promotion and Investment Corporation of Orissa Ltd. - a state government undertaking in eastern India) in November 1982. Ipitata is the first sponge iron plant in India using an indigenous technology. A total of 36 months, after the incorporation of the Company, was taken to implement the project at a cost of around US$ 30 million. This included a township for about 80 residents. It is worthwhile to mention here that while Tata Steel participated for the first time in its corporate history in an outside venture as a promoter-cum-technology
supplier, it also provided the technical consultancy to Ipitata comprising of design, project engineering and supervision of erection.

Ipitata is located at Joda in Orissa, about 160 km by road from Jamshedpur in an area of 300 acres of land, including the Township. The site was selected on the basis of the following:

(i) nearby source of rich deposits and mining facilities of iron ore.
(ii) an existing railway track and a state highway for rail/road transportation of coal and the product.
(iii) a perennial source of water immediately adjacent to the plant site.
(iv) proximity to a 33 KV power line.
(v) existing infrastructure facilities of Tata Steel's Mines Division, and
(vi) proximity to the market, mainly Tata Steel at Jamshedpur.

The project activities started in end 1982 with land acquisition, site grading, building facilities for construction jobs, raw materials tie-up and allied activities on site development, civil construction, structural fabrication/erection and parallel activities on procurement of equipment. The first half of 1985 saw the final erection work followed by trial runs of various equipment and instruments beginning in October. The hot
commissioning of the kiln was started on 27th December, 1985 - 4 days ahead of schedule - when Ipitata's 72 metre long 4.2 metre diameter kiln was lit up for the first time, marking an important milestone in sponge iron making in India. The production runs began in January, 1986, again exactly as per schedule, and Ipitata's kiln started producing sponge iron with 90% metallisation on 1st March, 1986.

The plant is, however, still undergoing some problems. Most of the problems relate to inconsistency of the raw material quality and specifications. Negotiations between the Ipitata management and the Government are on, for allotment of specific coal fields for supply of raw materials to the plant. Once this issue is resolved, it is expected that Ipitata can reach satisfactory operating conditions in the next few months.

6. AN OVERVIEW

There is a recognised need for an effective technology for extraction of metallic iron from its ores using coal. The rotary kiln process has been the only industrially tested process. However, it has not been commercially significant.
There are several technical problems with the process. Productivity and/or quality of the product are severely affected if the kiln operation is not optimized for each specific set of raw materials. Adequate supplies of consistent quality raw materials must be made available for satisfactory operations.

The kiln must be constantly monitored so that accretions do not build up. The temperature profile has to be controlled. Control of this process is through: balance between close sizing of inputs, placement of material (coal) in the kiln and, air injection into sections of the kiln.

Large quantities of waste materials are generated during the operation. Laboratory testing can be indicative, but large scale testing is required to pinpoint the extent of waste generation.

The waste materials are specific to the process and to find alternate use for them further development work is required. A lot of development work is under way to resolve the waste problem. Laboratory, pilot and fuel scale investigations need to be supported.

The rotary kiln process is not energy wise efficient. Almost half (40-45%) of the heat is carried away as surplus heat in the waste gases.
The technology status at the various organizations can be summarized as follows:

1. NML - has totally abandoned the rotary kiln process. They have developed an alternate process (Vertical Retort Process) and demonstrated technical viability on 1-1.5 tons per day (300 tpy) scale. A commercially viable size is estimated to be 4000 tons per year (12-14 ton per day) unit. Design and engineering is available from MECON. NRDC, is the agency for commercialization of this technology from the CSIR laboratory. Given, the history of sponge iron making technology - there is a need to objectively evaluate the claims of NML. If the claims are reasonable, the NRDC could take steps to support the operation of a demonstration unit.

   SIIL could be entrusted with the task of setting up and operating such a demonstration plant. If the process is successful, the Government would recover the expenditure from further sales of the process.

2. IPITATA - A consistent and systematic work has been done by Tata's. An entirely indigenous effort, where the scale up from a 10 ton per day to 300 tons a day plant is being attempted. The original schedule calls for
operations at 100% capacity by January 1986. The plant has been commissioned and is in operation.

Certain problems have, however, cropped up which are preventing trouble free operations. Engineers at Ipitata are working to solve these. Some time must be given for the Ipitata plant to reach full production capacity. Till then it is difficult to assess the success or failure of the Tata efforts.

3. SIIL - This organization has modified and adapted the imported Lurgi (SLRN) technology for 30,000 tpa plant. A modified 30,000 tpa plant has been made indigenously installed and commissioned within a very short time. SIIL has demonstrated capability to design and commission 30,000 tpa rotary kiln plants using Indian manufacturers.

SIIL have now designed a 120,000 tpa plant for Karnataka and claim that more plant designs up to this size can be developed. The scale up problem can be expected to be a minor one but until such a large plant is built - SIIL's capability cannot be proven.

SIIL has also initiated several developmental activities to improve the viability of the process. The briquetting of sponge iron fines will be tested on industrially significant scale in the next few weeks.
Bulk of the other wastes are being disposed off for alternate uses. While this may be a satisfactory intermediate solution, efforts at utilizing these wastes need to be supported.

The ore fines generated in sizing the input feed can be disposed in several ways. Agglomeration of fines is the approach. RDCIS is trying out cold bonding. There are several bonding techniques that could be reviewed for use. SIIL is proposing to use the fines as raw input to the kiln. The pre-reduced fines could be smelted in submerged arc furnace. This operation of high slag volume submerged arc furnace is not a developed practice. Hence, a control set of experiments are required to be conducted before commitment on investments. Industrial scale trials in smelting of pre-reduced fines have been conducted in Plasmamelt and AC and DC arc furnace. These alternatives should be included in the evaluation.

SIIL had sent waste sludges (0.05 tons per sponge ore scrubber and 0.07 tons per sponge gas scrubber sludge) to UNIDO, which has suggested setting up and ancillary unit for production of construction ceramics. The production of ceramics from waste clays has been commercialized by new units such as Spartit and Kera ceramic in A.P. Dialogue with these producers may be useful.
About 45% of the energy is present as sensible heat in the Kiln gases. There are three alternatives for using this heat. One is to recover this as a waste heat boiler. The use of waste heat boiler is well established in a number of processes and a careful evaluation of the economics of recovery of this heat should be done. The dust quality and loading for rotary kilns will be different and the impact of such dusts on waste heat boiler designs needs to be included in the evaluation.

A second alternative is to burn the char in a fluidised bed system which is also used to recover waste heat from the kiln gases. This new concept should be evaluated and supported if it shows promise.

The third alternative is the RDCIS proposal to use the waste heat to preheat. As this has to be first evaluated in a pilot plant stage, semi-commercial or commercial testing of this alternative would be premature.

4. RDCIS - The Direct Reduction Process Centre at RDCIS was created by Government of India. While they are doing useful and interesting work, the interaction between the other groups working on sponge iron technology and RDCIS can be improved.

Possibly, a high level committee such as Science
Advisory Committee of the Ministry of Steel & Mines can overview and channelize such an interaction.

7. CONCLUSIONS

In India, the Direct Reduction Sponge Iron process has been progressing through a tortuous route. Various R&D efforts have been undertaken to develop and optimise a commercially viable route for sponge iron making. Of these, the major ones have been the four different approaches discussed in this report.

None of the efforts has, however, been able to provide a suitable and viable alternative. Although success at various levels has been achieved, the costs have been high. Moreover, the nature and characteristics of the DR process has made each experiment, tried out in India, a unique case.

So many factors - technical, economic and, policy related - influence the viability of the coal based DR processes, that successful replication of any of these is difficult to predict.

Nevertheless, the experience gained, at least by the IPITATA and the SIIL groups, through persistent efforts, has helped them get a clearer understanding of the
intricacies of their respective processes. Given the right conditions, there is no reason why they should not be able to translate their efforts for wider commercial applications. In case of NML - they are still to go a long way on the experience curve, a premature effort to commercialise the VRDR process could very well lead to another setback.
## Table I

**World Production of Direct Reduced Iron Countrywise (1970-1985)**

(\textit{thousand tonnes})

<table>
<thead>
<tr>
<th>Country</th>
<th>Minimum Production</th>
<th>Maximum Production</th>
<th>1985</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Figure Year</td>
<td>Figure Year</td>
<td></td>
</tr>
<tr>
<td>Argentina</td>
<td>30 1976</td>
<td>990 1985</td>
<td>990</td>
</tr>
<tr>
<td>Brazil</td>
<td>10 1973</td>
<td>290 1985</td>
<td>290</td>
</tr>
<tr>
<td>Burma</td>
<td>10 1981</td>
<td>30 1985</td>
<td>30</td>
</tr>
<tr>
<td>Canada</td>
<td>200 1973</td>
<td>740 1985</td>
<td>740</td>
</tr>
<tr>
<td>India</td>
<td>10 1980</td>
<td>90 1985</td>
<td>90</td>
</tr>
<tr>
<td>Indonesia</td>
<td>10 1978</td>
<td>1000 1985</td>
<td>1000</td>
</tr>
<tr>
<td>Iran</td>
<td>30 1985</td>
<td>150 1978</td>
<td>30</td>
</tr>
<tr>
<td>Iraq</td>
<td>20 1980</td>
<td>20 1980</td>
<td>Nil</td>
</tr>
<tr>
<td>Italy</td>
<td>10 1978</td>
<td>10 1980</td>
<td>Nil</td>
</tr>
<tr>
<td>Japan</td>
<td>20 1977</td>
<td>30 1978</td>
<td>Nil</td>
</tr>
<tr>
<td>Malaysia</td>
<td>40 1984</td>
<td>520 1985</td>
<td>520</td>
</tr>
<tr>
<td>Mexico</td>
<td>620 1970</td>
<td>1720 1981</td>
<td>1460</td>
</tr>
<tr>
<td>New Zealand</td>
<td>20 1970</td>
<td>170 1985</td>
<td>170</td>
</tr>
<tr>
<td>Nigeria</td>
<td>80 1982</td>
<td>220 1985</td>
<td>220</td>
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<td>Peru</td>
<td>20 1980</td>
<td>80 1984</td>
<td>50</td>
</tr>
<tr>
<td>Qatar</td>
<td>80 1978</td>
<td>500 1984</td>
<td>490</td>
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<td>Saudi Arabia</td>
<td>10 1982</td>
<td>990 1985</td>
<td>990</td>
</tr>
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<td>South Africa</td>
<td>30 1973</td>
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<td>410</td>
</tr>
<tr>
<td>Sweden</td>
<td>10 1981</td>
<td>30 1982</td>
<td>Nil</td>
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<tr>
<td>Trinidad</td>
<td>20 1980</td>
<td>280 1983</td>
<td>220</td>
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<tr>
<td>USA</td>
<td>60 1970</td>
<td>790 1979</td>
<td>140</td>
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<td>USSR</td>
<td>20 1983</td>
<td>420 1985</td>
<td>420</td>
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<tr>
<td>Venezuela</td>
<td>30 1975</td>
<td>2640 1985</td>
<td>2640</td>
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<tr>
<td>West Germany</td>
<td>30 1970</td>
<td>510 1979</td>
<td>100</td>
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</table>

**Total** 11,000
## Table II

### Worldwide DRI Production Processwise (1970-1984)

(million tonnes)

<table>
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<tr>
<th></th>
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<th></th>
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</thead>
<tbody>
<tr>
<td>Midrex</td>
<td>0.06</td>
<td>1.11</td>
<td>3.97</td>
<td>4.94</td>
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<tr>
<td>Hyl I</td>
<td>0.62</td>
<td>1.09</td>
<td>2.33</td>
<td>2.86</td>
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<tr>
<td>Hyl III</td>
<td>0.10</td>
<td>0.39</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NSC</td>
<td>0.00</td>
<td>0.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Purofer</td>
<td>0.03</td>
<td>0.06</td>
<td>0.00</td>
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<tr>
<td>Armco</td>
<td>0.20</td>
<td>0.21</td>
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</tr>
<tr>
<td>Fior</td>
<td>0.02</td>
<td>0.22</td>
<td>0.33</td>
<td></td>
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<tr>
<td>Plasmared</td>
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<td></td>
<td></td>
<td>0.02</td>
</tr>
<tr>
<td>KM</td>
<td></td>
<td></td>
<td>0.00</td>
<td>0.01</td>
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<tr>
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<td>0.15</td>
<td>0.23</td>
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<tr>
<td>DRC</td>
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<td>CODIR</td>
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<td>0.12</td>
<td>0.08</td>
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<tr>
<td>ACCAR</td>
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<td>0.01</td>
<td>0.05</td>
<td></td>
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<tr>
<td><strong>Total</strong></td>
<td>0.73</td>
<td>2.69</td>
<td>7.20</td>
<td>9.21</td>
</tr>
<tr>
<td>Gas Based</td>
<td>0.71</td>
<td>2.46</td>
<td>6.83</td>
<td>8.54</td>
</tr>
<tr>
<td>Coal Based</td>
<td>0.02</td>
<td>0.23</td>
<td>0.37</td>
<td>0.67</td>
</tr>
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CHAPTER VII

ELECTRONIC INDUSTRY

1. CASE STUDY ON ELECTRONIC PABX
1. CASE STUDY ON ELECTRONIC PABX SYSTEM

1. ELECTRONICS IN INDIA

It has been well recognised that electronics can make significant contribution towards improvement in productivity, efficiency, safety, cost, and quality of life. For a long time, India has been content in living outside the Electronics sphere, unable to reap full benefits of the "Electronics Revolution".

In August, 1983, the Government of India announced a very ambitious plan for the electronic sector during the Seventh Plan period. At the broadest level the Plan document accepted:

(a) A 33% annual rate of growth between 1982 and 1984-85, which would push the value of electronics output from Rs.1,230 crore in 1982 to Rs. 2,165 crore in 1984-85.

(b) A five fold jump in value of electronics output during the 7th Plan - from Rs. 2,165 crore in the base year to Rs. 10,825 crore in 1989-90.

The production in electronic equipment and components in 1986 was around Rs. 3,460 crore. Of this, the communication and broadcasting sector contributed Rs.504 crore. The calendar year production figures from
1982-86 are given below:

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<tr>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Consumer electronics</td>
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<td>3300</td>
<td>5870</td>
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<td>Instrumentation &amp; Industrial</td>
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<td>2510</td>
<td>3350</td>
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<tr>
<td>Electronics</td>
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<tr>
<td>Computers</td>
<td>480</td>
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<td>Communication &amp; Broadcasting</td>
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<td>2700</td>
<td>3205</td>
<td>3800</td>
<td>5040</td>
</tr>
<tr>
<td>Aerospace and Defense</td>
<td>1085</td>
<td>1260</td>
<td>1490</td>
<td>1960</td>
<td>2220</td>
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<tr>
<td>Components</td>
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<td>2300</td>
<td>3030</td>
<td>4100</td>
<td>5100</td>
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<tr>
<td>Export Processing Zones</td>
<td>485</td>
<td>750</td>
<td>1035</td>
<td>850</td>
<td>1440</td>
</tr>
<tr>
<td>Total</td>
<td>12050</td>
<td>13600</td>
<td>18900</td>
<td>26600</td>
<td>34600</td>
</tr>
</tbody>
</table>

It can be seen that production in telecommunication and broadcasting sector is generally around 15% of the total electronic production.

2. TELECOMMUNICATION SECTOR IN INDIA

During 1983, when the ambitious electronic plan was announced, a major policy announcement pertaining to the telecommunication sector was also made. This aimed at throwing open of the manufacturing activities in
subscriber terminal telecommunication equipment, to the private sector. All along, it had been the sole prerogative of the Public Sector to manufacture telecommunication items. By this announcement it became possible for private sector to enter in a big way in the manufacture of various types of subscriber type telecom equipment, like: PABXs, electronic telephones, teleprinters, facsimiles etc.

Telecommunication hardware can be broadly classified into the following categories:

<table>
<thead>
<tr>
<th>Category</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Switching</td>
<td>40%</td>
</tr>
<tr>
<td>Transmission</td>
<td>25%</td>
</tr>
<tr>
<td>Subscriber</td>
<td>20%</td>
</tr>
<tr>
<td>Cable</td>
<td>10%</td>
</tr>
<tr>
<td>Outside plant</td>
<td>5%</td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
</tr>
</tbody>
</table>

The performance of the Indian telecommunication industry has been far from satisfactory so far. The major problems have been related to:

a) Non-availability - It takes years to get a telephone connection.

b) Reliability - Even if available it does not work properly.

c) Customer service - This is totally inadequate.

It has now been realised that telecommunication is an
essential item for our national development. Telephone
density and gross development products per year are
directly proportional to each other. Developed countries
generally have more phones while countries with less
phones are the those that are still developing.

In India there were operative telephone systems in
metropolitan cities like Bombay, Madras and Calcutta,
within six years of Alexander Graham Bell's invention of
basic device called 'telephone', in 1876. However,
telephone density is still very low as compared to several
developed and other developing countries. Telephone
density in India is 0.4 per hundred persons as against 80
in the USA, 27.1 in Singapore, 32.2 in Hongkong and 7.7 in
Korea.

This is mainly due to low priority accorded to
telecommunication in India. The expenditure made in this
sector by the Government over the years has been
inadequate and meagre, though the rate of return on
investment in this sphere has been as high as 26 per
cent.

For instance, the country spent a total of Rs.1,473
crore during a period of 28 years, starting from its first
five year plan in 1951 to the end of the fifth five year
plan in 1978. The amount spent during the sixth five year
plan was Rs. 2,336 crore as compared to the proposed outlay of Rs.4,010 crore for the 7th Five year plan. The draft 7th five year plan has proposed an outlay of Rs.13,768 crore, in order to near-satisfy the demand for telephones in the country and drastically reduce the waiting list for telephones by the end of this decade.

Another anamoly in the Indian telephone network is the uneven distribution of telephone connections in various parts of the country. More than 65 per cent of telephones in the country are concentrated in four metropolitan cities of Bombay, Madras, Calcutta and Delhi, which together account for less than five per cent of the total population. Also, over 80 percent of telephones are concentrated in urban centres with a population of one lakh and above. A vast rural segment of the country is thus, without this vital facility.

Other major weaknesses in our telecom sector have been:

a) A massive bureaucratic organisation with centralised authority, managing the Telecom sector. There has been lot of inertia to act but very difficult to motivate and make any changes.

b) The production organisations, mostly in the public sector, are highly inefficient with very large overheads.

c) There are no strong R&D organisations for time
bound development of products required urgently.

Recently, there has been a sudden realisation at the highest level, to the fact that telecommunication has to be recognised as a national resource for the future and has to be given the highest priority. The present Prime Minister announced five major technological missions. Telecommunication has been identified as one of the missions along with others like drinking water, oilseeds, eradication of illiteracy and immunisation.

3. DIGITAL SWITCHING EQUIPMENT

As mentioned above, switching equipment constitutes nearly 40% of the requirement of telecommunication hardware, and hence Government has identified this as a thrust area of expansion, by concentrating on the ways and means to increase the production capacity of the switching equipment. All over the world, digital technology has fully taken over the switching equipment area. In India too, a start was made in early 1980 with the induction of imported technology - through collaboration with CIT, ALCATEL, and the setting up of ESS-I factory at Mankapur, Uttar Pradesh.

At the time when the Government approved the setting
up of the ESS-I factory in Mankapur, the second factory ESS-II was also visualised and approved, to satisfy the pending demand at that point of time (1982). It was also realised that to meet the projected demand during the period 1985-90, there was an urgent need to have an ESS-III factory in operation during the seventh plan period.

Whereas, first generation E10B technology and second generation E10S technology were supposed to be inducted into the electronic switching factory ESS-I and ESS-II, the technology for the IIIrd switching factory proposed in the 7th Plan period was conceptualised to be two generations ahead of the E10B technology.

Although, if set up with foreign collaboration the IIIrd generation switching technology would have an advantage in telescoping the time period for commercial production, there were other serious drawbacks with it. Among these: high system cost, and large foreign exchange outflow for capital equipment, know how and raw materials. Also, technology absorption would be difficult because of the fact that the imported systems were highly software oriented. In any case such an approach would defeat the major objectives of long term self-reliance in switching technology.

With this background, considerable deliberation was
done by a high level committee of the Government, during 1984. This was with the purpose to chalk out a plan of action to implement the concept of establishing the IIIrd ESS factory based on successful development of indigenous technology, at a national development centre. Subsequently, the Centre for Development of Telematics (CDOT) came into existence and was charged with responsibility of developing an electronic switching system of the latest design, in a time bound programme of 30 months, and targetted expenditure of Rs. 36 crore

4. ELECTRONIC EPABX SCENARIO IN INDIA

Electronic Private Automatic Branch Exchange popularly known as EPABX, is only a part of the generic range of products belonging to the switching equipment technology. The products covered are: Main exchanges (MAX), Trunk exchanges (TAX), and Rural exchanges (RAX). These are all a part of the public switching network. EPABX, which is the subscriber end terminal equipment has capacities ranging from 5 extension to 2000 extensions.

There is a lot of commonality in the hardware among the different switching equipments mentioned above. Thus, looking at EPABX in isolation will deny the advantages that may accrue because of standardisation of common
hardware, specially when R&D is done for the development of a total switching technology. This was the most important point of advantage that was kept in mind when decision was taken to develop a digital switching technology of the latest generation. This decision automatically implied the availability of other generic products like the Rural Automatic Exchanges, Electronic PABXs etc.

Before we go into more details of COOT technology, it would be useful to discuss briefly the licensing policy and technology acquisition for electronic PABX’s, for manufacture by Indian electronic industries.

The idea of indigenous production of electronic PABX was conceived of as early as 1979-80, when one of the State Electronic Corporation, Meltron, was given Letter of Intent to set an EPABX factory of 50,000 line capacity.

This was followed by some more letters of intent, given to other State Corporations. At this time, the manufacture of telecommunication equipment was the exclusive prerogative of the State sector. The idea of centralized purchase of technology, instead of negotiations by individual State Corporations with various foreign companies, was mooted way back in 1982 by Department of Electronics.
A number of companies like GTE of Belgium, OKI of Japan and Jeomont Schenider of France were keen to offer technology for manufacture of EPABXs. Initially, it was the intention to standardize on one foreign technology only, by importing at a central point and sharing it for manufacture at different locations. Three technologies were short-listed after long drawn out negotiations by various committees during the period 1982-85.

It is interesting to note that between 1982-85 various committee headed by different persons deliberated to select proposals which were originally mooted in 1982. It took nearly three years for various Government departments to conclude discussions in an area, where within this time span, entirely new generation of equipments could be designed and manufactured.

When negotiations for centralized purchase of technology, for transfer to some of the State EDCs holding letters of intent were in progress, certain policy changes took place (1983), throwing open the manufacture of subscriber end telecommunication equipments to the private sector. Additional letters of intent were given to a number of private companies and some more state sector units - eighteen in all. These were for a total capacity of nearly 1 million lines. This was the scenario
sometime during early 1985, when CDOT's programme for
development of digital electronic switching was still in
the initial stages of activity.

5. INDIAN PABX MARKET AND ITS POTENTIAL

The following forecast has been made by Dr. S.N. Kaul,
noted Telecom Economist and Senior Director, B.I.C.P., on
the basis of the past trend in growth of PABX/PBX
extension lines, as available in the reports of Department
of Telecommunication.

It was found that annual rate of growth for 1974 to
1985 (11 years) was 13.45% for telephone districts (large
city telephone system) and 12.59% for the entire country.
Estimates of PABX/PBX demand made by Dr. Kaul, based on
above trends, upto 2000 AD is as follows:

<table>
<thead>
<tr>
<th>Year</th>
<th>Estimated demand of PABX/PBX lines</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Telephone Districts</td>
</tr>
<tr>
<td>1986</td>
<td>414,863</td>
</tr>
<tr>
<td>1987</td>
<td>470,663</td>
</tr>
<tr>
<td>1988</td>
<td>533,967</td>
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<tr>
<td>1989</td>
<td>605,785</td>
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<tr>
<td>1990</td>
<td>687,264</td>
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<td>1991</td>
<td>779,701</td>
</tr>
<tr>
<td>1995</td>
<td>1,291,654</td>
</tr>
<tr>
<td>2000</td>
<td>2,427,552</td>
</tr>
</tbody>
</table>

Presently PABX/PBX lines constitute about 22% of
total direct exchange lines in the country. The rate of 
DELs has been far too inadequate to meet the current 
demand, widening the gap between supply and demand of 
DELs. Apart from this, any estimate of demand for PABX/PBX 
extension suffers from a serious limitation on account of 
its demand remaining unregistered, unlike DELs where some 
indication of market can be discerned from the waiting 
lists. Consequently, manufacture of equipment is a result 
of demand actually registered, and not in an anticipation 
of demand.

It is likely that the ratio of PABX/PBX lines to DELs 
may undergo a substantial change, once the supply of PABX 
improves and the customers are convinced of reliability of 
the PABX equipment.

The obsession of retaining maximum number of DELs in 
commercial and Government offices was due, not only to 
the unreliable services of currently available PABX 
equipment (strowger), but also due to its delayed or 
outright non-availability. If EPABX is available to the 
consumers on demand, and service reliability is ensured, 
it is very likely that current proportion of PABX lines to 
DELs may increase from 22% to 30%. In such a case the PABX 
lines would be hired even though the projected supply of 
DELs remains unaltered.
The estimated trend of projected demands of PABX/PBX lines till 2000 AD for selected cities is given in Table-I. All India estimates are also included. An average number of extension lines per PABX/PBX is presently 24. This may increase to 32 in next plan, when customer group PABXs may come in vogue.

6. CDOT: ITS HISTORICAL BACKGROUND

Earlier we have discussed the circumstances leading to the creation of CDOT. Switching system formed major portion of the requirement of hardware in the telecom area. The Department of Posts & Telegraphs has been importing large quantities of switching systems, starting with strowger in 1948 to crossbar in 1963 and to digital types in 1980.

A high level committee (Sarin Committee), set up by the Government of India, to look into the problems of the telecom sector, stressed urgent actions on R&D for ESS factory, and its objectives, methodology and administrative structure etc.

A non resident Indian Mr. Sam Pitroda, showed keen interest in assisting to develop telecom systems in India. He made a highly impressive audio-visual presentation to
the committee members comprising of officials from the Post & Telegraph Department, Cabinet Secretariat and others. His proposal to develop software and hardware indigenously at low labour cost available in India, was very attractive. According to Mr. Petroda, our R&D, manpower was cheaper than that available in western countries. Also, electronic switching systems specific to Indian conditions were not available from abroad.

Mr. Petroda suggested setting up an organisation to undertake indigenous development of hardware and software. As a result, CDOT came into existence, with the formation of core group, during June 1984. CDOT was conceived, not only for development but also for transfer of manufacturing technology to the Indian market.

The main objectives, goals, strategy etc. of Centre for Development of Telematics are given below in detail:

OBJECTIVES

- Develop sophisticated telematic technology indigenously
- Digitize India's telephone network to improve overall service
- Be prepared for the Integrated Services Digital Networks (ISDN) for the future.
GOALS
- Increase Telephone Accessibility
- Improve Overall Reliability
- Develop Rural Communication

STRATEGY
- Self Reliance
- Labour Intensive
- Capital Sensitive

METHODOLOGY
- Establish New Organisation
- Develop New Products
- Develop Ancillary Industries
- Set up Manufacturing Plant
- Service and Maintain New Networks

ORGANISATION
- C DOT Registered Scientific Society
- Vested with Total Authority and flexibility
- Outside Government norms to ensure a dynamic operation as per Cabinet decision
- Jointly funded by D.O.E. and M.O.C. on equal basis. Managed by three tier management.

ADMINISTRATIVE STRUCTURE
GOVERNMENT COUNCIL:
- Minister M.O.C. - Chairman
- Chairman E.C. - Vice Chairman
- Government Secretaries - Cabinet, Finance, Communications and Electronics
- Eminent Scientists
- Project Board Members

STEERING COMMITTEE:
- Secretary D.O.E. - Chairman
- Member (TD) P&T Board - Vice Chairman
- Representatives of Finance - Expenditure and Economic Affairs
- User Representatives for Defense and Space Project Board Members

PROJECT BOARD:
- Executive Director (C DOT)
- Directors

7. THE CDOT PROJECT: SUMMARY
- Rs. 36 crore
- Three years

Universal Digital Telephone Exchange
- Modular
- Reliable
- Flexible
- Expandable
Variety of Applications

- PABX, Local, Trunk, Tandem exchange and combination of these for rural/ urban/metropolitan applications

Focus on simplicity

- Simple to design
- Simple to manufacture
- Simple to maintain and operate
- Plain Old Telephone service to begin with
- Enhancement to telematic services later on

Focus on Indian conditions

- High traffic; Many busy Attempts
- Large temperature Variations

Some configurations

- 128 port (P) Rural Exchange (RAX) PABX
- 256 port
- 512 port
- 2048 port Main exchange (MAX)
- 16000 port

Product Matrix

<table>
<thead>
<tr>
<th></th>
<th>128 P</th>
<th>512 P</th>
<th>2K-4K</th>
<th>16K</th>
</tr>
</thead>
<tbody>
<tr>
<td>PABX</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RAX</td>
<td>*</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>TAX</td>
<td></td>
<td>*</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>MAX</td>
<td></td>
<td>*</td>
<td></td>
<td>*</td>
</tr>
</tbody>
</table>
8. WORK CULTURE AND R&D AT CDOT

The work culture at CDOT is a unique experiment in organisational effectiveness and problem solving. It derives its origin from the conceptualisation of the organization itself.

When the organization was being setup, one of the first persons to be appointed was the Executive Director. A hard-core professional, he was given full responsibility and discretion to form a core group, which was to guide and direct the research, development and commercialisation efforts at CDOT. As a result, a cohesive group of dedicated personnel was assembled, who not only had the capability to undertake the rather difficult assignment at hand but, due to their previous association (most of the core group members had worked together before coming to CDOT), were able to develop a conflict-free inter-personal relationship at the work place. A pre-requisite for the effective functioning of any organisation, such a relationship has contributed greatly to the trouble free and time targeted operations of CDOT.

The work environment at CDOT is very flexible and informal. The majority of the approximately 200 engineers working with the organisation are fresh graduates from the Indian IIT’s. High perks, flexible working hours,
availability of the latest equipments and gadgets, exposure to the latest developments in the field of telecommunications, and a culture which encourages excellence, has made this group a highly motivated and result-oriented lot. To quote: "The staff is given freedom to think, innovate and experiment. A conducive work environment is provided where their talent and creativity can blossom. There is little hierarchy, bossism or red tape. Rules are observed in spirit and Finance acts as support service. There are no peons, no clerks and no section officers. Electronic Office Machines and Computers store all records and information. Promptness is the keyword and timely completion of assignments is of paramount importance. Three MBA's are employed for exclusively monitoring the activities of the individuals and the progress of tasks assigned. Every R&D engineer is provided with leased housing. Everybody is provided with office transport to and from the residence. Subsidised lunch is available during the working hours and free food for working outside the normal working hours or off-days".

The R&D at CDOT is marked by a very clear perception of its aims and objectives. Work undertaken has been in the form of a mission (called the first mission of CDOT), and is to be accomplished in 36 months. This has led to
the scheduling and targeting of every job undertaken. For instance, the product plan for the 128p PABX (DOT Version), targeted for 1987 reads as follows:

- Interface approval January
- SW Development Completion March
- System Validation March
- Documentation March
- DOT Evaluation begins April
- Product Clearance June

All projects undertaken, have a similar time scheduling.

The head quarters of CDOT and the software laboratories are in Delhi while the hardware design group and production facilities are located in Bangalore. Groups at both these locations communicate and interact very frequently and closely.

9. TRANSFER OF TECHNOLOGY BY CDOT TO INDIAN INDUSTRIES

As already outlined earlier 128 port PABX technology was a 'spin off' from the main R&D programme of CDOT for the development of digital main exchange.

For the first time, during August, 1985, the product was announced in a manufacturer's conference. The intention of CDOT was to transfer knowhow to parties who had competence to absorb this technology and productionise
and market it successfully. There was tremendous response to this offer, with more than 100 applications.

The selection of licensees was mainly based on their capability to establish R&D and production infrastructure quickly, as per the guidelines of CDOT. A deposit of Rs.1.4 lakhs, as initial payment of total know how fee of Rs.7 lakhs was stipulated. Prerequisite for further transfer of knowhow was based on the firms' establishing adequate production infrastructure in terms of manufacturing and test equipment, technical manpower and inventory of raw materials for quick production take off. 48 Units applied for manufacturing license and paid the initial deposit. There were several unique features in the transfer of technology phase of CDOT PABX which are discussed below:

A. Initial pre-operative production phase:

The applications for letter of intent and Capital Goods were submitted together by dozens of manufacturers and got cleared in one shot through project approval board in record time.

Procurement of imported capital equipment was done through ETTDC and supply to all the licensees was as per recommendation of CDOT. ETTDC tendered for the procurement of various capital equipment in bulk, and
therefore, got very good prices. This effected substantial savings for individual manufacturers importing these equipments.

As against original price target of Rs.30 lakhs, equipments were supplied by ET&T for around Rs.27 lakhs. The advantages of bulk buying was passed on to the licensees. All this was implemented in a record period of 8 months so that the production infrastructure of the licensees came up in a very short time.

In the case of raw materials of foreign origin, for initial start-up operations, ET&T went in for bulk purchase and made these available to the licensees as a total package in a record time of 3-4 months.

B. Vendor Development:

One of the highlights of CDOT PABX technology pertains to the high degree of indigenisation. This was possible because of the unique experiment done by CDOT in developing vendors in a systematic manner. From the inception of CDOT project, a series of vendor conferences were convened in Bangalore, Bombay and New Delhi. In these preliminary meetings with the Indian manufacturers of components and materials, the major programme of CDOT was announced together with details of requirement for various types of components, raw materials hardware etc. Details
of individual components, quantities required per systems were also indicated. Intended suppliers of components and materials were requested by CDOT to qualify themselves for vendor approval by submitting their profile, product range etc. A typical list of electrical and mechanical parts required in CDOT programme was indicated in detail. The list is given below:

**ELECTRICAL**

- Passive components
- Resistors
- Capacitors
- Transformers

- Active Components
- Diodes
- Transistors
- LEDs/LCDs

**MECHANICAL**

- Connectors
- Wires
- Tooling

- Printed Circuit Boards
- Frames/Bays
- Jigs/Fixtures

**SEMI-CONDUCTORS**

- ICs
- LSIs
- Microprocessors
- Others
- Instrumentation
- Software

- Transistors/Diodes
- Gate arrays-CMOS
- Memories
- Test equipment
- Services

Discussion were held between CDOT and more than 250 manufacturers of components and materials, who were members of Electronics Components Industries Association of India (ELCINA). CDOT followed this up by contacting organizations like LCSO, CIL, CACT, BEL, ITI, ISRO etc., for qualification approval; and, ERTL, ISI, ETTDC etc.,
for testing, standardisation and QC etc. Technical personnel of CDOT visited the suppliers' plants, inspected their equipment and closely monitored their manufacturing process. Follow up of vendor development programme was done in the second vendor's conference held during February 1986. The list of approved vendors was finalised before transfer of technology took place. A joint conference of vendor and CDOT PABX manufacturers was held on 8-9 December, 1986. Vendor list was constantly updated to add new parties. The transfer of technology started in June 1986.

C. Documentation:

Without effective support of documentation, any technology transfer activity can be totally ineffective. In this area again, CDOT programme of transfer of technology was unique in making available an elaborated programme to all the licensees during the transfer of technology phase. This is evident from the list of technology documents that have been made available to CDOT licensees. These are:

(i) Engineering design package

<table>
<thead>
<tr>
<th>Design Details</th>
<th>Technology details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Schematics</td>
<td>BOM</td>
</tr>
<tr>
<td>Other descriptions</td>
<td>Engineering Documents</td>
</tr>
<tr>
<td>Continuing R&amp;D support</td>
<td></td>
</tr>
</tbody>
</table>

(ii) Production Package
PCB layouts  Vendor lists
Test fixtures  Test procedures
QA/QC standards  Repair procedures
Assembly drawings

(iii) Marketing and support

Feature descriptions
Equipment configuration guide
Quotation software
Installation and maintenance
Documentation
Training
User documentation & training packages

(iv) Videotape packages on

Engineering  Production
Marketing  Field support and services

10. LEVEL OF SUCCESS ACHIEVED AND DIFFICULTIES ENCOUNTERED

In a period of 18 months from the start of transfer of technology of 128 Port EPABX, nearly 18 licensees have come out with their prototypes. Some of them have also gone into commercial production of these models. CDOT PABXs have been installed in some location for initial trials. As is expected of any new project of this nature, where R&D developed design is taken into commercial production, there are a number of teething problems that come up in the course of its productionisation.

One of the major problem pertains to type-approval of the design by the approval authority - Telecom Research
Centre (TRC). The first version of CDOT PABX, could not be offered for type-approval because this version did not have some of the features asked for in the DOT specifications.

Along with the transfer of technology, CDOT also worked continuously on updating the product features so that version 20/30 models fully meet requirement of DOT specifications. It is estimated that licensees would be in a position to productionise models of the required DOT specifications by the end of 1987.

11. EPABX TECHNOLOGY OF CDOT

EPABX technology of CDOT as discussed above is a 'spin off' from the major project of CDOT for the development of digital electronic main exchange(MAX). The family of the digital PABX already developed covers 64, 128 ports (256 and 512 ports are under development). The 128 ports EPABX was field tested in October 1985. CDOT announced technology transfer in March 1986. Some of the basic feature of PABX technology developed by CDOT are:

- Indigenous
- Digital PCM/TDM - 64 Kb. Sx
- 32 ch. CEPT A-LAW
- 2.048 M bit transmission
- Non blocking Switching Matrix
- Microprocessor controlled
- Modular and flexible architecture
A family of product line configurable to include
- 64P, 128P, 256P, 512P
- Basic feature package
- Ability to handle data immediately
- Redundancy beyond 8 ports
- Fault isolation and detection
- Easy to install and maintain
- On line and offline diagnostics
- Man/Machine interface to suit Indian conditions
- Low power consumption
- CMOS
- Convection cooling
- Only 6 basic card types for 128 P
- Line Trunk
- Control/Switch
- Signal Processor Tone
- Power supply
- Data capability for upto 1200 bauds per port

The benefits/advantages of CDOT technology as compared to other imported technologies are given below:

(a) Indigenous development

(b) Designed and developed by our own young engineers from scratch

(c) Based on most modern technology concept available

Leapfrogging in to the future digital PCm Microprocessor

(d) Designed to meet Indian conditions

Traffic Environment
Basic minimum features
Easy to install and maintain
Development of ancillary industries

(e) Family concept

Expandable from small to large
Commonalty of Hardware, Software, Training Documentation etc.
(f) Variety of applications

- Business
- Manufacturing
- Hospital
- Government
- Hotel
- University

(g) Committed product development plan

- Feature enhancement
- Voice/data integration
- Feature phone
- Voice/Data phone

(h) Overall cost effective solution

Also:

(i) Cost per line of CDOT technologies is around Rs.3000, which is far cheaper than those of any of the imported technologies.

(ii) Investments with particular reference to capital equipment is far cheaper in CDOT project, as compared to imported technologies.

(iii) Import content is very high in imported technologies and also there are several items which cannot be indigenised easily, at least for sometime to come.

(iv) Most of the production that has started on imported technologies is based on SKD/CKD imports and it will take very long to get into component level phase with independent sourcing of components. In the case of CDOT technology, at the initial stage itself, it starts with
components level imports with high degree of indigenisation.

12. DEFICIENCIES IN THE CDOT EPABX MODEL

It is essential to mention some of the weaknesses and deficiencies in the present model of the CDOT EPABX available for manufacture. The current model of 128 port meets a large demand of the market. There is, however, a requirement for larger capacities, which can be handled only through imported technologies. There are promises that CDOT is coming out with 256/512 lines option in the near future which may fill this gap.

Another important point pertains to the removal of various early bugs which always exist in a newly developed technology. Stabilisation period is needed for CDOT licensees in marketing the PABX with quality and reliability. However, one should not forget the fact that in the imported technology of PABX, considerable input of indigenous R&D is required for absorbing technology and indigenising production. Thus, given identical conditions, over a period of time CDOT technology will have a strong foothold, especially when it is working on a continuous basis on a range of digital switching technology, to provide support to the domestic
manufacturing units.

13. OVERVIEW OF CDOT PROJECT

As compared to any other indigenous technology in the field of electronics system, developed and productionised so far, CDOT PABX technology could be classified as a very high level of achievement in Indian R&D. The very concept of setting up a specialised organisation for development and transfer of technology to the domestic industry has been a unique experiment in technology transfer - of indigenously developed knowhow.

The features of a successful transfer that have been adequately demonstrated by CDOT have been:

(a) Documentation
(b) Vendor development
(c) Continuous interaction of R&D and Industry
(d) Interaction between CDOT licensees and vendors
(e) Anticipating and meeting the requirements of the domestic industry
(f) A unique organisational set-up and work culture, geared towards commercialisation of R&D output

CDOT set for itself a goal of 36 months and demonstrated that indigenous R&D can be developed and
commercialised in a relative short span of time. The CDOT technology for main exchange is to be used for setting up the IIIrd Electronics Switching Factory. The achievements of CDOT have shown, in the 128 port EPABX productionisation by large number of manufacturers, that it will not be long before the organisation will be successful in doing so.

14. ALTERNATIVES AVAILABLE TO INDIAN TELECOM SECTOR IN EPABX TECHNOLOGY

In early 1985, licenses were issued for manufacture of EPABX systems, each for a capacity of 50,000 lines each, to a number of private sector manufacturers and also State Electronic corporations. These are listed as under:

1. ITI
2. OSEDC
3. Meltron
4. UPTRON
5. WEBEL
6. UPSIDC
7. Escorts
8. Blue Star
9. Unitron
10. Delton Cables
11. J.K. Business Machines
12. Rishi Electronics
13. Tata Industries
14. Superphones
15. Larsen & Toubro
16. NRI
17. Mahindras
18. Usha Microprocessor
These units were supposed to tie up with one of the three technologies selected for centralised purchase, by the Department of Electronics. The technologies were:

1. GTE ATEA, Brussels, Belgium
2. Jeumont Schneider, France
3. OKI, Japan

Although initially there was lot of enthusiasm and competition amongst various licensees to tie up with one of the approved technologies, there were several factors that finally resulted in several units falling out of competition or opting for COOT technology. The reasons were:

(a) Markets for PABX in India was not commensurate with the total licenses available. There were doubts whether there would be an adequate market, if all the licensees go in for production.

(b) Investment in the project as stipulated by the collaborators was very large, amounting to nearly Rs. 4 crore for capital equipment.

(c) The import content was high and indigenisation possibilities were low - resulting in high cost/time.

The most important deterrent to foreign collaboration came with the announcement of CDOT technology during middle of 1986. Several of the licensees either opted for
CDOT technology or dropped out of the race. Some of the parties who opted for CDOT technology were:

1. Meltron
2. Superphones
3. Larsen & Toubro
4. ITI

M/s Rishi Electronics, WEBEL NRI, USHA, Unitron, Mahindras dropped out of the project. Thus by September 1987, active manufacturers who were fully committed to manufacture EPABX with imported technologies were:

1. Escorts with JS technology
2. Blue Star with JS technology
3. Uptron with JS technology
4. NODE in joint venture with PSIDC, with OKI technology
5. Tata Industries with OKI technology
6. J K Business Machines with OKI technology
7. Unitel in joint venture with OSEDC with GTE technology
8. Delton cable with GTE technology

It would be interesting to discuss briefly salient features of projects available through imported technologies of OKI, GTE and JS. Generally these are digital TDM PCM types going up to 2000 lines starting from 50 lines. The cost per line, based on current prices of raw materials, is around Rs.5000-6000. Detailed comparison chart of different EPABX technologies are given in Annexure-I.
### TABLE I

**PROJECTED DEMAND OF PBX/PABX LINES**

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**TABLE - I**

**PROJECTED DEMAND OF PBX/PABX LINES**

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<td>Simplex</td>
<td>Simplex</td>
<td>Simplex</td>
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<td>RAM with battery or floppy disc drive</td>
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<td>Cartridge or floppy disc drive</td>
<td>Cartridge or floppy disc drive</td>
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Remarks: All Maxima for extension lines and Trunk lines are mutually exclusive and are not possible simultaneously.
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Remarks: Full range may be used for voice, data, text and image.
### OKI ELECTRIC COMPANY

**Model:** IX 10  IX 20  IX 30  IX 40  IX 50  KE 1000  M  KE 1000-1  KE-1000LM

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**Remarks:** Original design conforming to 24 channels TDM with U-Law PCM CODEL; modified for Indian environment of 30 channels & A-Law PCC4M.
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CHAPTER - VIII

CASE STUDY ON THE ROLE OF THE NATIONAL RESEARCH DEVELOPMENT CORPORATION
NOTE ON THE NATIONAL RESEARCH DEVELOPMENT CORPORATION

1. BACKGROUND

1.1 The National Research and Development Corporation of India (NRDC) played a role in promoting technology transfer for the manufacture of Chlorosilanes and Monocrotophos. NRDC was established by the Government of India just for this purpose. It may be of interest to discuss the role of NRDC in promoting development and transfer of indigenous technology.

1.2 During the last many decades, a large amount of research work has been going on in universities, R&D institutions, and industry, which has relevance for the development of technologies to produce goods and services. Also, a number of patents are being taken by scientists, engineers and technologists. If any patent is put to use during its life, the inventor can collect royalties. Trading in patents is a well established activity in most developed countries.

About forty years ago, the Government in UK felt that in order to promote the transfer of knowledge and knowhow from R&D institutions and universities to industry, a promotional agency linking R&D institutions and industry was required. This became very important when, during and
after the Second World War the government funded quite a lot of R&D activity in universities, higher technological institutions and industry.

1.3 In 1949, the National Research Development Corporation of UK was established.

1.4 Similar thinking led to the establishment of the National Research and Development Corporation in India in 1953. It is to be noted that during the War years 1939-45, local R&D activity as a part of war effort received a philip. The Government of India was keen that they should also take some initiative for promoting the transfer of technology from R&D institutions to industry. It was during this time that the Council of Industrial Research was established for establishing and managing a large number of national laboratories like the National Physical Laboratory, National Chemical Laboratory, National Metallurgical Laboratory, the Central Fuel Research Institute, the Central Leather Research Institute, etc.

The Government of India felt that there should be a promotional and link organisation for promoting transfer of knowhow and technology from R&D institutions, national laboratories and universities to industry. Several such organisations got established elsewhere in the world. For example, the Research Corporation of USA, a private
foundation; ANVAR, France, a Government organisation; and, the Research and Development Corporation of Japan, also a Government supported institution. Similar institutions exist in Canada, New Zealand, Sri Lanka, USSR and Hungary.

1.5 The National Research and Development Corporation of India was established in 1951 under Section 25 of the Company's Act. NRDC is a non-profit making corporation. When it was established, it had an authorised capital of rupees 10 million. This has since been increased to Rs. 30 million. The main objects with which the NRDC was established are the following:

a) To develop and exploit in the public interest, for profit or otherwise:-

i) Inventions, whether patentable or otherwise, of Council of Scientific and Industrial Research including, technical and engineering 'knowhow' of processes

ii) Patents and inventions of different departments of Government of India and state Governments, commodity research committees, and other statutory research organisations, including technical and engineering 'knowhow' of processes

iii) Such other parents as may be voluntarily assigned, by general or special agreement, by universities, research institutions or individuals, and

iv) Such other processes and patents, the development of which may be entrusted to the Corporation by Government of India
b) To enter into reciprocal arrangements with similar organisation in other countries, to exploit Indian inventions in those countries and their inventions in India;

c) To issue exclusive and/or non-exclusive licences on such terms and conditions regarding payment of premia, royalties, share of profits and/or any other basis as are considered advisable to commercially develop inventions and ensure commercial production of the products of inventions;

d) To secure cooperation of such state-owned or state controlled industries or any units thereof, as are deemed or are likely to be interested or necessary to develop the new processes or inventions, and reimburse such industries any loss that they may incur;

e) To enter into agreement with a private firm or firms to develop inventions by trials at their works and to reimburse them any loss that may be incurred during these trials;

f) To install and work pilot, prototype or semi-scale units, or full commercial plants to develop a particular invention or inventions and ensure production from such invention or inventions, to sell or otherwise dispose of the products of such inventions on payment or otherwise and generally on such terms and conditions as may be deemed fit;
g) To transfer by sale, lease, hire, or otherwise dispose of any pilot plant, prototype plant, semi-scale or full commercial plant to any firm, individual, association or institute and entrust the same with commercial production of any products of invention or inventions for which the plant or plants had been installed on such terms and conditions as may be deemed fit;

h) To afford facilities for advising and assisting government departments, universities, research institutions and individuals in filing applications for patents and prosecuting the same before the Controller of Patents and to frame rules for the purpose and to vary them from time to time;

i) To distribute a share of profits, premia and/or royalties from any particular invention or inventions to government departments, institutions, organisations, universities, or individuals from whom such invention or inventions were received and to frame rules for the purpose and vary them from time to time;

j) To reward, in special circumstances, particular invention or inventions by gifts, rewards, ex-gratia payments or in such other manner as may be deemed fit.

1.6 The other objects of NRDC mentioned in its
Memorandum and Articles of Association are essentially enabling activities for achieving the main purpose for which the organisation was established.

2. PERFORMANCE OF NRDC

2.1 During the early years from 1953 to around 1969 NRDC was functioning in a low key which is clear from the number of processes referred to NRDC for exploitation, the number of licenses, the processes that went into production, the amount of premia and royalty collected, and the staff employed by NRDC. Only from 1969-70 NRDC picked up momentum. This is clear from data given in Table 1. As a matter of fact, nothing much happened during the first decade of the functioning of the NRDC.

2.2 Until 1969-70, NRDC was also not financially self-supporting for carrying out day-to-day activities. It had to depend upon government grants and loans for its existence. Under the statute under which the NRDC of India was established, the organisation can keep 30% of total premia and royalty collected from its licenses. The rest goes to the inventor and institutes where he works. Because the amount of money collected by way of lump-sum and premia was relatively small, the amount that could be kept for operations of NRDC was also small - not even adequate to
meet day to day expenditure of the organisation. In 1969-70 there were cumulative losses amounting to about Rs. 35 lakhs out of a subscribed capital of Rs. 50 lakhs.

Output:

2.3 In Table 1 the number of processes that have gone into production until 1984-85 is given. Processes that went into production number 433 by 1984-85. Licenses in production number 834. The total annual value of production is Rs. 564 crores. Table 2 gives these data in some detail from 1970-85.

2.4 Table 3 lists the top 12 processes in production in terms of annual value of production in 1985. Prominent items with value of production exceeding Rs. 100 million per annum are infant food, tractor, bricks made in high draught kilns and ABS plastics. It is said that there are other processes about to go into production with an estimated annual value of production of more than Rs. 10 million. They are elastic fasteners for railway sleepers, mini-cement plant, beta napthol, 5 thread 2 needle industrial sewing machine, monocrotophos, sorbitol, DDVP and phosphamidon.

2.5 NRDC has been active in promoting technology development through collaboration with industries and R&D institutions. Some of the processes supported including the equity participation by NRDC are given in Table 4. About
Rs. 85 lakhs were contributed by NRDC for the development of these technologies. The total number of projects done as of 1985 is approximately 95 with a total investment by NRDC of Rs. 4.55 crores. Normally NRDC contributes up to 50% of development costs or 26% equity in the company.

2.6 NRDC during recent years has been active in the field of development of technology for use in rural areas, what is called development and promotion for "rural technology". Here they have been trying to establish in different parts of the country, demonstration centers so that those interested in this area could actually go and see these demonstrations and utilize the technology in their villages. NRDC has so far opened 29 such 'Centers' in the country.

3. INVENTION PROMOTION

3.1 Another important activity of the NRDC is Invention Promotion. Every year on Republic Day and Independence Day NRDC gives awards for outstanding inventions. NRDC also publishes periodicals in Hindi and English for promoting inventions. The organisation offers assistance to inventors for patenting their invention and for their commercialisation.

3.2 NRDC also acts as an agency for giving a WIPO
Award (WORLD INTELLECTUAL PROPERTY ORGANISATION) in India since 1983.

4. EXPORT OF TECHNOLOGY

4.1 NRDC has made some progress in the export of Indian technology. Table 5 gives a list of them.

5. DISCUSSION

5.1 A review of the activities of NRDC of India and comparing these with those of similar institutions abroad would be worthwhile. The number of technologies commercialised by NRDC has been very impressive. This compares very well with the record of NRDC of UK, Japan Research and Development Corporation, ANVAR France and Research Corporation of USA.

While the number of processes commercialised is good, the total amount of production out of these technologies is very small in terms of monetary value. This is essentially due to the fact that Indian R&D establishments have not been involved to any great extent in the absorption of imported technology and development of significant new technologies. That being so, NRDC had to handle only those technologies that were available to it. NRDC cannot be faulted on this score. The indigenous R&D
system isolated from the main steam of industry in the country is responsible for this state of affairs.

It may be worthwhile to note that even today India does not have much technology to offer for export or even for indigenous use. This has resulted in the continuous import of technologies into the country even though some industries have been functioning for over 75 years.

5.2 Another important matter which limits the activities of NRDC is lack of technical and financial resources. While the resources available to it were perhaps adequate for the development of the technologies available today, they are not really adequate to develop high technologies for example in the field of plastics and polymers, fibres, iron and steel, power generation equipment, machine tools, metallurgy, electronics etc.

The problem of resources of NRDC was never seriously discussed because the technologies available to it for commercialisation did not require very large financial resources. This picture will change when one would like to make a serious attempt for the absorption and upgradation of imported technology and development of indigenous technology to meet national needs.
6. IS THERE A NEED FOR SUCH AN ORGANISATION?

6.1 A perusal of the objects with which NRDC was established, clearly indicates that there can be enough work in the country for such an organisation, if India wants to make a serious effort in the development of technology. Even today, NRDC type of organisations exists in many developed countries - UK, France, West Germany, USA, Canada, New Zealand, USSR etc. Among the developing countries such organisations exist in India, Sri Lanka, Mexico, Egypt, etc. The real problem is the lack of clearly spelt out plans, leadership and resources. An indepth review of the activities of NRDC with a view to make its programme more meaningful in the development of indigenous technology is now due. The review should take into consideration experience of such organisations in other countries.

7. CONCLUSION

7.1 NRDC as constituted now, but with more resources - technological, managerial and financial will be in a position to contribute in a significant way, to the development of indigenous technology and its transfer to industry. This is proved be experience not only in India, but also in other countries, especially the developed countries. If developed countries find a need for such an organisation inspite of capabilities that exist in their R&D
institutions and industry, one cannot seriously question the need for such an organisation in India which is wanting to achieve national self reliance.
## TABLE 1

### EXPLOITATION OF PROCESSES BY NRDC

<table>
<thead>
<tr>
<th>Year</th>
<th>Processes referred</th>
<th>Licence Agreements signed</th>
<th>Processes went into production</th>
<th>Lumpsum value</th>
<th>Royalty value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. Cumulative</td>
<td>No. Cumulative</td>
<td>Rupees in Lakhs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1962-63</td>
<td>32 648</td>
<td>40 266</td>
<td>8 64</td>
<td>1.28</td>
<td>2.89</td>
</tr>
<tr>
<td>1963-64</td>
<td>33 681</td>
<td>27 293</td>
<td>7 71</td>
<td>1.50</td>
<td>4.17</td>
</tr>
<tr>
<td>1964-65</td>
<td>27 708</td>
<td>36 329</td>
<td>19 90</td>
<td>1.14</td>
<td>5.71</td>
</tr>
<tr>
<td>1965-66</td>
<td>38 746</td>
<td>66 397</td>
<td>6 96</td>
<td>1.99</td>
<td>6.33</td>
</tr>
<tr>
<td>1966-67</td>
<td>62 808</td>
<td>46 443</td>
<td>8 104</td>
<td>1.65</td>
<td>6.83</td>
</tr>
<tr>
<td>1967-68</td>
<td>163 971</td>
<td>55 490</td>
<td>20 124</td>
<td>2.94</td>
<td>5.07</td>
</tr>
<tr>
<td>1968-69</td>
<td>97 1068</td>
<td>67 565</td>
<td>17 141</td>
<td>6.43</td>
<td>10.43</td>
</tr>
<tr>
<td>1969-70</td>
<td>64 1132</td>
<td>92 657</td>
<td>28 169</td>
<td>3.59</td>
<td>9.04</td>
</tr>
<tr>
<td>1970-71</td>
<td>82 1214</td>
<td>90 747</td>
<td>18 187</td>
<td>7.73</td>
<td>13.62</td>
</tr>
<tr>
<td>1971-72</td>
<td>139 1353</td>
<td>135 882</td>
<td>23 210</td>
<td>9.50</td>
<td>19.08</td>
</tr>
<tr>
<td>1972-73</td>
<td>151 1504</td>
<td>200 1002</td>
<td>15 225</td>
<td>15.19</td>
<td>20.87</td>
</tr>
<tr>
<td>1973-74</td>
<td>102 1606</td>
<td>238 1320</td>
<td>30 255</td>
<td>16.51</td>
<td>14.38</td>
</tr>
<tr>
<td>1974-75</td>
<td>120 1726</td>
<td>262 1502</td>
<td>39 294</td>
<td>20.43</td>
<td>16.62</td>
</tr>
<tr>
<td>1975-76</td>
<td>102 1828</td>
<td>227 1809</td>
<td>36 330</td>
<td>17.14</td>
<td>44.97</td>
</tr>
<tr>
<td>1976-77</td>
<td>97 1926</td>
<td>166 1975</td>
<td>10 348</td>
<td>16.97</td>
<td>51.54</td>
</tr>
<tr>
<td>1977-78</td>
<td>90 2015</td>
<td>167 2142</td>
<td>21 369</td>
<td>15.42</td>
<td>44.98</td>
</tr>
<tr>
<td>1978-79</td>
<td>46 2061</td>
<td>144 2286</td>
<td>12 381</td>
<td>10.93</td>
<td>46.77</td>
</tr>
<tr>
<td>1979-80</td>
<td>45 2106</td>
<td>132 2480</td>
<td>17 398</td>
<td>16.33</td>
<td>56.46</td>
</tr>
<tr>
<td>1980-81</td>
<td>41 2147</td>
<td>119 2537</td>
<td>10 408</td>
<td>10.52</td>
<td>72.75</td>
</tr>
<tr>
<td>1981-82</td>
<td>33 2180</td>
<td>127 2664</td>
<td>8 416</td>
<td>17.34</td>
<td>85.08</td>
</tr>
<tr>
<td>1982-83</td>
<td>28 2208</td>
<td>120 2784</td>
<td>11 427</td>
<td>32.90</td>
<td>72.32</td>
</tr>
<tr>
<td>1983-84</td>
<td>25 2233</td>
<td>136 2920</td>
<td>5 428</td>
<td>20.53</td>
<td>85.63</td>
</tr>
<tr>
<td>1984-85</td>
<td>18 2251</td>
<td>138 3058</td>
<td>5 433</td>
<td>16.62</td>
<td>69.31</td>
</tr>
</tbody>
</table>

**SOURCE:** NRDC
# TABLE 2

**INDUSTRIAL TECHNOLOGY TRANSFER STATISTICS**

<table>
<thead>
<tr>
<th>Upto Year</th>
<th>No. of Licences in production</th>
<th>Total annual value of production (Rs. in crores)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>250</td>
<td>11.0</td>
</tr>
<tr>
<td>1975</td>
<td>566</td>
<td>78.2</td>
</tr>
<tr>
<td>1980</td>
<td>770</td>
<td>277.4</td>
</tr>
<tr>
<td>1985</td>
<td>834</td>
<td>564.0</td>
</tr>
</tbody>
</table>

**SOURCE:** NRDC
TABLE 3

TOP 12 PROCESSES IN PRODUCTION

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Process</th>
<th>Annual Value of Production (1985) (Rs. in Lakhs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Infant Food</td>
<td>3,000</td>
</tr>
<tr>
<td>2.</td>
<td>Tractor</td>
<td>1,570</td>
</tr>
<tr>
<td>3.</td>
<td>Bricks using high draught kiln</td>
<td>1,500</td>
</tr>
<tr>
<td>4.</td>
<td>ABS Plastics</td>
<td>1,000</td>
</tr>
<tr>
<td>5.</td>
<td>Phthalate Plasticizers</td>
<td>800</td>
</tr>
<tr>
<td>6.</td>
<td>Acetanilide (Dye intermediate)</td>
<td>350</td>
</tr>
<tr>
<td>7.</td>
<td>Beta Naphthol (Dye Intermediate)</td>
<td>285</td>
</tr>
<tr>
<td>8.</td>
<td>Hydrazine Hydrate (Chemical to treat boiler feed water)</td>
<td>200</td>
</tr>
<tr>
<td>9.</td>
<td>Ethylenediamine (Textile lubricant)</td>
<td>240</td>
</tr>
<tr>
<td>10.</td>
<td>Sorbitol (Raw material for Vitamin C)</td>
<td>230</td>
</tr>
<tr>
<td>11.</td>
<td>Benzyl group of Chemicals (Perfumery Chemical)</td>
<td>120</td>
</tr>
<tr>
<td>12.</td>
<td>Cinema arc carbons</td>
<td>120</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>9,415</td>
</tr>
</tbody>
</table>

Say Rs. 94 crores

SOURCE: NRDC
TABLE 4
SOME NRDC SUPPORTED PROJECTS

<table>
<thead>
<tr>
<th>Product</th>
<th>Laboratory</th>
<th>Collaborating industry</th>
<th>Total cost of share projects (Rs. in lakhs)</th>
<th>NRDC’s current status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beta naphthol</td>
<td>CFRI, Jealgora</td>
<td>M/s. Eastern naphtha Chem Ltd, Dhanbad</td>
<td>148.0</td>
<td>Completed in production</td>
</tr>
<tr>
<td>Gallium</td>
<td>CECRI Karaikudi</td>
<td>M/s IALCO Madras</td>
<td>8.4</td>
<td>In progress</td>
</tr>
<tr>
<td>Colour TV</td>
<td>CEERI Pilani</td>
<td>M/s CEL Sahibabad</td>
<td>20.0</td>
<td>Completed, in production</td>
</tr>
<tr>
<td>Poly carbonate</td>
<td>SRI, Delhi</td>
<td>M/s Nuchem Plastics Ltd., Faridabad</td>
<td>14.0</td>
<td>Completed</td>
</tr>
<tr>
<td>Dall Milling</td>
<td>CFTRI Mysore</td>
<td>M/s Dandekar Works, Thana</td>
<td>1.0</td>
<td>Completed, in production</td>
</tr>
<tr>
<td>Facing chuck horizontal boring and facing machine</td>
<td></td>
<td>M/s Ravjeet Engg. Specialities P. Ltd., Pune</td>
<td>2.7</td>
<td>- do -</td>
</tr>
<tr>
<td>Tool room microscope</td>
<td></td>
<td>Modern Dial Gauges and Measuring Instrument Co. Madras</td>
<td>2.4</td>
<td>Completed</td>
</tr>
<tr>
<td>Milling and Drilling machine</td>
<td></td>
<td>M/s Purushottam Engg. Works, Bangalore</td>
<td>5</td>
<td>Completed in production</td>
</tr>
<tr>
<td>Item</td>
<td>Details</td>
<td>Production</td>
<td>Status</td>
<td></td>
</tr>
<tr>
<td>---------------------------</td>
<td>-------------------------------------------------------------------------</td>
<td>--------------</td>
<td>-----------------</td>
<td></td>
</tr>
<tr>
<td>Spliting Machine</td>
<td>M/s Hindustan Engg. Works Kolhapur</td>
<td>2.3</td>
<td>Completed in production</td>
<td></td>
</tr>
<tr>
<td>Energy saving CEERI</td>
<td>Titanium Egpt. and Anode Mfg. Co. Madras</td>
<td>50.0</td>
<td>In production</td>
<td></td>
</tr>
<tr>
<td>Anode for Caustic soda</td>
<td>Industry Karaikudi</td>
<td>3.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beta naphthol</td>
<td>CFRI Dhanbad Oswali Chemicals Ltd. Cuddalore</td>
<td>270.0</td>
<td>Under commissioning</td>
<td></td>
</tr>
<tr>
<td>Blood bags</td>
<td>Chitra Tribunal Inst., Trivandrum</td>
<td>186.0</td>
<td>Trial production</td>
<td></td>
</tr>
<tr>
<td>Briquetting of coke breeze/</td>
<td>CFRI Dhanbad Met coke India P. Ltd. Calcutta</td>
<td>40.0</td>
<td>Commissioned but since closed</td>
<td></td>
</tr>
</tbody>
</table>

* Loan

SOURCE: NRD
<table>
<thead>
<tr>
<th>S.No.</th>
<th>Technology</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Suri Transmission</td>
<td>West Germany</td>
</tr>
<tr>
<td>2.</td>
<td>High draught kiln</td>
<td>Nepal</td>
</tr>
<tr>
<td>3.</td>
<td>Active carbon from saw-dust</td>
<td>Philippines</td>
</tr>
<tr>
<td>4.</td>
<td>Spice-elecresin project</td>
<td>Malasia</td>
</tr>
<tr>
<td>5.</td>
<td>Spice-elecresin project</td>
<td>Nepal</td>
</tr>
<tr>
<td>6.</td>
<td>Syntan-PKR</td>
<td>USA</td>
</tr>
<tr>
<td>7.</td>
<td>Fountain Pen Ink Project</td>
<td>Kenya</td>
</tr>
<tr>
<td>8.</td>
<td>Nasal Filter</td>
<td>USA</td>
</tr>
<tr>
<td>9.</td>
<td>Buff coloured Pepper</td>
<td>Sri Lanka</td>
</tr>
<tr>
<td>10.</td>
<td>Writing Ink</td>
<td>Kenya</td>
</tr>
<tr>
<td>11.</td>
<td>Fruit Bars</td>
<td>Guinea</td>
</tr>
<tr>
<td>12.</td>
<td>20 Projects</td>
<td>Burma</td>
</tr>
</tbody>
</table>

**SOURCE:** NRDC
BIBLIOGRAPHY
ADVISORY COUNCIL FOR APPLIED RESEARCH AND DEVELOPMENT
AND ADVISORY BOARD FOR THE RESEARCH COUNCILS : 


BAR-ZAKAY, S.N. : Technology Transfer Model.


288


FORKER, O.D. : Business, Government and University Cooperation - Cornell University, Biotech 1984, USA.


OECD : Universities under Scrutiny - OECD, 1987


SIDHU, G.S., RAO, G.S.: From Laboratory Research to Industrial Production; Transfer of Technology under Indian Conditions - Some Case Studies from Regional Research Laboratory, Hyderabad - Int. Seminar on Technology Transfer 11-13 December 1972, CSIR, New Delhi.


TILAK, B.D: Rational and Methodology of Industrial Research and Its Transfer to Industry - International Seminar on Technology Transfer, 11-13 December 1972, CSIR, New Delhi.


WAXMAN, E.: University-Industry Collaboration - The Ontario Confederation of University Faculty Associations, Vol. 4, No. 23.

WILKINSON, J.B.: Commercialization of Industrial Research Results - UNIDO (06669), 1975.

WOLFF, M.F.: Bridging the R&D Interface with Manufacturing - Research Management.