

7th INTERNATIONAL TNO CONFERENCE

Acquisition of Technology for Innovation,
Technology Transfer versus R & D



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Editor: A. Verbraeck
Graphs and drawings: A. Ramon

Preface

The Proceedings only contain the papers presented at the 7th International TNO Conference. Inclusion of the panel discussion, held at the end of the second morning, turned out to be impossible, as, due to a technical failure, the discussion was not recorded and is lost. We succeeded however, in retrieving the subjects that were discussed.

Immediately after the presentation of his paper Dr. Bogers had to answer a number of questions about Haeffner's model and its implications for science policy in government and private enterprise.

Then, attention turned to other subjects. Prof. Castagné was questioned about the contention in his paper that most European industries had not played the European game yet. Mr. Klevering was asked to enlarge somewhat on the sales strategy of a medium-sized and highly specialised industry like Enraf-Nonius. The next theme was transfer of technology to the developing world and here Mr. Huart had to bear the brunt of the discussion. Predictably, the recent oil crisis cropped up and everyone agreed that it had created a wholly new and extremely serious situation. Mr. Okano pointed out that his country depended on imported fuel for nearly all its energy and that the recent price increases had had serious consequences already for the economy. He maintained that Japan was in serious trouble and he warned that most countries in the developed world might be in the same situation within a few years. On this rather pessimistic note the discussion was closed.

The Hague, August 1974.

A. Verbraeck

Technology transfer and the innovation process

A. W. Pearson
Director R & D Research Unit
Manchester Business School
Manchester
Great Britain

The theme of this conference, 'Acquisition of Technology for Innovation' is one which is guaranteed to promote discussion amongst any scientific and managerial gathering. The sub-title 'Technology Transfer versus R & D' is one which is likely to make this discussion more heated, because it immediately suggests a conflict. In the words of the conference brochure, the term 'technology transfer' is used to indicate several activities, such as

- licensing, acquisition of patents
- acquisition of specialised companies
- acquisition of specialists

and R & D can be organised in different ways, namely

- in-house R & D
- contract R & D
- spin-off R & D from technology institutions in different fields.

The big question is whether these activities are competitive or complementary, and I am sure that this topic will arise in a number of the subsequent papers. I am equally sure that the answer will be that it depends upon many factors. Our own research in the United Kingdom suggests that the responsibilities for acquisition policy and for R & D management often lie in different parts of the organisation, and that the two are not frequently enough seen as alternative means of achieving a given end and perhaps more importantly, that in many situations a close linkage between the two activities can significantly influence the introduction of new technology.

If this is the case in other countries, and there seems little reason to doubt it, we can usefully spend some time examining some of the research findings which are relevant to the problem of technology transfer before looking at some of the organisational structures which are being adopted by a number of companies in order to promote innovation in its broadest context.

First, however, let us look at some definitions, as this is an area where much confusion arises because of the lack of agreement among different groups as to what we are talking about. The definition I am going to use is taken from Bar-Zakay (1) and says that

"Technology transfer can be described as the generation and/or use of scientific or technological information in one context and its re-evaluation and/or implementation in another".

I hope this is wide enough to satisfy most people - in fact it is probably a little too wide, and I would like to narrow it down somewhat by making a distinction, as was done by Brookes (2) between vertical and horizontal transfer

Vertical referring to the transfer of technology along the line from the more general to the more specific. In particular it is the process by which new scientific knowledge is incorporated into technology, and by which a state-of-the-art becomes embodied in a system, and by which the confluence of several different, and apparently unrelated, technologies lead to a new technology.

Horizontal transfer occurs through adaptation of a technology from one application to another, possibly wholly unrelated to the first.

Chakrabarti (3) has suggested that analysis of these two types of technology transfer would show that horizontal transfer is generally a inter-organisational process, where-

as vertical transfer generally involves an intra-organisational process. This is probably an oversimplification, but the distinction between vertical and horizontal transfer appears to be worth making, because it allows us to look at some research findings which are relevant to these two aspects and also at some organisational measures which tend to assist one or other of these processes. Finally, we can consider some recent developments which look like being capable of assisting both.

Vertical Technology Transfer

Some relatively recent research by Baker and Freeland ⁽⁴⁾ has provided useful data on the way in which information and ideas are developed and encouraged in an R & D environment. This work was carried out in the United States in the late '60s but it would be surprising if similar findings were not true of many companies in other countries at the present time.

The main feature of the work is that it looks at the way in which ideas find their way through the system, or perhaps are prevented from doing so, before they are translated into projects and organisational resources are allocated to their progression. The results of the research are many and various, but some of the keypoints which are relevant to the present discussion concern the barriers, explicit or implicit, which exist to reduce the possibility that good ideas will get far enough to be given serious consideration by senior management. The basic data collected in the investigation relates to the comparison of the quality of ideas which were submitted by researchers for serious consideration with those which for one reason or another were not formally submitted. In their research the investigators developed a mechanism whereby these two sets of ideas were compared by panels of judges against certain criteria. Their findings are presented in table form, which can conveniently be summarised as in Figure I.

The major points are

- a) 60% of the ideas which were not formally submitted were rated as excellent or good as against only 34% of those which were submitted, and
- b) 23% of the ideas which were not formally submitted actually achieved project status, i.e. they had organisational resources allocated to them as against only 7% of those which were submitted.

The summary of factors resulting in ideas not being submitted is illuminating and is shown in Table 1.

The major reason, i.e. time pressures, is certainly one which has cropped up time and again in our own research and is often given as the major reason why some R & D directors and managers have said that they find difficulty in utilising all their 'free' research funds.

If this is the case then it is important to ask how the situation might be changed, but before attempting to answer this question let us look for a moment at some of the research which is relevant to horizontal transfer.

Horizontal Technology Transfer

The research which is relevant to this area is very extensive. Almost every innovation study which has been done in the post war period, and there have been many, throws some light on this topic. The Manchester studies of 84 innovations which received the Queen's Award for Technological Innovation are reported in *Wealth from Knowledge* ⁽⁵⁾. Some of the interesting findings are summarised in Table 2.

This suggests that a major source of new ideas is from other organisations and in particular the mode of entry is through people. Other studies both in the U.K. and in the

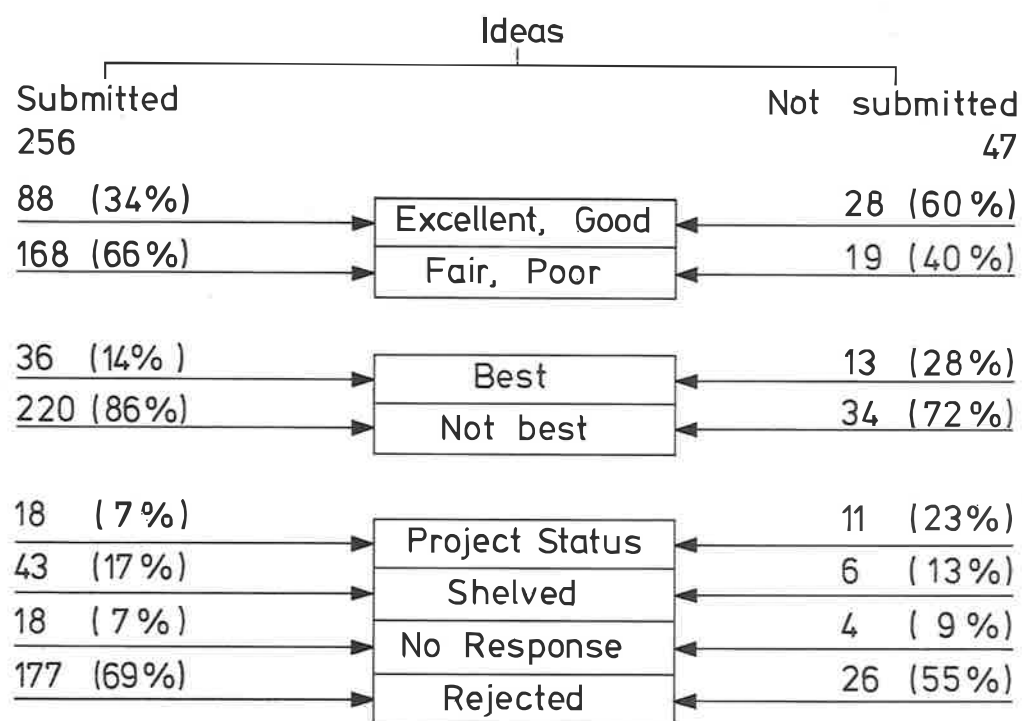


Figure 1

Factors	N	%	Idea Ratings		
			Fair, Poor	Good Excellent	Best
Time Pressures	28	60	14	14	4
Anticipated Negative Evaluation from Management	4	9	0	4	2
Negative Evaluation from Peers	3	6	1	2	1
Negative Evaluation by Group Leader	2	4	1	1	1
Previously rejected by Management	2	4	2	0	0
Submitted, No response	8	17	1	7	5
total	47	100	19	28	13

Summary of Factors Resulting in Ideas Not Submitted

Table 1

Transfer via person joining the firm	20 $\frac{1}{2}$
Common knowledge via industrial experience	15
Common knowledge via education	9
Commercial agreement (including takeover)	10 $\frac{1}{2}$
Literature (technical, scientific and patent)	9 $\frac{1}{2}$
Personal contact in U.K.	8 $\frac{1}{2}$
Collaboration with supplier	7
Collaboration with customer	5
Visit overseas	6 $\frac{1}{2}$
Passed on by government organization	6
Conference in U.K.	2 $\frac{1}{2}$
Consultancy	2
Total	<hr/> 102

Method of Transfer of 102 key
Technical Ideas
(The categories are NOT mutually
exclusive-hence the $\frac{1}{2}$ scores)

Table 2

United States, over different periods and using different methodologies, have come up with similar findings. For example the Project Sappho research team at Sussex University report that "successful innovators make more effective use of outside technology and scientific advice, even though they perform more of the work in-house. They have better contacts with the scientific community not in general but in the specific area concerned" (6). These results suggest that the encouragement of communication between people in different locations of one organisation and across organisations is something which is likely to have an impact on the innovation process. Until recently, however, there was some doubt that this could easily be achieved. The earlier work of Allen in the United States (7) suggested that communication fell off very rapidly with distance and that a geographical separation of only 25 yards was sufficient to reduce the probability of information transfer to a very low level. However, this mainly referred to informal communication, as later work by Walsh and Baker (8) and by Allen and Cooney (9) showed that communication can and does take place over very long distances if the need or desire exists. In the Allen and Cooney study of scientists in Ireland these distances span hundreds of miles.

Walsh and Baker found that work relationships or project membership are a very strong determinant of communication patterns. Allen and Cooney found the same, but they also analysed how contacts which were not required by the nature of the work came about. Their findings are shown in Table 3.

This shows that contacts are caused most often by people becoming acquainted through working together in the same organization, but of other contacts a high proportion are between people who previously worked together and then changed jobs, and a significant proportion met at university or at conferences.

Table 4 shows that the experience of having worked together in the same organisation is a major underlying cause of communication among the three sectors of the R & D community in Ireland.

The importance that good working relationships play in the technology transfer process is amply demonstrated in a recent study by Norris (10). This was concerned with the industrial utilisation of innovative ideas from Manchester University. The research involved interviews with a sample of 95 members of the University staff and looked at the ways in which the results of their research were communicated to industry. The analysis shows that a first stage of success, meaning that a firm was persuaded to put some of its own resources into an idea or invention was attained in a quarter of those communicated voluntarily, but in every one of those arising from industrial research contracts and consultancies. Not perhaps surprising, as it might be assumed that research which has been commissioned is more likely to meet a need at the point when it comes to fruition. However, an important additional finding is that a second stage of success, meaning that the invention had been used or manufactured commercially and was not known to be a failure, was attained in two thirds of those arising from industrial contracts, as distinct from only one fifth of all other inventions.

Some interim conclusions

The above research findings suggest that technology transfer in the vertical sense is hampered by the perception of barriers between the idea generation and the project initiation stages, for reasons which reflect both individual pressures and also expectations. They also indicate that technology transfer in the horizontal sense is likely to be improved if people are provided with opportunities to mix with people from other disciplines, and other organisational backgrounds. Finally, they suggest that communication between such people is encouraged through common working relationships, and through common backgrounds.

Way in which contact was established	proportion
Participation in current working relationship	36.1
Previously worked together in the same organization	19.1
Met in university	13.6
Met through professional society membership or conference	11.9
Introduced by mutual acquaintance	6.2
Formerly had working relationship	3.1
Other	10.0
Total	100.0

Sources of Domestic Communication Contacts (787 Instances)

Table 3

Way in which contact was established	Contact between		
	Universities and research institutes %	Research institutes and industry %	Universities and industry %
Previously worked together	28.4	22.8	36.1
Met in university	28.4	13.5	22.2
Professional society or conference	21.0	34.0	19.5
Mutual acquaintance	16.0	6.8	2.8
Former working relationship	3.7	0	8.4

Sources of Communication Contacts Between Individuals
in different Sectors (excluding current working relationships)

Table 4

Some implications for management

There is no single management style which is likely to be appropriate for all situations, but there are certain trends which are developing in many companies and which would appear likely to influence the rate and direction of technology transfer.

The first of these is the recognition that R & D can and should work fairly closely with other areas of the business towards common goals. The concept of the relevance tree as described by Hubert (11) is a useful one, and a simple representation of this method is shown in Figure 2.

This form of presentation helps to indicate how different parts of the R & D programme relate to specific areas of the business activity, in this case defined in terms of brands. A perhaps logical development, particularly in very large organisations, is to establish within R & D coordinators whose responsibility is to work closely with similar people from other functional areas to ensure that the needs of the different parts of the business are conveyed to the appropriate scientific and technical people and also that the skills and ideas of the R & D people are brought to the notice of those who might make use of them at the earliest possible time. An essentially interactive process, and one which is almost certain to promote vertical transfer, if only because it helps to ensure that ideas and needs are more closely matched in a time context. Most of the output of R & D requires very much larger sums of money expending in order that its potential can be fully realised. It is therefore obvious that a proportion of R & D, however good in a technical sense, will not be fully exploited because it does not fit into company plans which may have been laid for many time periods in advance, and which do not provide adequate spare resources to capitalise on such opportunities. Forewarned of potential technical alternatives means forearmed, and it is very necessary if technology transfer and innovation are to be optimised.

However, it can be argued that this very approach could reduce the possibility of horizontal transfer because it tends to encourage a type of tunnel vision – a preoccupation with pursuing existing aims along well-defined guidelines. If this is the case it can be overcome in a number of ways.

1) The specific use of idea generating techniques which make use of group activity, e.g. brainstorming, and by ensuring that these groups are chosen so as to bring together people from many parts of the organisation, from different functional areas, and in the case of the multinationals from different countries. This can help in reducing the not invented here or N.I.H. factor, and a number of organisations have found it very effective in improving the understanding between, for example, R & D and marketing people, and between people with different cultural backgrounds. It could also be valuable at this stage to bring in outside people, for example from contract research organisations or research associations and universities, to help introduce new ideas.

The use of this approach has been described by Rickards (12) and by Geschka (13) and has been found to be successful in a variety of situations. Effective use of this type of group working has also been described by Woods (14) as helpful in identifying and eliminating potential problems in, for example, production processes, and here assists in promoting vertical transfer.

2) The development of simple but visible methods of project appraisal which allow for the possibility that ideas do not always fit into existing structures and may need rerouting. For example, a question should be asked about whether the location in which the proposal is put forward is the best place in which it should be progressed. It may well be that another laboratory within the company is better equipped or the idea may be better developed within a division or through the use of contract research facilities. With regard to the production and marketing aspects it could be that the idea does not fit well into the existing divisional framework in which case it may be better handled by a group which is outside the more normal organisational structure. The forms which this might take are many and various, but the key point is the need to make

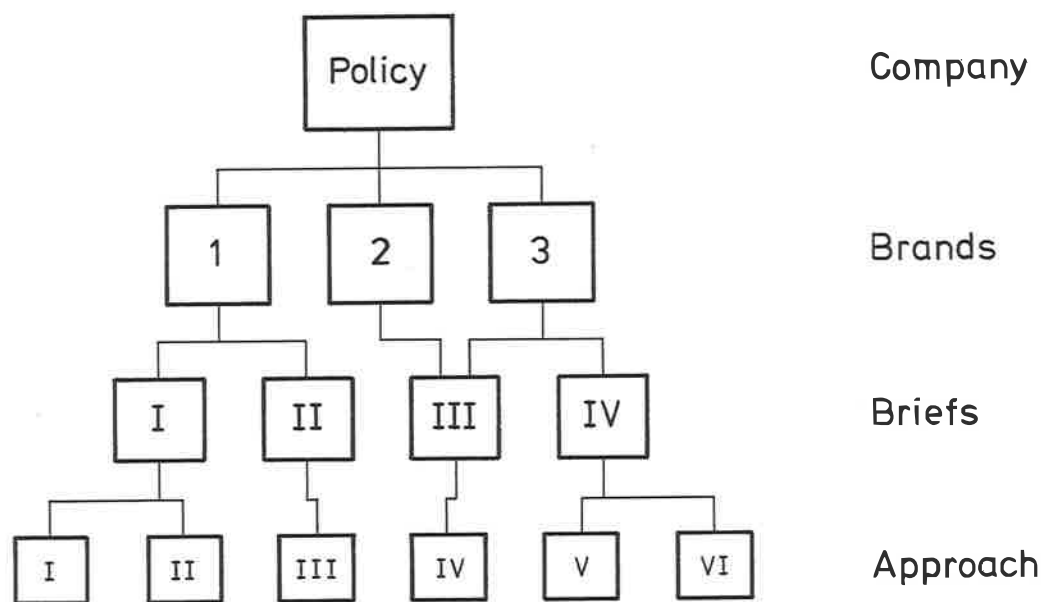


Figure 2

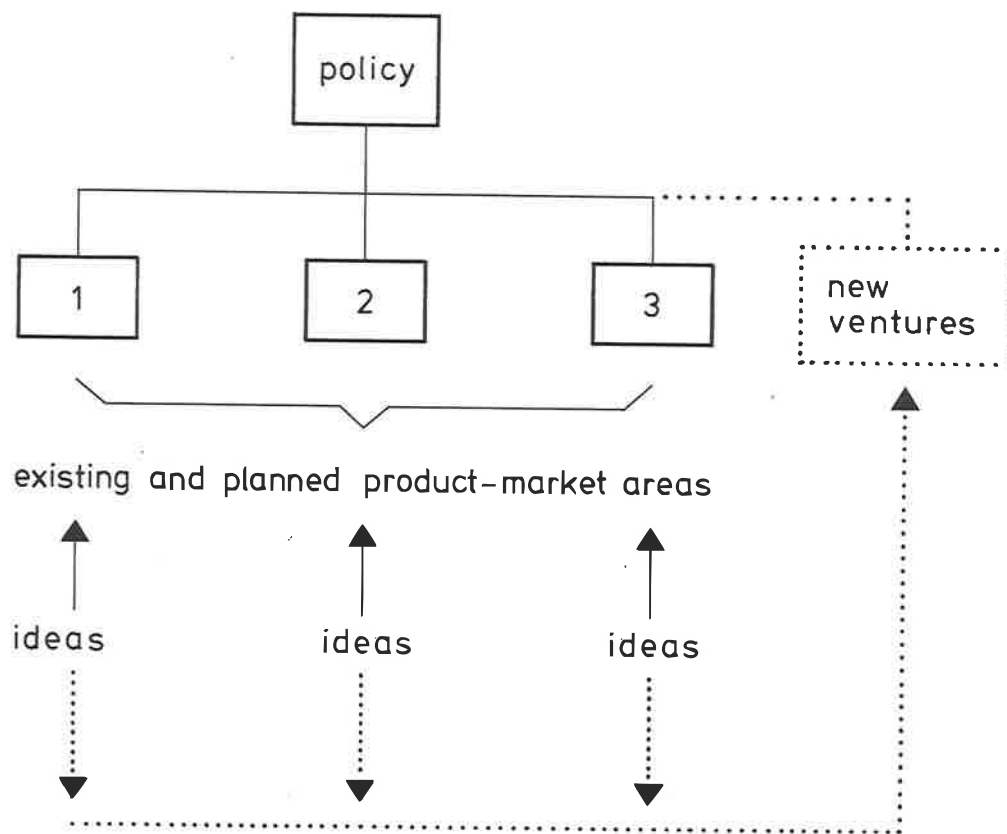


Figure 3

visible these alternatives at an early stage, so that ideas are not prematurely rejected, either formally or informally, due to a lack of knowledge about the availability of resources and/or the wider possibilities for exploitation.

3) The creation of 'opportunity seeking' groups within an organisation which are orientated towards seeking out ideas for new business opportunities. Our recent research suggests that almost half of the medium sized and large U.K. companies are actually looking at such an operation if they do not already have one in being. Gardner (15) and Vernon (16) have described their activities in this field and both are operating successfully. Such groups can fit comfortably into or alongside the divisionalised structures which are fairly commonly encountered, and in fact the relevance tree can now be extended as shown in Figure 3.

This new ventures group acts as a sink for almost any ideas in an organisation which are looking for a home and in the longer run when its existence becomes widely known will almost certainly act as a magnet for ideas. Vernon describes how the first two products which entered their new business venture operation made use of a principle developed and patented within the central research laboratory and which did not appear to be capable of being utilised anywhere else in the organisation. Perhaps a lucky combination of idea and need, but one which may not be so very rare.

4) Finally, a major point to be considered is the way in which project grouping, or work orientation, might be used to bring together people from different parts of an organisation and hence encourage the likelihood of technology transfer, particularly that of a horizontal nature. Some organisations are already using this to good effect, but it is unlikely to be of long standing value if the projects are not chosen carefully. Any suggestions that they are being set up without any real objectives except to promote communication are likely to prove disastrous in the long run. Fortunately this need not be the case, because the potential for unification has been thrust upon most companies through the onslaught of environmental pressures, and not just those relating to pollution etc., but including pressures brought out by shortages of materials, by the energy crisis, by social and political pressures, and by movements such as that towards common policies in the E. E. C.

Some of these movements can be detected already and are reported in various documents coming out of the Division for Industrial Information and Consumers of the Commission of the European Communities. For example a recent bulletin (17) mentions the improvement of working conditions and job enrichment and suggests that 'simple, unhealthy, dangerous, tiring and repetitive tasks which are performed manually can often be replaced by automatic devices or by a straight-forward automated system. When a larger number of industrial operations or processes have to be performed simultaneously more complicated hardware is often necessary. Recent developments in the sphere of electronics and fluidics suggest the possibility of replacing man by machinery for jobs of an increasingly complex nature'. Many other examples could be quoted, but clearly a greater awareness of the way in which attitudes and values are changing is not only going to encourage technological developments but also the rate at which they are put to use.

This suggests that it is useful to consider an organisational form as shown in Figure 4, i.e. as a matrix.

The value of looking at an organisation in these terms is that it identifies some of the most crucial issues which it is likely to face in the future, and it indicates how these impinge upon different parts of its activities. It therefore helps to identify the mechanism which it might be necessary to set up in order that the organisation can identify alternative futures, and their likely effect on different areas. The vertical parts of the matrix need coordinators in the same way as the horizontal, but these do not necessarily have to come from R & D or to be scientifically or technologically trained

		<u>ENVIRONMENT</u>									
		internal					external				
Product Market Area		Equal Pay	Level of skills	Individual needs	Group needs	Etc.	Energy	Materials	Government legislation	Social pressures	Etc.
1											
2											
3											
4											
	A										
	B										
	C										
	D										
	..										
	L										
	M										
	N										
	O										
	..										

CO-ORDINATION

Figure 4

people. This structure therefore helps to put R & D in the context of the business. It is now being used by a number of organisations with the coordinators not only providing information to their colleagues concerned with product areas as to likely trends in economic, social and political forces. They are also receiving information from those same colleagues which puts them in a better position to anticipate changes which might be occurring or about to occur in other areas. The two-way aspect of this information exchange must therefore encourage technology transfer because it focusses on 'needs' and in all the studies of innovation it is apparent that needs play an important part in promoting success.

Conclusions

In conclusion therefore it is argued that many of the problems of technology transfer have in the past been caused by lack of communication between the different parts of an organisation and with other organisations. In addition innovation has been slowed down because of the lack of identification of needs. Structures which are based on relevance, if coupled with appropriate safety valves in the form of opportunity seeking groups are very likely to encourage innovation. They can do this by promoting vertical technology transfer while not discouraging horizontal transfer, but the most powerful stimulus for innovation at the present time is the environment, both internal and external, in which an organisation operates. This is the aspect which requires most careful attention, and by development of an appropriate structure and mechanisms for sensing changing needs the process of technology transfer will inevitably be encouraged. It also provides most organisations, and particularly the multinationals with the opportunity to bring together people from different functional areas and different countries to work in groups concerned with specific and important issues, something which has been shown to be of value for promoting wider communication and successful innovation.

Finally, it helps to put the whole innovation process in an organisational context. It focusses attention on external or environmental issues and causes the company to examine alternative mechanisms for helping it to achieve its chosen objectives. It does not necessarily specify in advance what the alternatives might be, or which might be given preference as the most appropriate means. From this startingpoint it is possible to be more objective about the relative merits of for example acquisition of R & D, and in the latter case between the use of in-house or contract facilities or the many combinations of all those methods.

This paper has paid most attention to the problems of increasing technology transfer through organisational structure, and this has been done purposely because a number of papers which follow concentrate on acquisition and licensing policy. We are therefore going to be given the opportunity of examining many aspects of the technology transfer process and hopefully conclude that R & D management and acquisition policy can both contribute effectively to the innovation process, and that they need not necessarily be in conflict, but can be of most benefit when they are accepted as being complementary.

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Acquisition of new technologies as an alternative to one's own research

Dr. D. Altenpohl
Director of Technology
Alusuisse
Zürich
Switzerland

When one considers the different situations in various industries, regarding the needs of new technology and new products and their dependence on in-house research and development the question arises whether there is any common denominator for the present audience, which represents large differences in company structures and goals. Trying to answer this question, I would say, yes there is a common background of recent experience about the need and value of in-house research versus acquisition of technology or of research from third parties.

Let me remind you here of the three main elements in the innovation process of industrial firms. Number one is in-house research, number two is product - or process - development as a result of this research, and number three is acquisition or licensing of research results or technology from a third party. Now, what are the incentives and what are the limiting factors for each of these approaches to achieve innovation?

First I want to mention four terms, namely: research, development, technology acquisition and technology transfer. I will briefly summarize how the American Industrial Research Institute (IRI) distinguishes a research intensive company from a development intensive company. IRI defines a research intensive company as one that has to investigate a large number of possible products or a large number of design specifications that yield several alternative solutions.

A development intensive company has to deal mainly with existing, well-designed specifications, research is completed. The main technical task is to produce engineering solutions to available alternatives.

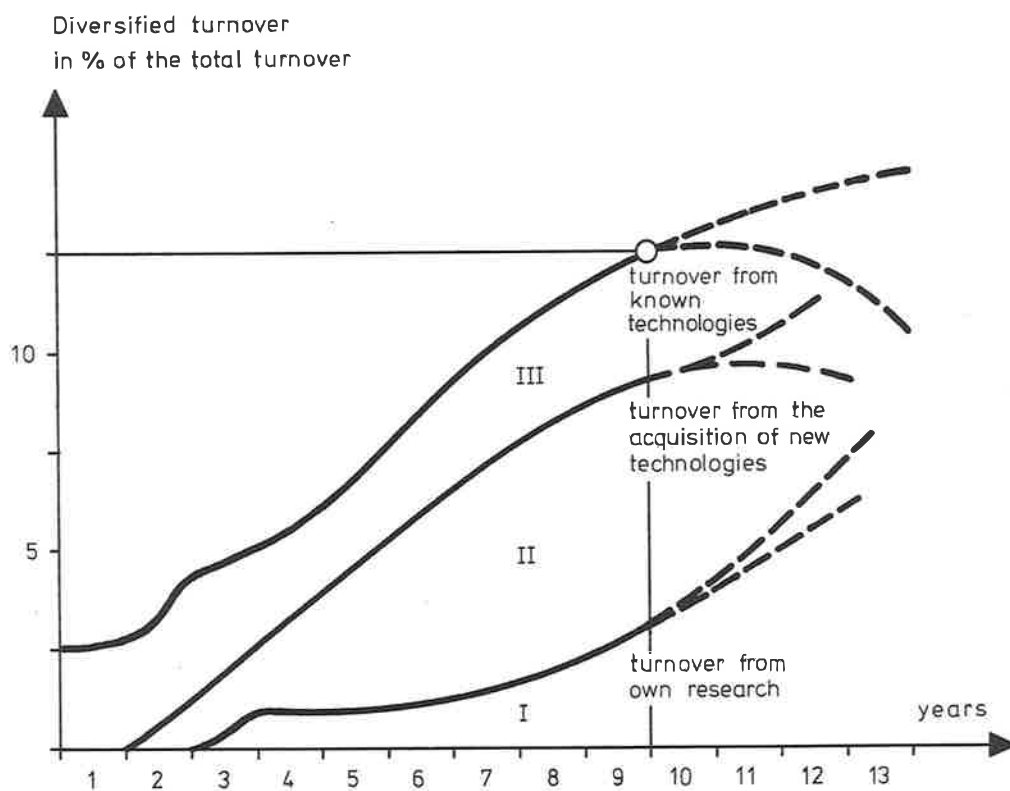
Technology acquisition: is a case where you pay for the acquired technology either by taking a license or by purchasing another company or by making a joint venture. There exists another, rather similar way of technology transfer (but which might be free of charge): this is for instance NASA-fallout or other available new technology or research results, perhaps from a different type of industry, being transferred into the own R & D or investment program. I will for the rest of my paper use the term "technology acquisition", which includes both versions of technology transfer.

My examples are mostly development oriented, but technology acquisition could also be used in the world of true research.

Acquisitions of technology as a very fair and legal method of keeping up in the front line of modern technology, can best be illustrated by the success of Japanese industry. Technology acquisition has even been described as a so-called "Japanese method". In the last 20 years, Japan took 13'000 licenses of foreign products or processes, but in recent years Japan has granted many licenses to other countries. This illustrated the volume and importance of trade in new technology in our days.

I will try to explain a few of the rules of technology acquisition. The concept I shall present is not a complete one, but will serve as a basis for discussion and for further consideration.

First I shall choose the example of an (unidentified) company wanting to enter into new activities by diversification. In figure 1, we have plotted schematically the turnover achieved by diversification in percent of the total turnover of the company. We assume that at the beginning the company has diversified only about 2,5 percent of its turnover.



Achievement of new turnover by diversification (schematic)

figure 1

Now we describe schematically the next 10 years, and we distinguish between three sectors.

Sector I is turnover resulting from in-house research, which this company started in the first year with the purpose of diversification. After two or three years we can expect a small influence on the turnover since it is well known, from existing research laboratories, that about seven to ten years is required before the real impact comes out of research as new turnover.

Sector II is acquisition of technology, and here we assume that this brings the company into diversification much faster than their own R & D (sector I).

Sector III is turnover from investments, based on well known technologies.

You will see in the next figure why we distinguished between sectors II and III. The main difference between them is that sector II needs a certain research effort before investments can be made and turnover can be achieved, whereas sector III does not. Sector III is just plain investment using well known technology with very little research. In sector II, the so-called leverage system is applied, where a certain research element is needed to make the investment successful. Sector I comes entirely from the company's own research.

In the next figure (Fig. 2) we have chosen the example of sector I for new turnover based on company sponsored research. We assume 10 units each year for research. These units could be 10 million dollars or another currency. After about 6 - 10 years you can reach a sizable amount of new turnover generated by your own research. The advantages are obtaining proprietary know-how for future investments, and training of specialists, which applies as well for section II. The disadvantages are the six to ten years of large expenditure for R & D until large new turnover is possible. And another disadvantage is relatively high risk.

In the next figure (Fig. 3) we look at section II, which shows new turnover based on acquisition of technologies, new to the acquiring company. This technology should have passed the prototype or pilot stage successfully. The advantages of this procedure would be that the engagement only happens if the risk can already be calculated, which means after this technology has reached a certain maturity. The second advantage is the quick availability of new technology with relatively low R & D expenditures.

There are also disadvantages of course, such as payments of license fees, determining the value of a company providing the technology, and some problems with searching for available opportunities. Still there will be in many cases quite a difference in favor of section II compared with section I.

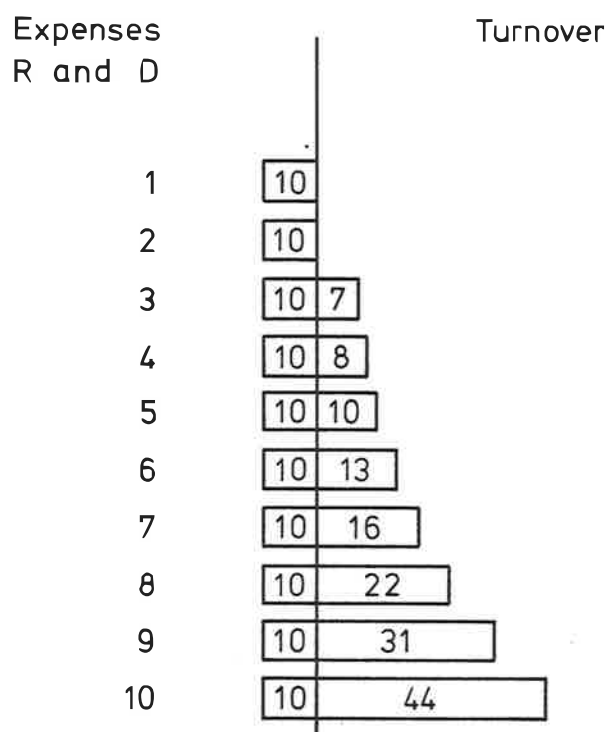
The next figure (Fig. 4) describes the increase of turnover by investing in well established technology (sector III).

The advantage of putting a lot of money into a conventional plant with very little R & D involved are low expenditures in R & D, further that timing and cash flow of the project can be rather accurately predicted. This is a typical project which large industries carry out all the time to erect another steel mill, another PVC or concrete plant and so on. Very little R & D is typical for this sort of investment.

The disadvantage is that there is no technological advantage over competitors and investment is endangered by new developments. This leads to conclusions in favor of sector II, which is acquisition of technology (Fig. 5).

Low probability of failure and co-operation with or financing by third parties are easier to obtain. R & D expenditures are rather low, by reason of the leverage. It is an effective way to arrive at short or medium-range diversification, and easy adaption of the supply to the demand in different markets, which means flexible marketing strategies.

Ratio: Expenses for R and D to corresponding turnover



Advantages:

1. Obtaining of own basic knowledge for future investments.
2. Training of specialists, also for section II.

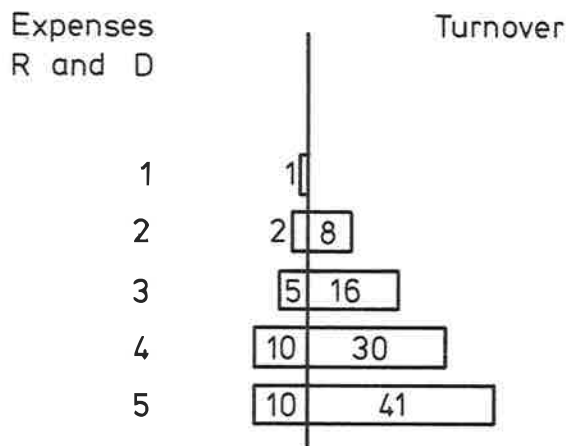
Disadvantages:

1. 6-10 years expenses for R and D until larger turnover is possible.
2. Relatively high risk.

Section I- Turnover based on own research

Figure 2

Ratio: Expenses for R and D to corresponding turnover



Advantages:

1. Engagement only if risk can be calculated.
2. Quick availability of new technologies with relatively low R and D expenses.

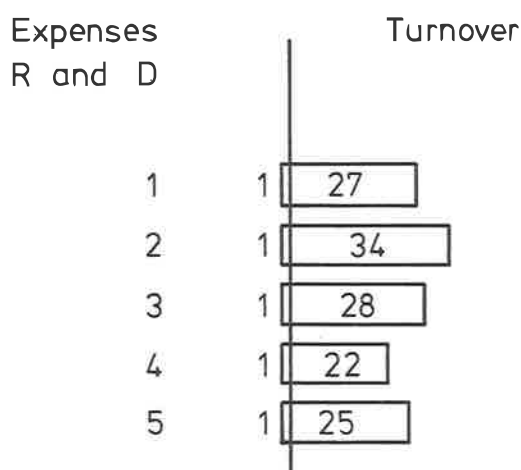
Disadvantages:

1. Payment of license fees, company value, etc.
2. Difficulties with the search for suitable objects.

Section II- Turnover, based on acquisition of technologies

Figure 3

Ratio: Expenses for R and D to corresponding turnover



Advantages:

1. Low expenses for R and D.
2. Consumption of time and money clearly definable.

Disadvantages:

1. No technological advantage over competitors.
2. Endangering of the investments by new developments.

Section III- Turnover, based on known technologies

Figure 4

- Low probability of failure
- Cooperation with, or financing by third parties easier to obtain
- R & D expenses rather low
- Effective way for short-to medium range diversification
- Easy adaptation of the supply to the demand in different markets = flexible marketing strategy

Advantages in the Acquisition of Technology

Figure 5

This last point will be described in figure 6. It means that if a company wants to penetrate into new markets, for instance into countries of the third world, acquisition of technology might be a very flexible instrument for doing so. You might be well off in acquiring technology and in then implanting it in a chosen new market.

Figure 6 explains methods of exploiting an invention in different areas by adapting it to specific needs of the local market. This activity is well suited for a multinational company with its specific resources in R & D and marketing. Figure 6 leads us to a specific group of TT Activity, providing technological know-how to developing countries, a hot issue at this very moment. As it turns out, multinational companies are best suited to transfer technology into developing countries. Certainly, they have nowadays and in future to avoid becoming a dominating power.

Technology acquisition has to be interrelated with the company's organization and present activities. Basically each large company can acquire any existing technology. But a lot of failures have shown that some requirements have to be met for a successful acquisition. A basic factor is the general organizational structure of the company that wants to acquire something. If this company is mainly profit-center-oriented it may acquire everything profitable that is available for acquisition, as the conglomerated in the United States have shown. We then have the case of merely financial acquisition, and new technology can be neglected. Another extreme is a monolithic company with one main product, where no action has been taken so far regarding new types of activities because of lack of expertise, management capacity, research capacity, and so on. Technology acquisition in this case might then be a real tool for diversification.

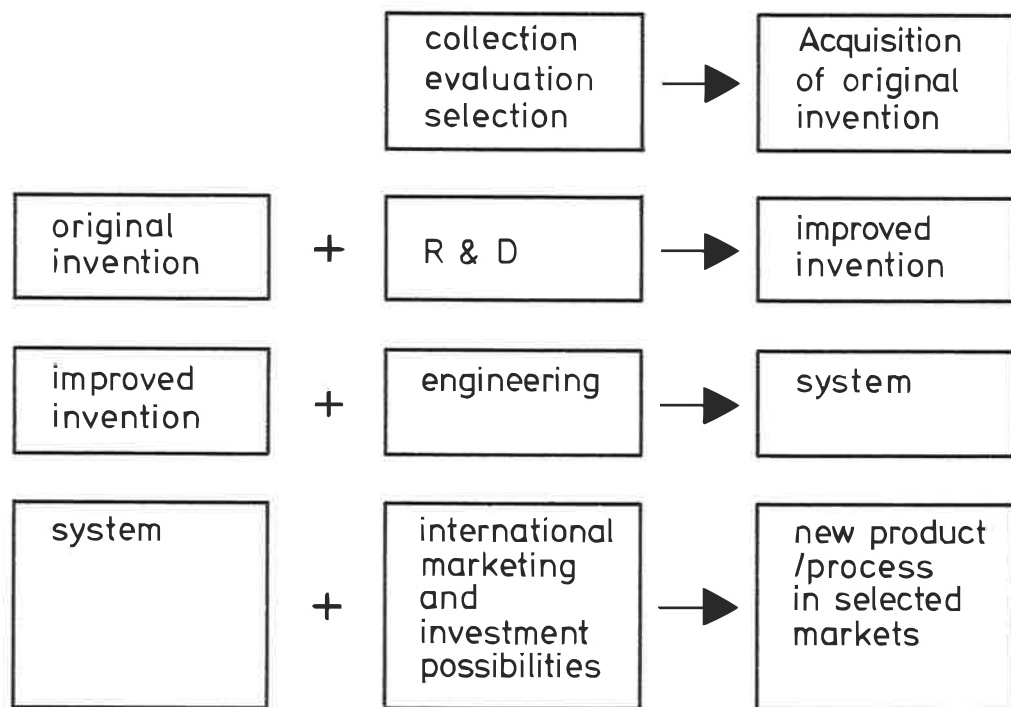
The next figure (Fig. 7) shows one of the possible organizational forms to acquire new technologies in a large company. In our example a "new ventures group" exists which evaluates various technologies. There is a selection committee, which then makes proposals to general management. In this committee there is always a member of the division, responsible for realization, and the so-called "new ventures group", who are professionals, who can compare 20 or even 50 different items according to standard criteria.

The next figure (Fig. 8) gives a brief explanation of a case of technology transfer resulting from interaction between basic research and new technology. We have chosen the case of NASA-fallout. Plotting technological progress, or "technological sophistication" against time, we went back to the ten years between 1960 and 1970 when most of the NASA basic research was carried out. In our example, the highest sophistication is represented in the basic research of NASA.

The technology of aerospace construction lags behind theoretical designs. It is well known, for instance, that basic research has already provided the design of much further improved propulsion systems but technology could not follow (for instance: Lack of heat resistant material for prolonged use at 1400°C). This means that the problem was solved theoretically in the laboratory but could not be realized in actual practice. The civilian technology, which also keeps improving all the time, is much further below in sophistication and progress than the NASA technology.

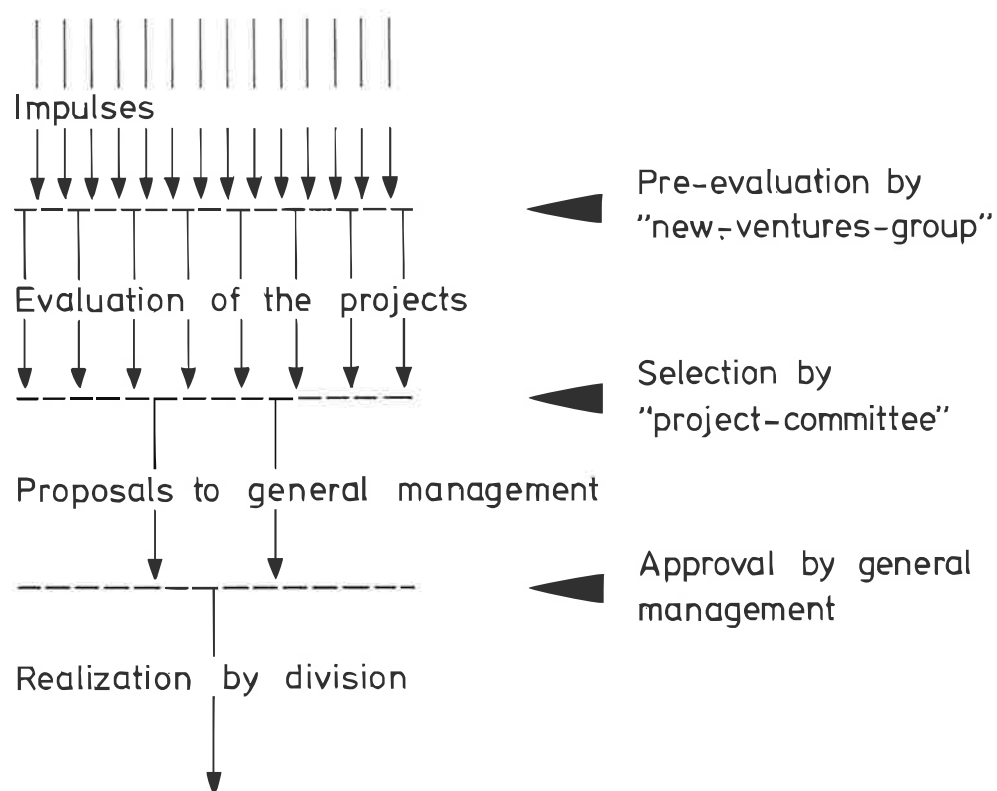
It has often been predicted that basic research and technology of NASA and other government-financed research centers (two upper curves in Fig. 8) will lift civilian technology. Therefore in figure 8, curve "d" was expected. If there would be no influence of NASA-fallout, we would have curve "f". What happened so far corresponds to about curve "e". The main problem that our American friends have described to us is that NASA and other advanced technology centers moves ahead much faster than the civilian technology. Thus, the gap between the two groups of technology is widening, as it is shown in figure 8.

Therefore the taxpayer and even leading men in industry say that the US-government should slow down the fast advancing basic research and technology activity because of



Contribution of a Large Company to Utilization of an Invention

Figure 6

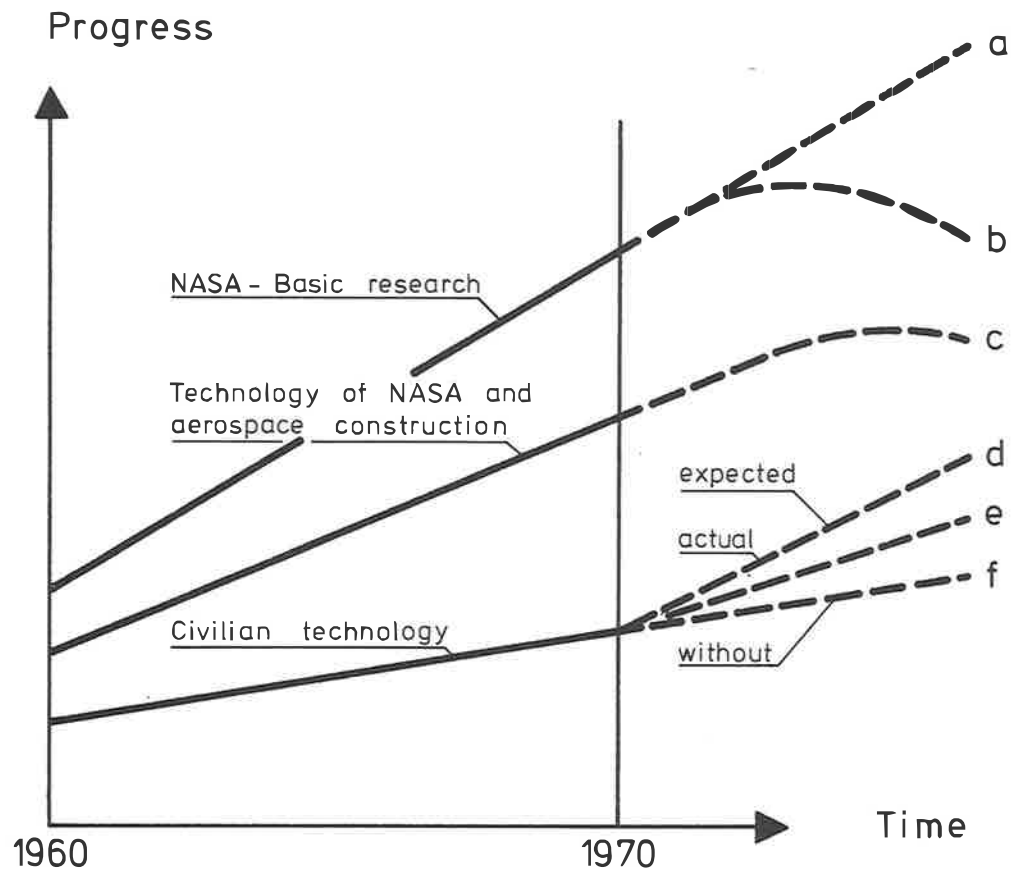


Members of the project-committee:

- new-ventures-group
- division responsible for realization

Acquisition Procedure for New Technologies

Figure 7



- a - constant
 - b - declining
 - d } proposed effect of NASA-technology
 - e } on civilian industry
 - f }
- > expenditures

Example for interaction
between basic research
and new technology (schematic)

Figure 8

the widening gap to civilian nonaerospace applications.

I have chosen this example because NASA has made their reports available also to companies outside the US, except for a very few specific subjects. I assume that it is certainly more than 95% of their documentation and expertise, which NASA now has made available for civilian application.

We have illustrated in the next figure (Fig. 9) the number of projects which a research institute might investigate, versus the total expenditure for one new product going into true production. As we can see, about 50% of the expenditure is only for selecting projects, coming down to three prototypes or two so-called "zero-series". The timing for technology acquisition is, when perhaps between 40 and 80% of the money has been spent.

Looking at figure 9 the question comes up, whether it is possible to find someone who spends a lot of money sorting out many ideas to make the results available to a third party. But there are such organizations, not only NASA and other Government supported research teams, who are trying and sorting out virtually hundreds of ideas, materials and processes. Also, large private R & D institutions like GE make "fallout" of their work available to third parties. Inputs for technology acquisition or transfer often come from quite different industries, than the industry finally using the fallout.

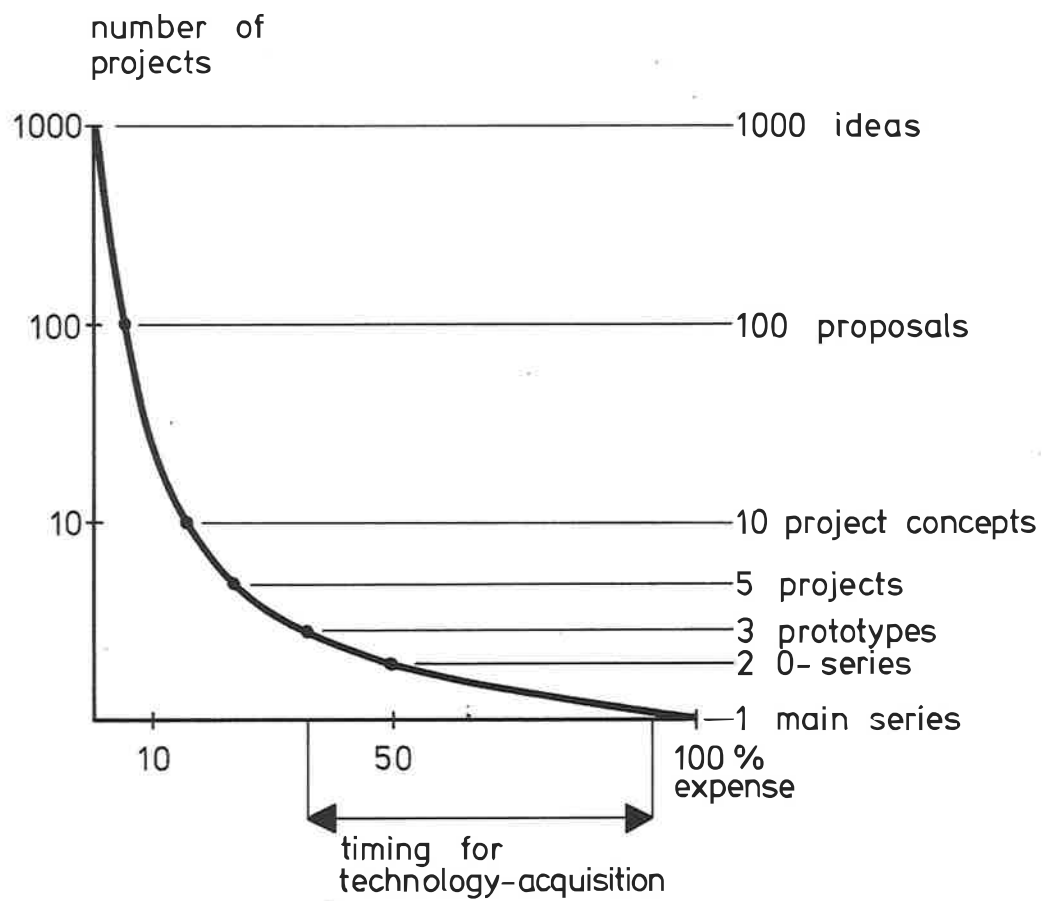
In the next figure (Fig. 10) we have plotted against time the maturity of a product or process, beginning with the original idea. In phase "a" this invention or development, like so often, makes good progress at first. Afterwards it is for some time difficult to predict whether it will succeed, stagnate or collapse. In our example it disappears from view, perhaps for years. I sometimes compare projects in stage "b" with a little mountain stream that goes underground, disappears between rocks, so you believe it is gone forever. But further down it comes out again. Perhaps not much has been lost of the original input. This comeback might take, in our time scale, a few years or even more than ten years. After this comeback the project might make good progress as we have shown in section "c" of the curve.

We have explained in figure 10 that there are three different possible timings for technology acquisition. Some courageous people might acquire during time interval "a". I can give you an example of this.

A master of the art of technology acquisition is Mr. Hutzenlaub, who many years ago acquired a rather unfeasible development called the "Wankel"-engine and recently sold it jointly with the original inventor for a large sum to General Motors and to six Japanese companies on a license basis. The Wankel-engine was acquired at phase "a", where leading experts did not believe in success and while prototypes were still under test, it went through phase "b" but came back again. Although phase "b" is also a time for acquisition, the best timing is certainly "c", where the probability of success is already easier to establish. Most large companies would acquire here.

What are the reasons for the developing group giving up here at "c" or needing someone else as promoter? Some of the possible reasons are lack of capital or lack of experts or no feasible application or they just cannot solve a detail problem.

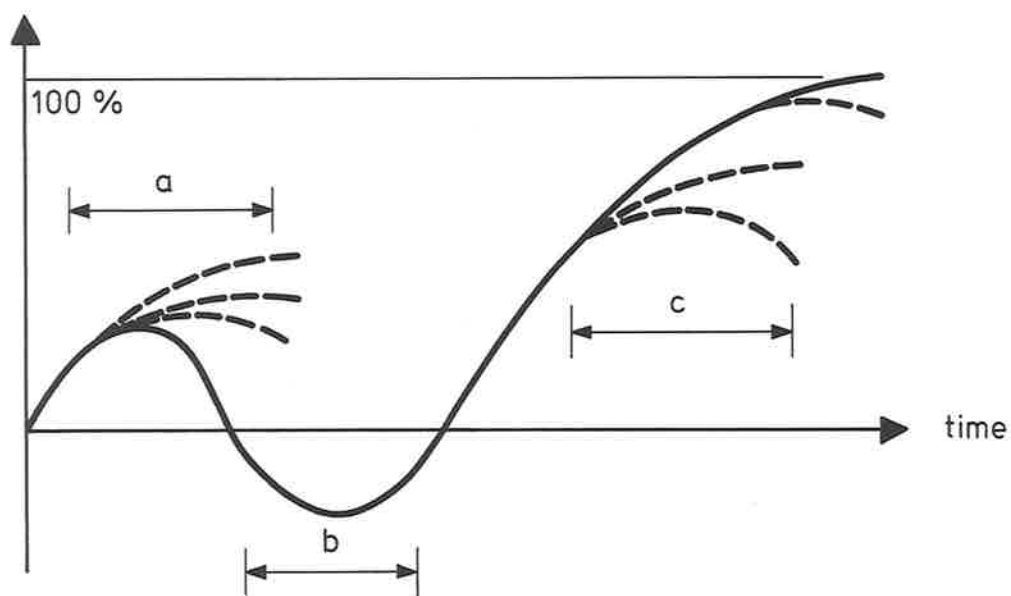
According to findings of the IRI New York (1972), acquisition in chemical industry in the US has been rather small in the last ten years relative to total sales. But recently licensing has increased at a remarkable rate. Consultants and employees of chemical companies are touring Japan and Europe constantly. They have the following main reasons for doing so:



Timing for Technology Acquisition During R & D - Process

Figure 9

Maturity of
product / process



a
b
c } possible timing for technology acquisition

Reasons for failure of previous promoter in c

- | | |
|--------------------|------------------------------|
| 1. Lack of capital | 3. No feasible application |
| 2. Lack of experts | 4. Problems cannot be solved |

Timing and Reasons for Technology Acquisition

Figure 10

1. Present economic climate: licensing is surer, less risk.
2. To get technology which is already in existence.
3. Many companies that would not have licensed several years ago will do it now as one way to get additional funds.

A survey has shown that two-thirds of the IRI companies present at a specific seminar had formal license-seeking groups. One third of them were created in the last two years. These licensing groups report either directly to the president, to the patent department or to the corporate marketing vice-president.

My exposé was mainly directed to new developments of such industries as metallurgy, metals transformation, machinery, electrical equipment, cars and heavy chemicals, therefore not so much to industries that are very research-dependent like pharmaceuticals. The industries which I have named are, in the coming years of the seventies, more development than research oriented. If a company of this group wants to diversify or to establish activity in a new advanced technology, it can, to a certain extent, rely on acquisition of technology as a supplement to their own research. But remember that the sector II, which is mentioned in figures 1 and 3, needs trained research people because of the "leverage". So you always need experienced personnel in the research department to judge and to further develop the acquired "new" technology. Therefore technology acquisition has to be well balanced against in-house research. Technology acquisition can very well provide strength and success to a number of industrial R & D groups.

Figure 11 gives finally a schematic description of the innovation process, consisting of six subsequent steps. A successful innovation is therefore one, which reaches stage VI with a positive cash flow.

The main element of technology transfer is not to have all six steps carried out in the same organization or company. Preferably, a technology acquisition is carried out towards the end of the process, between stage III and VI.

Government agencies recently insist, for instance in Germany and the USA, that federal research subsidies should lead to innovations, therefore the subsidized program should be carried on until stage VI. This often requires technology transfer between a research organization and a production company approximately in stage III or IV (or close co-operation already much earlier).

But also industrial companies are nowadays pushing harder to find profitable items resulting in successful innovation by technology transfer.

Cash Flow

innovation process

+ (income)

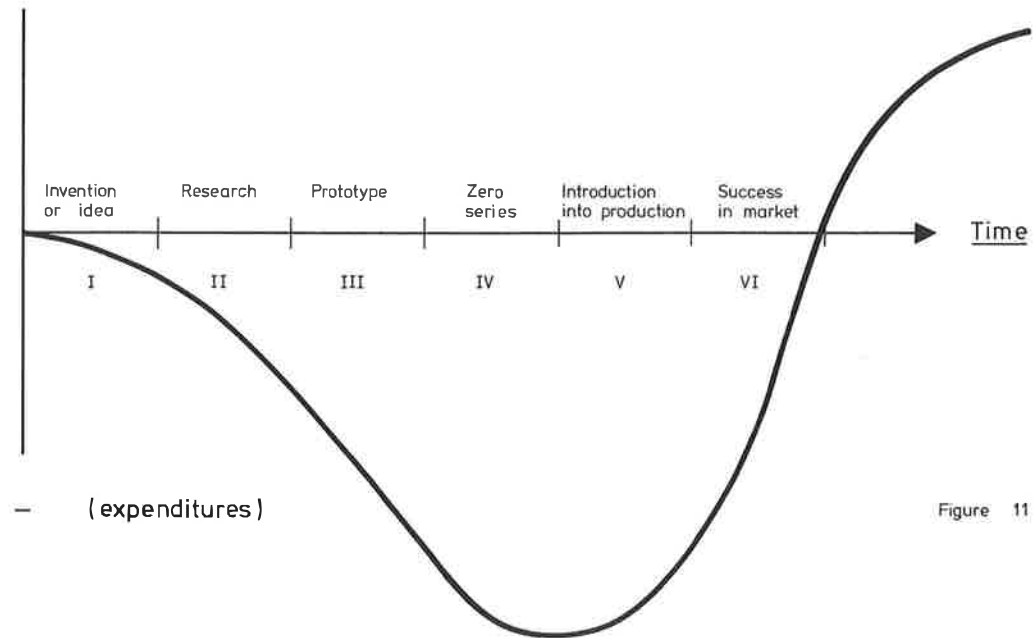


Figure 11

DISCUSSION

Question

Although I belong to a company who has implemented what the speakers have described this morning in every detail and although I have indeed contributed to the development of some of the techniques and am operating them successfully, I was most interested by their presentation and most gratified by the thoroughness with which it has been presented. I feel that I might be of some use to this audience if I say something about what it feels like to have the worm's eye view of the stripe of operation and organisation, what it feels like to be someone who has to operate the system and try and make it work. I think the most important factor I would draw attention to, is that if technology transfer is operated properly, there is an enormous work load on the managers who operate it. Good communications in practice means a very large amount of committee work. I myself am a full-time member of five committees, and I report at least to another five. Just work this out on the basis of monthly meetings and you can sit down and write out my diary pretty accurately. Since I am also a working scientist, this makes it rather difficult to do creative work.

Secondly, on the point of Dr. Pearson's how ideas are transferred. I think that the good operation of technology transfer depends not only on establishing the right organisation, but also on establishing the right personality mix. I have seen many technology transfer actions collapse because they were established by decree between individuals who were unwilling to co-operate. Such pressures will often demotivate people from working together and encourage them to work elsewhere, something which under a great deal of pressure of work is frequently justifiable.

One final point, which perhaps did not come out clearly, although I am sure the speakers would agree with me. They have stressed that R & D in a particular organisation must be able to evaluate outside ideas and contribute to them. I would take this a little further. I think R & D must be continuously working in the areas which are of interest to the company and to acquire, what we call, 'scientific capital'. If a problem arises, it is far too late to start working on it. If you have not been in the area for some years already, you are going to be ineffective. Therefore, if a company can afford it at all, the R & D effort must be continuously maintained to do fundamental or fundamental applied research in an area which will build up the scientific capital in the topics of technology of most interest to the company.

Finally, a question to Dr. Pearson. He mentioned 'new ventures' activities and in the way he drew it on his diagram, it seemed to be outside the R & D function. Now, there are arguments for having it in R & D and arguments for having it outside R & D, and I would be most interested in the views of Dr. Pearson.

Answer

(Pearson) I mentioned that about half the companies we have been discussing - and that is a large group - had 'new ventures' activities. I think that the balance of having them in R & D or outside, was slightly in favour of outside. It is very difficult to assess performance, but I think the general opinion is that those outside R & D are operating a little bit more successfully than those inside R & D. But, of course, that depends on how you define success. Those outside, tend to be working in a wider field, the ones working in R & D tend to be rather more constrained by the existing technology, and secondly, do not appear to have the same power to exploit. They do market analysis, they suggest areas that might be developed, they investigate whether the technology is available and whether there is a potential market. But with 'new ventures' groups outside R & D, you actually see them going ahead and doing it. There is evidence that more products and processes have come out of 'new ventures groups' outside R & D than inside ones. But the sample is not large and does not allow of definite conclusions.

Question

As far as the pharmaceutical industry is concerned, one key element of a programme of product acquisition is the availability of products for exchange, products that can be used in negotiations. In our experience, a firm sometimes is willing to offer a product only if it gets another product in return by licensing, instead of receiving money. This is an important fact, because it points out the importance and value of own R & D. You can only acquire a new product in this way on the basis of your own R & D capability. I think it is necessary to emphasize this, because in discussions about product acquisition versus in-house R & D, these two processes for acquiring a new product are often seen as inimical, rather than as complementary. I think that both ways for acquiring a new product should be seen as synergetic, as in-house R & D and technology transfer can lead to the same result: a new product. But this will have an influence on the research objectives; if you accept exchange of products as one of the forms of technology transfer, then you must have a set of compounds that can be offered to interested parties. This also leads to a spreading of the risks. And it is easier to evaluate a new product if you can fall back on your own and licenced products. I would like to hear the opinion of Dr. Pearson and Dr. Altenpohl on this.

Answer

(Altenpohl) I agree. Pharmaceutical and chemical companies should maintain a strong research division, not only for safeguarding their own position, but also for swapping products and processes. There seems to be a tremendous market in this field. I have been surprised to hear that in the United States virtually all large chemical firms have licence seeking and licence offering groups traveling all over the world. This is a quite new development, it did not exist even five years ago.

(Pearson) Yes, I do agree. I have one point to make, and it may be somewhat theoretical, but it has practical implications. If you are in an area of very high uncertainty - and the pharmaceutical industry is in that area - the probability of success is very small and the funds that have to be invested are very high indeed. Then swapping technology, products and processes tends to lessen the risk.

In the past many firms wanted to exploit the results of their own R & D, but there has been a change here. For if you are in a field where the degree of success is very low, there will be many periods of time when there is nothing, and suddenly you will have two or three things together and you cannot exploit all of them. Then you must be prepared to buy your technology during the lean periods and to sell it outside in the other situation. This policy enables you to stabilize your cash-flow position.

Question

At a rather similar conference that I was attending recently, Prof. Jevons gave the first paper, and he said: Science is the acquisition of knowledge. Here I would like to bracket science and research. Now technology, which I regard as possible development, can be defined as "the capability to do things". In other words science or research does play a strong supporting role, but not, necessarily, an initiative tole. Scientists respond to problems presented to them, they do not necessarily generate the project, but are able to promote its further progress by the introduction of innovative ideas. Would you like to comment on these points?

Answer

(Pearson) I think the whole of the innovation field is bedevilled by the fact that for every single case which gives you some rule, there is another one that gives you other rules. The Pilkington case, for example, does seem to be not untypical of technological developments. Here the engineering and technological side came first, but R & D played a significant part at a later stage, when problems had to be solved. And the engineering and chemical industries accept that many developments start in a fairly prag-

matic way, but that you have to look at the basics of it, in order to optimize the conditions and to improve the efficiency as such. But there are certain cases, like in the pharmaceutical industry, where it is the other way round. There the markets are well defined, you know where you can sell drugs and there are strict rules. The stimulus has to be creativity in innovation in the R & D department. It is from there that you take the ideas and you put them through very extensive process development and testing procedures.

So I would not disagree with Prof. Jevons, but say only that different industries have different ways in which they operate.

	Original plants (tons per annum)	Current economic size (tons per annum)
Epoxy resins	1 000	20 000
Polystyrene	5 000	25 - 50 000
PVC	5 000	> 100 000
Polypropylene	5 000	50 000
Polyethylene	1 500	60 000
Ethylene oxide	10 000	100 - 150 000

Table 1

Is it cheaper to buy a process than develop one's own?

Dr. A. M. Thrush
Shell International Chemical Company
London
Great Britain

You will perhaps have noticed that the title of my presentation has changed somewhat during the various editions of the programme, sometimes it is: "It is cheaper to buy a process than develop one's own", and sometimes it is: "Is it cheaper to buy a process than to develop one's own?"

This apparent uncertainty sums up pretty well our own experience in this field. I have recently looked back through the history of various developments in my own company to see whether there are any general guidelines to be deduced from our experience. The obvious thing which seems to come out clearly is that it all depends upon the question "At what stage in the development of a new product or process do you wish to enter the field with a commercial plant?"

If one plots the cost of development against time one gets the familiar "S" curve, i.e. at the beginning of the development the research expenditures are relatively small and then as one enters into the fullscale development stage they rapidly increase, flattening out again later as the project comes near completion. If one wishes to be in with the commercial exploitation at an early stage in this development then there is no way of avoiding very substantial research and development effort, and it makes no difference in these cases whether the idea originated in one's own laboratories or whether one acquired the invention under licence from a third party. To illustrate this point, let me give some examples from our own experience. I would like to stress that I have confined my examples to our experience in the chemical field which, of course, is highly research oriented and maybe the conclusions would not be completely applicable to other fields.

Not that I want to suggest that this sort of development curve only occurs in relatively young industries. Although an industry as a whole has reached a very mature stage it is quite possible for a new development in that industry to have its own "S" curve. This frequently happens in the petroleum industry and even in an industry as old as glass the development by Pilkingtons of their float glass process shows that new "S" curves can start in very old industries. The fact that Pilkingtons are currently earning many millions per annum in royalties, shows how important a development is was. But to return to our own experience in the chemical field.

Firstly, where we have "bought in" an invention at an early stage of development. Any large organization must, of course, always be on the lookout for any inventions arising either from small inventors or small companies who do not possess full capabilities either for technological development, marketing or raw material supply position to exploit fully their ideas on a world-wide basis.

Naturally, we, just as I'm sure most other industrial organizations, are subjected to a constant stream of offered inventions - perhaps as many as a hundred per year and only one or two of these have any real chance of getting off the ground in a substantial way. Nevertheless, from time to time one has the opportunity of acquiring a licence under an invention which fits with one's own capacities for further development. However, when such an opportunity does arise one can usually only acquire the undeveloped basic idea which, hopefully, will already have been protected by patents, and one must be prepared to invest in considerable further research and development to bring the idea to commercial fruition.

Looking back, we can see that we have successfully done this in the field of epoxy resins, where we took a licence in 1947 under the early work of Devoe & Raynolds, which was predominantly on the use of epoxy resin in the surface-coating field.

Devoe & Raynolds was an American Paint & Varnish manufacturing company and, although the principal end use for the epoxy resins was in this field, they felt they did not have the resources to exploit their developments to the full. For this reason, they en-

tered into discussions with Shell Chemical Corporation in the USA, who were in a much better position to manufacture epichlorhydrin - one of the starting materials - and, in fact, already had some of this material available from the manufacture of synthetic glycerine.

Perhaps even more important than this, Devoe-Raynolds came to the conclusion that the subject called for much more research and development expenditure to resolve the shortcomings exhibited by the laboratory-made products and to resolve commercial manufacturing problems.

It was in this field that the various Shell companies (including a very substantial contribution from the Dutch laboratories) were able to contribute by being prepared to invest considerable money and effort in the further research and development need, with the result that over the years several hundred patents were added to the original licensed portfolio. Although the royalties paid for this licence for use of these inventions outside the US has been several million dollars, this has been a small figure compared with the additional R & D expenditure that has been necessary over the years in this field.

A similar situation arose in the case of the "drin" insecticides - Aldrin, Dieldrin and Endrin - where the original inventions were controlled by a small American firm called "Versicol", who did not have the capabilities of commercializing this on a world-wide scale, and so we acquired the world-wide rights under licence.

In this case, the royalties were even higher but, once again, the products were eventually a commercial success. However, this success was only achieved after we had expended a very large sum on our own research and development effort in the field of development of the manufacturing process and of agricultural and toxicological trials. In neither of these cases were we actively looking for the type of invention which we acquired and, of course, it was no criticism of our own research organizations that we had not developed these ideas internally but any large organization ought to be prepared to take these opportunities as they arise and to be perpetually on the lookout for this type of process where it possesses the capability of bringing the exploitation of an invention made by a small organization to a profitable conclusion.

The great difficulty is always to be able to select the idea that has real commercial potential from the hundreds of ideas which are on offer from outside inventors. Of course, the original invention may not have originated from a small company and I suppose polypropylene is an example of this, where the patent covering the basic invention was licensed to several companies who then proceeded to spend considerable sums of their own research and development money on the further development and commercialization of the original idea. At the time we took this original licence in 1955, polypropylene was a new plastic and very much remained to be discovered about its economic manufacture, its various applications and the properties of each grade required for each application. Once again, it was necessary for us to mount an extensive R & D programme, leading eventually, as you may know, to our erecting several manufacturing plants in various countries. In this case too our R & D expenditure was large compared with the royalty payments, even though these were high.

Now, of course, polypropylene has reached a much more mature phase in its development and several companies are offering their process for licence. This means that nowadays a new entrant into field can purchase commercially proven technology and a mature product range for a royalty that will probably not exceed, say, £ 2 million for a large-sized modern plant.

I have looked back at our research and development costs in this field and find that they have been an order larger. It is therefore clear that it would not make economic sense for a company or country wishing now to enter into the polypropylene field to try to independently develop their own process when the complete technology is available for a fraction of the original development costs. (However, the new entrant following the licensing approach for a performance product like polypropylene should realize, however, that it will probably prove necessary for him to "up-date" his product range in the course of time; the know-how for this he will either have to acquire from his licensor or obtain through own R & D).

We can see that the same sort of situation also exists in similar products that we have

developed in the polymer field, such as polyisoprene or SBR rubbers.

Similarly, in the field of ethylene oxide manufacture, we sell our process at only a fraction of our cumulative R & D expenses in this field.

This brings me on to those cases where we ourselves found it possible and economically attractive to purchase commercially proven technology rather than carry out our own development work. In these cases it is clear that what we were interested in acquiring was not so much the innovative idea but rather the commercial experience gained by having operated a full-scale plant and product line, i.e. we were wishing to manufacture a product which had already reached the flat part at the top of the "S" curve. This was the case where we purchased the British Petroleum Licence for Phenol manufacture and the Nitric Acid process from Montecatini-Edison. In both of these cases, completely proven designs were available and experience had already been gained in large-scale operation of the plants in other locations; furthermore, both cases concerned "specification" products. We calculated in these cases that the royalties we were asked to pay were considerably less than the estimated cost of developing similar processes ourselves.

With the benefit of hindsight, we still believe this was the right decision.

There is another intermediate series of examples where we bought commercially proven technology but still found it necessary to continue our own research and development work, i.e. we purchased at a point before the S-curve had flattened out.

Thus, for example, we took licences for the manufacture of both High Pressure Polyethylene and Polyvinyl Chloride. In both cases there had been commercial experience of the processes on a large-scale and we no doubt paid at the time less than it would have cost for us to have repeated the development - not to mention the perhaps more important aspect of the time that was saved. But, nevertheless, at the stage at which we took the licences, the products were not so mature that further development of product requirements had ceased and so we have had to maintain an R & D effort to keep ourselves up to the developing market requirements.

Our experience has therefore been that if we wanted to enter the commercial exploitation at the early stage, the option was not open to us to buy a completely developed process and therefore it was inevitable that this large R & D expense should be incurred. If, however, we wished to enter the commercial exploitation at a stage further along the "S" curve, when the product or process had reached a mature stage, then it is in our experience almost certainly cheaper to buy a commercial process based upon a third party's commercial experience than to start late in the game and develop one's own process. At an intermediate stage in the "S" curve, it is cheaper to buy a process, but one must supplement it with own R & D.

We have found a few exceptions to this where we have been able to use our particular expertise in a special field to develop a process to match an existing process available from a third party at a cheaper price than the licence fee, but these are rather exceptional cases and they are limited to areas in which we had already built-up a very substantial background knowledge and really it is then a question of adapting this knowledge to the specific requirements of the new process. Moreover, they were cases where the licensor did not have real full scale experience of the process we needed, and so we could not avoid some R & D for the modification of the process.

From the comments I have made above, you might get the impression that our research is always successful but, of course, I have perhaps no need to point out, the greatest risk is not that one will spend more on developing a process than one would have had to spend on buying the process from a third party but that one will spend a lot of money and effort on research and not end up with any commercially useable results. This may, of course, happen if one had been unable to solve the technological problems but an even greater danger is that by the time one has finished one's development work, the original objectives no longer fit the commercial needs of the current situation. I can, perhaps, give two cases of this in our own experience:

Firstly, the process for the manufacture of butadiene from n-butene by oxidative dehydrogenation using iodine. When we started the development of this process it seemed a very promising route to obtain low-cost butadiene and, after much difficulty and effort, the technological problems were more or less solved but by this time butadiene

had become available by extraction of naphtha cracker streams to a far greater extent and at a far lower cost than had been anticipated, which undermined the whole economic need for the dehydrogenation.

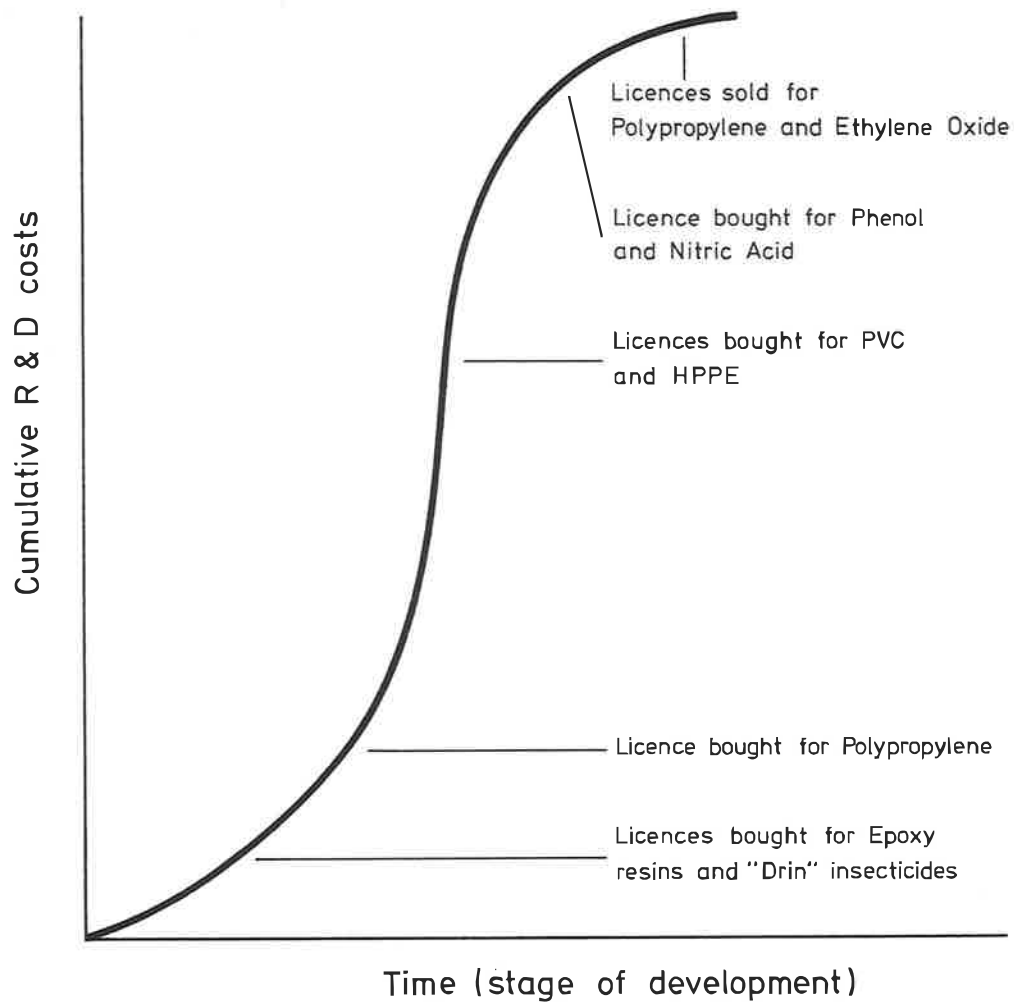
Another case was the development of the Shell Chlorine Process, which was a modified Deacon Process designed to overcome a problem of excess, not easily utilizeable, hydrogen chloride. After much money and effort had been spent in developing this process, the problem disappeared simply by an alternative outlet arising for the hydrogen chloride. Once again, there is a strong advantage in buying technology, because you do not have to buy it until you need it and therefore the chance of buying something that you don't in practice need is remote, whereas research expenditures has to be incurred several years before the commercial need is confirmed.

Of course, some people might be tempted to think that it must therefore always be better to avoid this waste of money on research and development and not enter fields at a very early stage but to wait until they are more mature and then buy the technology. I have from time to time heard that view expressed in my own organization. But it is not as simple as that because, although if one enters the field at an early stage one takes a great technological risk, if one enters a field at a later stage there are other types of risk. Thus, for example, the technology may be completely proven and one may be able to buy for a reasonable sum a more or less trouble-free process, but at that stage there will certainly be much more competition from other products and it will almost certainly be necessary to construct plants for a large scale to be economical in the advanced stage of that technology. The table gives some examples.

This will necessarily involve the investment of very large sums of capital and thus involve larger financial risks, even in a technologically risk-free area. Nevertheless although there are obvious advantages in being in at the early stage of a development of new products or processes, for those companies or countries wishing to enter a field at a late stage it obviously does not make sense for them to attempt to redevelop for themselves processes already available elsewhere and they are far better advised to buy the technology and devote their research and development efforts to the development of newer processes or products not yet available from other parties.

May I conclude by saying that I believe that it is the role of the licensing man to try and make the statement: "It is cheaper to buy a process than develop one's own" true. And I believe that an increase in the flow of technology under licence would make a positive contribution to society by preventing undue duplication of effort in the R & D field.

Just as the second-hand car salesman - no matter how reprehensible you may find him - performs a useful task of preventing cars being merely discarded when the original owner wants a new one, the licensing man also prevents waste of technological effort - with the added advantage that the original owner can continue to use the technology even after he has sold it.



Graph showing points on the usual development curve at which licences have been bought or sold

Figure 1

DISCUSSION

Question

I would like to know: How is your licence balance? Do you spend more or do you earn more.

Answer

Well, as a matter of fact we earn more than we spend, and in our annual reports we are tempted to boast about this. But I think that really, you should not compare this, you should never take your income from licensing and subtract the sum you have to spend as a licensee. You really should add them together, because this sum is a measure of the utilization of technology.

Question

There is something that I have missed in your presentation, and that is the influence of your sales organisation. If you are diversifying by buying new technology, this means that you will have to handle in the near future a number of new products. If you have a good sales organisation or one that can be enlarged rather easily, you can afford to buy your new technology rather late. But if you have to build up your sales organisation also, it seems to me that you will have to buy rather early. Do you agree with that?

Answer

Well, we are in the first situation. We have a large sales network and for us it is usually a question of adding new products to an existing network. But if you have not and if you have to build up your sales force, this does not mean necessarily that you have to buy rather early. It is usually possible, and often your licensor will welcome it, to enter into a pre-supply arrangement. You arrange to buy your technology three or four years hence and in the meantime you start to sell the product of your future licensor. Of course you have to plan this rather carefully, but you still can buy a mature process.

Question

I take your point that licensing can reduce your technological risk. But there are other risks, and I can think of a number of cases where there has been litigation between licensees and licensors. Some of these processes were not very successful and some can only be described as a near disaster. So I think that you do not always ensure permanent happiness by licensing.

Another point I want to make, is that if you do your own research, the profitability is much greater. The early people in polypropylene were able to charge much higher prices and make much greater profits than those who licensed later and built their enormous plants.

The last point I want to make, is that your own R & D can make existing processes obsolete. When a firm went into making phenol from cumene, there were very good phenol processes available for licensing. But they chose a new route and inadvertently made all other processes obsolete.

Answer

I quite agree with the first part of your remarks. Licensing can reduce your technological risks, but there are other ones and you cannot avoid them all. Your remark on profitability sums up, I think, the point I wanted to make. I think that buying a process is cheaper than developing it yourself, but I did not say that it is more profitable. Usually, it is not. If you are in from the start, you have two advantages. You don't

have to build a larger plant and the table at the end of my paper did show just that. Secondly, the price of the new product tends to be rather high for some time, and in this way you recoup your heavy investment in R & D. The curve that Dr. Altenpohl showed, is, I think, quite illuminating in this respect. But I do think that buying processes and licensing does have a place. At the risk of abusing my own profession, I have likened the license man to a second-hand car dealer. You may not like them very much, but I think they have a place in society, and I think that it is the job of the licensing's department to see to it that technology is widely used, rather than thrown away or not exploited in certain areas.

Question

I have a question about the S-curve you showed. What exactly do you mean by costs, does that include the costs of commercial introduction of a new product?

Answer

No, it are only the development costs, but these can include the manufacture of a pilot plant, and that is of course one of the unprofitable elements. And this is why, at the end of your R & D sequence, costs are going up steeply, because there you have to erect your pilot plant and to do your trial marketing.

So you do include trial marketing in you total costs?

Yes.

The role of foreign technology in Japan's development in the post war period

Mitsuya Okano
Manager of Foreign Department
Sumitomo Chemicals Co. Ltd
Osaka
Japan

Mr. chairman, ladies and gentlemen:

It is very pleasant being back in Rotterdam again. And I am especially honoured to have the opportunity to share this platform with so many distinguished speakers. When I looked at the title of my paper, I remembered something of my past days. I entered the company in 1949, 4 years after the end of World War II. In those days when I was told by my superior to make a trip to Tokyo from Osaka, I had to reserve a place in the train a few days in advance. Seldom reservation of a seat was possible. All what we tried to do was to buy a ticket and to get on the train somehow. The car was so jammed that the people got in and out through the windows. It took 14 hours to go to Tokyo and I sometimes had to stand on my feet most part of that 14 hours. But a young man as I was I still liked to be ordered to go to Tokyo. Now the bullet trains do Tokyo and Osaka in 3 hours and 10 minutes and they leave Osaka at every 20 minutes. Comfortable seats are guaranteed in air-conditioned cars and I must go to Tokyo at least once a week and I hate it.

There has been no time as now when the people in Japan have lost so much confidence in making forecasts. Things change so quickly and so drastically that what was true yesterday is no longer applicable to today's situation. If I had been standing here on this platform two years ago, I probably would have started by saying how fast the Japanese economy was growing and how greatly we were embarrassed by an unduly large foreign exchange reserve. But the Japanese miracle of economic growth is already a story of the past. I believe everybody knows that, compared with the majority of industrialized world powers, Japan since the war has experienced a very remarkable growth. During the decade of the sixties, yearly figures of 11 to 15 percent growth were fairly common. Businessmen, economists and commentators tried to explain why such a high growth rate of the economy was possible for Japan. Some said it was because the Japanese people are diligent and hard working or because their educational level is high. Others said it was because we had very clever bureaucrats and their well planned policy guided the economy in the right direction. Some western scholars said with a light tone of envy that it was because there had been a very close and co-operative relation between the Government and industries.

High capital investment

I agree with most of those observations, but if I am asked to indicate only one factor which contributed the most to such a high growth rate, I would choose the high rate of capital investment as the primary factor.

In the years from 1965 to 1970, investment into fixed assets in Japan increased at an annual average rate of 17.4 %. In comparison the figures for other countries include the 2.5 % of the U.S., 3.6 % of the United Kingdom and 4.3 % of West Germany. To finance such rapid increase of investment, Japanese industries had to rely heavily on borrowed funds. You may be surprised to hear that the rate of owned capital as against the total assets of the corporation, averages only 20 % in Japan. Before the war it used to be at around 60 % and it is also around that level in the U.S. and other western countries.

Increases in capital investments however brought the following effects:

First, it increased the effective demand. Due to such vigorous capital investment, the

demand for steel, cement, machinery, etc. increased rapidly. To produce more steel, more cement and more machinery, they invested more money to expand their plants. Secondly, vigorous investment created more jobs and increased people's income. This, in turn, created more demand for consumer goods.

Thirdly, the high rate of capital investment enabled us to promote the change of the Japanese industrial structure. As living standards increased, consumer emphasis shifted from food to clothing and then to housing. In the industrial sector, the emphasis shifted from light industry to the heavy and chemical industries. New investments were generally directed toward the sector which was expanding the fastest, and the sectors in which international demand was high. This was possible because the rate of investment was high.

Fourthly, vigorous investment into the growing export industries increased productivity and reduced production costs. This boosted the international competitive power of Japanese industries. Let me cite the example of steel. In 1952, to produce one ton of Steel it required 6.03 man hours in Japan. By 1962, the figure had been lowered to only 1.86 man hours.

Thus Japan was able to acquire more foreign exchange. This, in turn, enabled her to undertake further plant expansions. This resulted in a sort of multiplication effect and the growth of the Japanese economy was boosted to a very high tempo.

Why has capital investment been so high in Japan? A prime factor was rapid technical innovation by Japanese industry. When there are rapid technical innovations, management must invest in new, better facilities to produce new and better products, as otherwise it would not be able to meet competition. Thus, Japan's investment boom was also paralleled by a great technical innovation boom.

In short, the pattern of development was, that the rapid technological innovations induced high capital investment and in turn boosted production, reduced costs, increased foreign exchange earnings and boosted the Japanese economy.

In such post-war boom of technological innovations, the most characteristic feature was a vigorous introduction of foreign technologies.

Japan joined the society of industrialized nations during the Meiji revolution in the latter part of 19th century and ever since has continued to introduce foreign technologies. Power stations, radio's, automobiles, trains and almost all industrial products were introduced from abroad. Even the first war-ship of our navy was one bought from England. At the beginning of World War II, Japanese industrial technology had come up fairly close to the international level. However, Japan had been isolated from the western world for about 10 years, before and during World War II, and in the meantime there had been remarkable progress of technical innovation in western countries while in Japan there was practically no progress. As soon as the war ended, Japanese industries rushed to introduce the advanced foreign technology to catch up with the western nations. The technologies which were introduced after the war, were the most advanced ones available in those days. Due to the devastation of industries by war, the companies could build new plants on open land, which were based on such modern processes. They had not much to lose even when they totally discarded old facilities. Devastation of plants by war was unfortunate for Japan, but from the point of view of promotion of innovations, at least it made that easier and it even may have been fortunate. Not only novel processes, but also novel products have been introduced in Japan by foreign companies, such as electric washing machines, television sets, transistor radio's, electronic computers, petrochemical products etcetera.

Innovation also occurred in export industries. When world demand for cotton textiles leveled off, the Japanese invested money in plants for rayon and synthetic fibers. When new products, such as transistor radio's, tape recorders and television sets came on the market, they rushed to expand their plants to produce these new products. According to Japanese Government statistics, of the total value of goods manufactured in Japan in 1972, 40 % was accounted for by products which had been introduced after the end of the war. This ratio was even higher in electric industries and chemical industries. It was 50 % for electrical plants and nearly 100 % for petrochemical products.

By far the majority of these new products and processes came from abroad and they were in the sector which was the fastest growing in postwar economy. In the period from 1950 to 1960, when the Japanese economy was in the stage of rapid postwar development, the average rate of growth of all manufacturing industries was 21 %. Whereas the output of the products, manufactured by the processes introduced from abroad, increased at the phenomenal rate of 72 % per year.

This is a good proof that the introduction of foreign technology was one of the major driving forces of the postwar economic development of Japan.

A small electric company in Tokyo, employing 500 people, was making tape-recorders in the late 1940's with annual sales of a quarter of a million dollars. They had discovered the possibility of application of transistors to radio's, so they introduced the semi-conductor technology of Western Electric Co. In 1955, this company introduced their first set of transistor radio's on the market. By the late 50's their sales were already 10 million dollars, and last year they sold one billion dollars of all kinds of electric goods. The name of the company is Sony.

All the major Japanese transistor manufacturers started their business by introducing the knowhow of Western Electric, RCA, GE, Philips, etcetera. Although they started production 6 years later than their licensors, their total production of transistors surpassed the total of any country by 1959 and now they export about 80 % of their output. Television is another typical example.

When Japanese industry desired to go into this promising new field, they found that most of the basic patents on TV were in the possession of RCA, Westinghouse, EMI and Philips. Japanese industries licensed the patents and knowhow to go into this field. More than 60 cases of licence agreements have been entered in this field in the period from 1951 to 1961.

Toyo Rayon Company started to study synthetic fibers during World War II. The studies were conducted under the disguise that they were studying plastics for aircrafts, because the Japanese military government did not like to see any research efforts going on in fields other than those related to military purposes. As soon as the war was over, Toyo put the results of their research into practice, and by 1948 they had constructed a plant to produce socks made of a polyamide fiber, which was slightly different from Du Pont's nylon in its molecular structure. But in 1950, only two years later, they made an astonishing decision. It was the most significant management decision ever made in their corporate history, I believe. They abandoned their own process of polyamide fiber and introduced Du Pont's nylon technology by paying as initial fee a lump sum of 3 million dollars, in addition to 3 % royalty.

When you consider that the total annual sales of Toyo Rayon in that year were only 50 million dollars, you can imagine how drastic their decision was. But the company grew rapidly after that and when their competitors rushed to get into this field, Toyo was already the leader and the largest textile firm in Japan. In 1973 their sales amounted to nearly 1.1 billion dollars, and this makes them one of the world's largest synthetic fiber manufacturers.

The Japanese petrochemical industry is perhaps the best example. The Japanese petrochemical industry now ranks as the second largest in the free world. It has a capacity of 5 million tons of ethylene per year. Japan's petrochemical industry came into existence in 1958, when a small-capacity ethylene cracker was installed by Mitsui Petrochemical Co., and in the following year by Sumitomo Chemical Co. and Mitsubishi Petrochemical Co. Between 1960 and 1969, the value of production increased 15 times. The annual growth rate was 35 percent. Thus, the petrochemical industry became one of the key elements of our economy.

But what is striking here, is the very heavy dependence on foreign technology. In the total output of petrochemicals, as high as 92 % are products manufactured using imported technology.

For example, all of our low-density polyethylene is manufactured using imported technology.

The percentage for polypropylene is 91 %, for polystyrene it is 92 %. In comparison, let me cite a few figures of other countries. West Germany makes all its polyethylene by its own technology. All polypropylene and 46 % of styrene monomer are also pro-

duced by their own technology. In the United Kingdom, they manufacture, I think 24 % of their polyethylene and 26 % of their styrene monomer by their own technology.

Why has Japan had to rely so heavily on foreign technology? It is simply because our petrochemical industry started much later than in western countries. When the war ended and the Japanese economy started to take off, the chemical industry rushed to buy foreign technology to catch up with the western world. The quickest way was to buy their proven processes. Have we been right in buying technology rather than developing our own is not my subject today. It has been discussed by the other speakers this morning and I fully agree with their excellent analyses. I only point out that, in the case of Japan, it appears to have been a wise choice because of two reasons. First, we were lacking the foundation on which to develop new petrochemical technology because of the war-time gap. Secondly, our economy was just beginning its come-back, and the companies were short of research funds, and we could not wait until our research laboratories turned out new processes. The figures will prove this. As I said before, starting from practically zero in 1958, we came up to the second position in the free world in just about 15 years.

Such a very rapid growth has come about largely because of the assistance extended by companies in the United States and Europe. As to exchange of technology between Japan and these foreign partners so far, it has been almost one-way.

Since 1950 there have been some 14,000 cases of license agreements with foreign corporations. Of these, about 60 percent were with U.S. companies. The total amount of license fees paid by Japan to foreign countries in 1969 amounted to 430 million dollars. The total license fees received by Japan from overseas licensees in the same year was only 54 million dollars, or 12.5 percent. This ratio is far below the corresponding figures for West Germany and France. They receive on the average around 40 percent and 60 percent, I think.

When we look at it from a different angle, the ration of license fees paid by Japanese corporations as against the total disbursement of R & D expenses has been at around 15 % in 1950s and early 1960s.

However I shall not be fair if I don't mention the technological innovations made by our own industries.

There are numerous instances in which Japanese firms have developed improvements and sold such improved technology to other countries.

An excellent example is seen in Japan's steel industry. As in the case of most of Japan's industrial capabilities at the end of the war, steel capacity was meager, only 1 million tons per year. Today the industry ranks third in the world and has an annual capacity topping 100 million tons. Japan's steelmakers have developed many improvements in the various ironmaking and steelmaking processes. Today, Japan's steel-making technology ranks with the best anywhere, and the industry leads in several sectors. Among these are basic oxygen steel, use of computer control, capacities of blast furnaces and preparation and handling of steelmaking raw materials.

Japanese automobile industry is also one of the fastest growing industries in Japan. Although it is not comparable in its size to the big three of the U.S. or Volkswagen, they are a major supplier of automobiles in the world market. And here the development of technology came out of their own research laboratories. This is mainly because the famous Japanese bureaucrats did not open the door of the Japanese automobile market to foreign big business and tried to foster the Japanese car industry by the principle of self-reliance.

Perhaps our greatest pride is the bullet train of the New Tokaido Line. The trains run at a normal speed of 210 kilometres per hour under automatic and central train control system and they have not had even a single casualty in the past 10 years.

The licenses of Japanese technology to foreign companies are gradually increasing in number and fees received. The ratio of 12.5 percent which I have just quoted compares with an average figure of only 8.4 percent for the period 1950 - 1969, and the figure is now increasing by about two percent a year.

Now let me touch briefly on the more recent situation. Here I will sound like a pessimist. The growth figures which I have quoted and the rosy prospect of Japanese econo-

my lasted only until the end of the sixties. The Japanese people have been concentrating their efforts on rebuilding industry and expanding their materials affluence during the past two decades and a half. The young but small Japanese giant, symbolizing Japan's economy, started to grow at a remarkable pace. However, as he grew, he began to cast larger and larger shadows. The shadows portended rather ominous signs of unwanted side effects of a too-fast industrial and economic growth. Some of our wiser leaders, several years ago, began sounding warnings about the overly fast economic growth. However, most of the people did not listen.

First of all, the rapid growth of Japan's exports had caused friction and led to protectionism and talk of quotas in some parts of the world. The great imbalance of trade triggered two revaluations of the Yen within two years, amounting to a total of almost 35 percent.

Internally, environmentalists stepped up their opposition. Although our total land area is 10 times larger than Holland, nearly 80 % consists of mountains and we have ten times as many people as Holland.

You will no doubt have read of cases of severe pollution of the atmosphere or of mercury poisoning of fish and shellfish. The government policy is giving priority now to the rectification of such undesirable side effects.

As a result it has become extremely difficult to obtain the permission of local governments for expansion of plants. The opposition of local residents is so strong that the construction of thermal power stations is now greatly behind schedule. Last year, the power companies could start only 11 % of the construction work which they planned to start for that year.

Another serious domestic issue is inflation. The rate of inflation has accelerated since the beginning of last year and by autumn it had become a very serious one. Just about that time the oil crisis broke out and brought further complications. The government took emergency measures and postponed expenditures for public spending, raised the official discount rate and enforced a very tight money policy. But the inflationary trend could not be brought under control.

The increase in the consumer price index in December last year was 19 % higher than in the corresponding period of 1972. This was by far the highest rate of inflation in the world. In the coming spring labour negotiations it is expected that the workers will get an average pay raise of 20 - 30 %.

In spite of the loud talks of oil shortage, Japan's import of crude oil increased by 16 % in 1973. The problem now lies not so much in the quantity but in prices.

Last year, Japan imported 290 million kiloliters of crude oil and paid 6 billion U.S. dollars for it. To import the same amount of oil this year, we would have to pay 6 billion plus 9 billion dollars on top of that. However, Japan's foreign exchange reserves have diminished from a peak of 20 billion dollars in 1973, to 12 billion. As of today, our forecasted trade balance this year will make it most difficult to pay so much for the import of crude oil alone.

It was a great mistake for Japan to take it for granted that we could continue to buy as much oil as we needed at economical prices. About 70 % of Japan's energy output is derived from oil and 97 % of this must be imported. We are therefore trying to scale down the economy but it will be awfully difficult and will inevitably cause serious friction and dislocation in various sectors of our industry.

Conclusion

Now, in concluding my remarks, I wish to briefly summarize by presenting the following points:

1. Foreign technology was the major factor in the technological innovation in postwar Japan;
2. Technological innovation played one of the key roles in the postwar investment boom which was most contributory to the postwar development of the Japanese economy;
3. We are now seeing gradual increase of licensing of our own technologies;
4. The days of very rapid economic growth of Japan have ended. The growth of economy will be much slower hereafter;

-
5. Finally, Japan is on the road of cutting down or relocating labour intensive and heavy energy consuming industries, and encouraging more technology-orientated industries.

As we all know, the Netherlands is world famous for flowers. But in Japan, Netherland is also known as the country which ushered us into the western civilization for the first time in our history. It was as early as in 1609 that Dutch flag fluttered at Nagasaki and 16 Dutchmen stayed there. It was the only window through which the isolationist feudal Japan could peek into the advanced western civilization and it is through such window that we first introduced advanced western technology. It gives me a great pleasure to be able to report to you how Japan has developed since you taught us modern science 3 and a half centuries ago.

DISCUSSION

Question

I was most impressed by the record you gave of the development of Japanese industry. Belonging to a company that licenses processes to your country I would like to say that the co-operation is excellent and that the product you are making is at least as good, if not better, than the one we make.

Now, two questions. When you described the rapid development of Japanese industry, you stressed the importance of enormous capital investment. I would like to know what the bank-rate was in Japan during this period. What was the interest Japanese industry had to pay for borrowing money and was there enough money available at that time?

My second question refers to something that has been bothering me for a long time. I have found out from experience that patenting in Japan is extremely difficult. In fact it is more difficult than in the United States, and that is difficult enough. I wonder to what extent this is a deliberate government policy and to what extent this is considered to have contributed to the technological advance of your country.

Answer

As to the question of the bank-rate, we are now paying from 8 to 11 %. It depends on the risk, low risk borrowers pay about 8 %, when there is a rather high risk the rate is higher. But we have a special deposit rule, saying that a part of the money borrowed should stay at the bank. Mostly it is 20 % of the sum, and so the actual rate of interest is higher than the official bank-rate.

The second part of your question, on patenting, is rather difficult for me, as I am not an expert. But I think that one of the reasons for the difficulties may be that we have a different patent system, that does not acknowledge product patents, but only process patents.

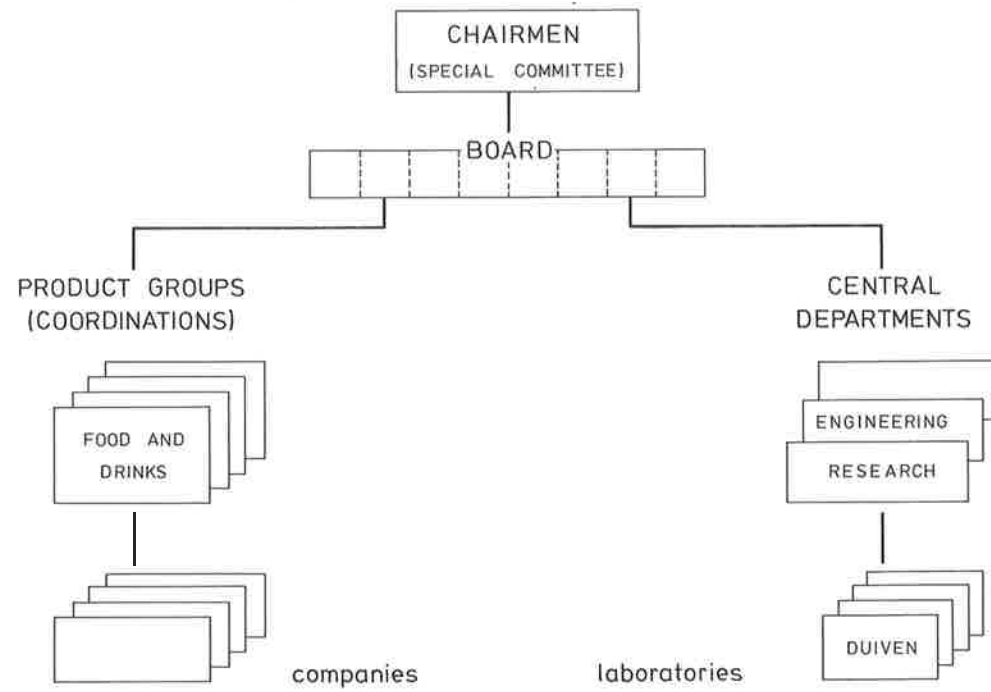


Figure 1

Advantages of increased involvement of factory development staff in R & D project teams

Ir. J. J. Hollestelle
Unilever Research Duiven
Zevenaar
The Netherlands

This paper will explain what we at Unilever Research did to get high involvement of factory staff in the introduction of new processes and equipment into existing production lines. This has not been an easy process and, as a matter of fact, it took us about six years to arrive at a system that works well. I will illustrate it with three case histories which will be discussed in full - including the less successful aspects - as I do not intend to disguise the mistakes we made and the things we did wrong. For what is the use of making mistakes if you don't learn from them?

Let us first have a short look at the organisation of Unilever (Figure 1). The Unilever group comprises a great number of production companies all over the world, and each company belongs to a certain Product Group. Examples of these groups are: Edible fats and Dairy products, Foods and Drinks (incorporating a wide range of food products from frozen vegetables to jam), Chemicals, Toilet preparations and so on. The companies have their own development units. The Research Division is a centralized service department for the whole of Unilever with laboratories in Great Britain, Germany, France, the Netherlands and India. Generally, a laboratory has the companies of one or two Product Groups as its main customers. Every company pays a certain percentage of its turnover to the research fund. If a company has problems, these are first discussed with the central co-ordination staff of the Product Group concerned. Discussions with Research management follow and after that it is decided which laboratory will be assigned to assist the company. My laboratory is at Duiven and operates mainly in the field of Food and Drinks; so my three case histories will all come from this field.

Unilever Duiven should not be seen as a research laboratory only; it is in fact a highly sophisticated development establishment. For solving the problems that are placed before us we use the project system, with a project team and a project co-ordinator. It is quite usual to have specialists on raw materials, quality, quality control, product formulation, processing and engineering in a project team. The Foods and Drinks Product Group touches on so many specialized fields that only a multi-disciplinary approach enables one to reach the research goals in a reasonable time.

The project co-ordinator has overall responsibility for the project, for concluding it in time and within the budget agreed upon. He also maintains contact with the company that has asked for the research and keeps management informed. His counterpart at company level usually is someone from the development staff. Management is informed regularly of progress and should be warned immediately if unforeseen difficulties threaten to cause a delay or warrant an additional outlay of finance. Nowadays we have a number of people from the company on the project team and quite often one of them is the project co-ordinator. This system has not been in existence for a long time and it took us about six years to arrive at it.

To illustrate this, I now turn to my first case study, which will take us back to 1967. The project was concerned with the dosing of chicken meat in canned soups and it originated in Research. We had seen that production companies had difficulties with the dosing of some expensive materials like meat. Some types of canned soups have pieces of meat in them and as a producer you have to see to it that each can contains at least a certain amount of meat. But meat is a costly ingredient, and if you can put this certain amount into all cans and so avoid an overweight of meat in some cans, you are able to lower your production costs. All this may sound quite simple, but actually meat is a vulnerable raw material which is extremely difficult to dose.

In 1967 it was usual for Research to take the initiative and we did this, being sure that we had recognized a rather serious problem and that we could see some possible solutions. So we went to one of our production companies and talked things over with them. They were very interested and told us to start, and Research management promptly provided us with a budget. A project team was formed with no-one from the production company in the team. Then we started the series of steps that leads to the successful completion of a development project. I have to add that when speaking of development in this connection, I mean in all cases the development of a process or equipment or both, and not the development of a product. Figure 2 gives a simplified survey of the nine stages of this project. At the right is the time-scale; the two graphs show the relative amounts of involvement of Research and of the production company at each stage. In the first stage we worked out a definition of the problem and here the company was involved. Then we went back to our laboratory and worked all alone on the next two stages for about eight months. We did a feasibility study, which included a literature search, a patent search and a very thorough search of the market for existing equipment that would do the job. It is a rule that we never develop our own processes or equipment when these can be bought outside. We did a model test, just to get an idea about the complexity of the problem. And we started the design, the building and the testing of a pilot plant machine, and after trials with this we contacted the company and told them of our progress. They wanted a demonstration of the machine, and it was only in the fourth stage of the project that there was some involvement at company level. The next stage was the design of the production machine, and that was done nearly wholly by us. It was only when we had to prepare for the introduction of the new equipment into the production lines that there were regular contacts between the production company and Research. The next stages of acceptability tests, however, was again carried out wholly in Research. For the installation of the new machines we had to rely rather heavily on the facilities the company could provide. We then started the last stage: the transfer of the new equipment to the factory. We attended to a number of teething troubles and then gradually withdrew. The whole project had lasted only two years and we were rather proud of ourselves to have solved a difficult problem in so short a time. We were ready to turn our attention to other projects, but that was not to be for some time yet. We were saddled with this project for another year. There were all kinds of troubles in production, e.g. adjustment problems, and we were sent for time and time again. Some problems turned out to be minor or even trivial, and a research assistant of mine was once sent for because a bolt had worked itself loose. It slowly dawned upon us that people in production refused to accept responsibility for the new equipment, and when searching for the cause of this, we had to admit that our own behaviour was at the bottom of it. We had underestimated a number of psychological factors and behaved like a troop of foolish elephants. There was active resentment towards Research at the factory. People were not angry with us so much because we had solved a known and difficult problem, but deeply resented that they had not been consulted and that their large practical knowledge of dosing had not been used. It took us about a year to get the new equipment accepted, and that of course was a costly lesson. So we readily promised ourselves never to make this mistake again.

In the second case study I selected, we succeeded in avoiding this mistake, but made a number of other ones. This time, the problem came from a production company which had a very successful product on the market, a specially shaped hamburger. The production set-up of the shaping process however, was very labour-intensive and capacity could hardly be increased. Research was requested to look for a solution to the shaping process, which enabled a higher capacity and involved less labour. Moreover, a further requirement was that the hamburger, which was pre-fried after the shaping process, should maintain its shape during frying. This requirement was the real problem that had to be solved as, depending on the alignment of the meat fibres, the shape of the hamburger after the frying process was subject to variations. And solving this was far more difficult than just increasing the capacity. After the project team had been formed, we asked the company to appoint a few of their people on it and they did so readily. However, they did not tell us that their develop-

DOSING OF CHICKEN MEAT

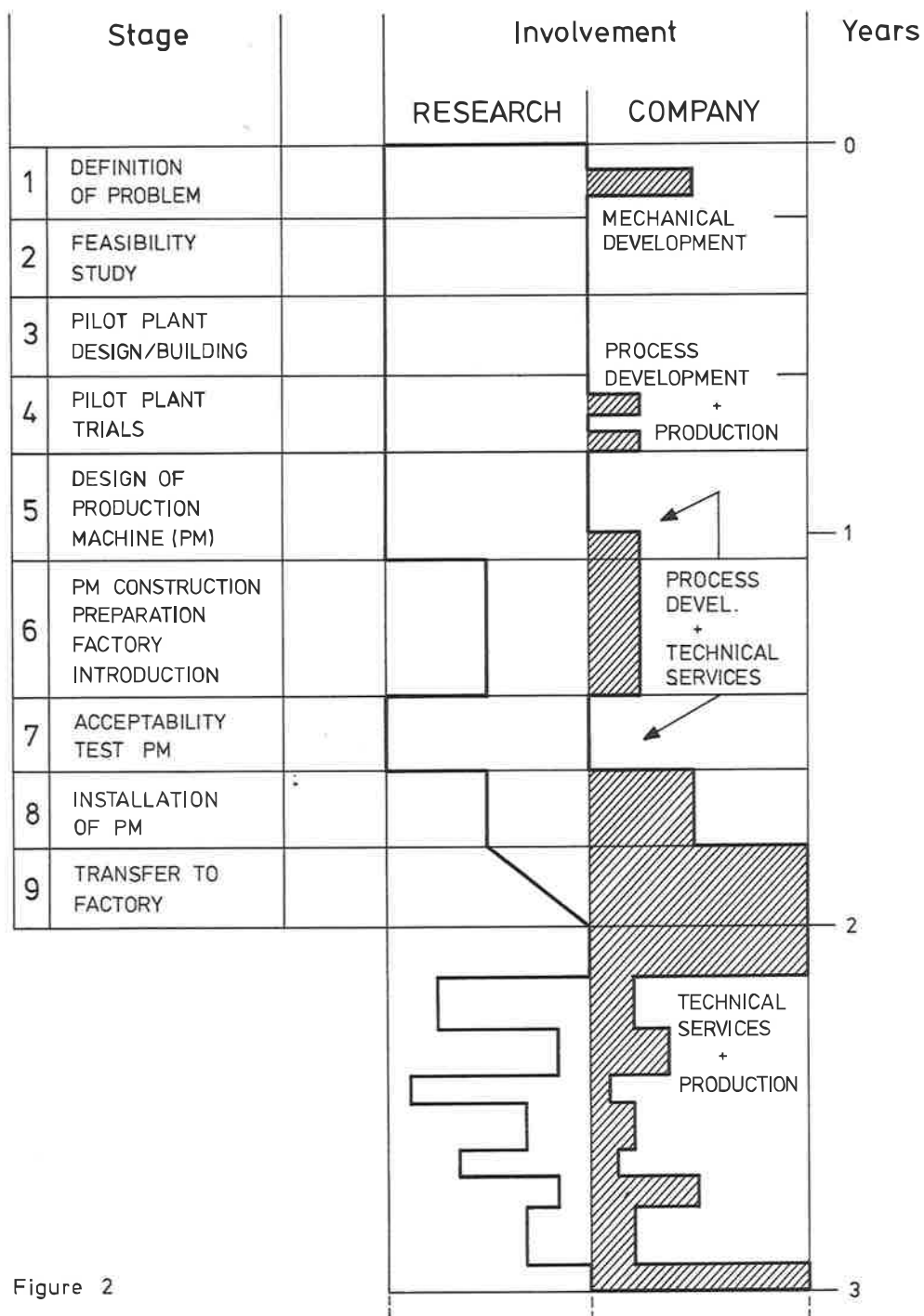


Figure 2

ment unit had been studying the problem unsuccessfully for a year. The company did not put these people in the project team but, for reasons of their own, chose people from another department. So we had the wrong people on our team from the start. However, we did not know that in the first stages and we went on quite happily to find a solution to the problem set. Figure 3 gives a survey of how we did it. Its composition is the same as Figure 2: nine stages of the project with a time scale and the relative degree of involvement of Research and the company. Comparison with Figure 2 shows that we succeeded in getting a far greater degree of involvement on company level. Difficulties arose only when we reached stage 4. We had prepared five shapes, all slightly different, and we were fairly sure that one would do the job. The company started testing these shapes and the people who had been investigating the problem unsuccessfully had a say in this. So it is perhaps not surprising that none of our shapes was deemed acceptable and all were turned down.

The company people who had studied the problem before us, resented being left out and resorted to the well-known psychological strategy of getting their own back. Although that is not nice, it is certainly quite human.

We were a bit surprised, but we went back to our benches and in another five months we came up with eighteen shapes, all slightly different. The company thought that they were all new and we did not tell them that we had put in the original five (see Figure 4; the original set of five are indicated by crossed circles). Again, this was not nice on our part, but it certainly was human! After renewed testing, the company selected five shapes, three of which had been in the original set! Then the central marketing department was consulted and they selected one which would meet all requirements. As the devil would have it, this was one of the shapes in our original set of five. I know that it may sound like high comedy to you, and we have learned to see it as such. But at the time we were absolutely furious. Five months of research were shown to have been superfluous, and in the meantime the company was incurring unnecessary costs due to lack of a good machine for forming hamburgers.

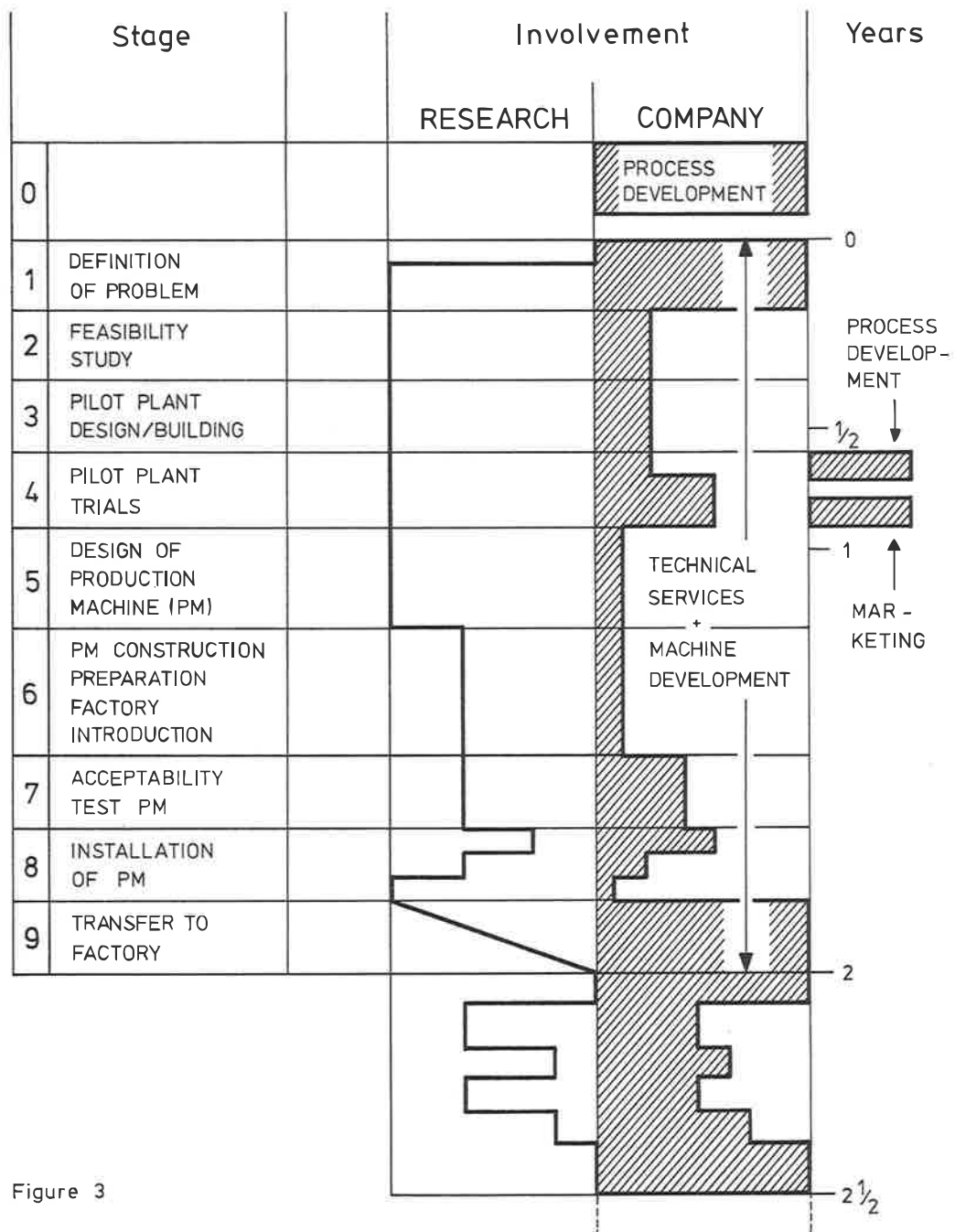
When we came to stage 5 - the design of the production machine - we found that we had made another mistake. We asked our central engineering division to assist us with the design and, of course, nothing was wrong with that. But it became evident very soon that we were much too late. The engineering division did not know a thing about the problem, nor about our reasons for preferring one solution to another. Time and time again we had to explain things that were perfectly clear to us and this caused delays; this was very unfortunate, as the company was awaiting a solution with eagerness. We had asked the engineers to assist us at the start of stage 5, but we should have sought their assistance at the end of stage 2, if not even earlier.

After we had passed stage 5, the rest was plain sailing. Although the nominees from the company on the project team were not the people we should have had, they constituted a perfect liaison with the factory and when we arrived at stage 9, transfer of the new equipment did not cause great problems. As you can see in Figure 3, we were consulted a few times after transfer, but that was about real difficulties and not for tightening bolts.

Looking back, we could be content, but not wholly so. Our policy of involving the company at all stages had worked well, even better than we could have expected. But we saw two important mistakes, one at company level and the other in Research. We at Research did not see sufficiently clearly the necessity of involving at an early date in our project the specialists who we knew would have to be asked for assistance. The company made things difficult for us by appointing the wrong people on the project team and by not informing us about the previous history of their request for assistance.

I can now turn to my third and last case study, which is about the dosing of fish (Figure 5). Actually we had two separate dosing problems, since there were two different products into which fish had to be filled. Fish dosing is very difficult because fish meat has a rather loose structure and tends to fall apart during processing. No customer accepts fish which has fallen apart; he wants whole pieces of fish on his plate and not a mass of white fibres that smell like fish but don't look like real fish. After intensive discussions with the company, we decided to tackle the two dosing problems together

HAMBURGER FORMING MACHINE
































FINAL CHOICE	
TEST 3	    
TEST 2	                 
TEST 1	    

Figure 4

up to the end of the feasibility studies. Then it was decided which problem would be investigated first. This project is not yet finished completely; we are still at the penultimate stage of acceptability tests, but we are sure that transfer to the factory will occur within half a year. Already we are turning to the second dosing problem I mentioned. Comparison of Figure 5 with Figure 2 shows that this time we practised everything we had learned since 1967. The company was involved heavily from the start and it's various departments were brought in at each stage whenever necessary. Just to give an idea of the complexity of this project, I included the initials of the departments at the extreme right. In the first stages we had a company man as overall project co-ordinator, who was promoted after 1½ years. It was then decided that one of the Research members should get the overall responsibility for the project, including the installation of the equipment in the factory. However, in this project extremely good liaison with the factory was crucial, so the new man was transferred to the company temporarily and has been directing the project from there. Another thing that stands out from Figure 5 is the length of the project. In the first two I gave as case studies, we made a number of mistakes and still could finish in two to three years. This one has taken nearly four years. We have often wondered whether we could have solved the extremely difficult problem of fish dosing successfully if we had been as ignorant of the right techniques of project management as we were in 1967.

To conclude, I'll give you the six rules we distilled from our experiences:

- Don't try to solve company problems without company involvement.
- Have the right company staff in the project team.
- Don't hesitate to change the project team.
- Ensure intensive contacts with, and involvement of, company staff.
- Let the company staff co-ordinate the activities of the company.
- Plan the project carefully and inform company staff about changes of plan immediately.

Maybe the third and the last rule call for a short comment. The research team should be flexible and able to adapt to changes in circumstances.

So you should not hesitate to change your research team whenever that is necessary, but you should do so only for sound reasons. And it almost goes without saying that it should be explained carefully to everyone concerned why these changes were thought to be necessary.

As to the last rule, failure to inform the company staff to changes of plan, is one of the worst sins a project co-ordinator can commit. As soon as it happens, the aims of the company and the laboratory start to diverge, and this should be averted at all times and at all cost.

FISH DOSING

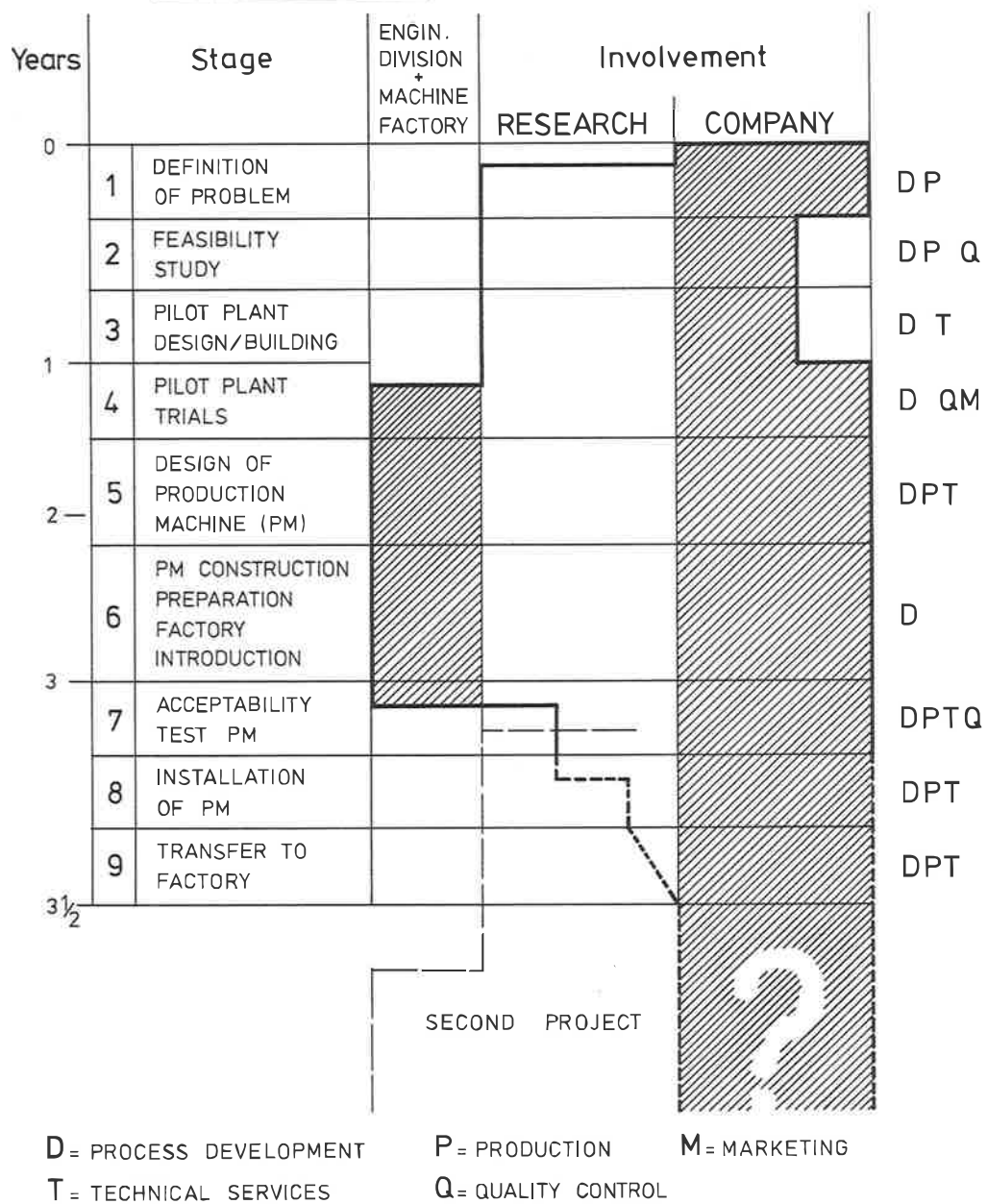


Figure 5

DISCUSSION

Question

I think that most of us here could provide Mr. Hollestelle with quite a number of different examples from outside the food industry. It seems to be an endemic disease of large organisations that, for anything you are doing, your most difficult customers are in fact your colleagues. I wonder whether Mr. Hollestelle or some in the meeting can explain the rather strange psychology of this. As probably you know from the newspapers, we in Britain sometimes have demarcation disputes between, say, the electricians and the mechanics in a factory, and it is quite stupid and quite unnecessary. But in my experience you find demarcation disputes too much higher up, at the managerial level. When you talk to staff members of large companies, you often find the same bloody-mindedness between each other in management as on the factory floor. Now, why should this be so?

Answer

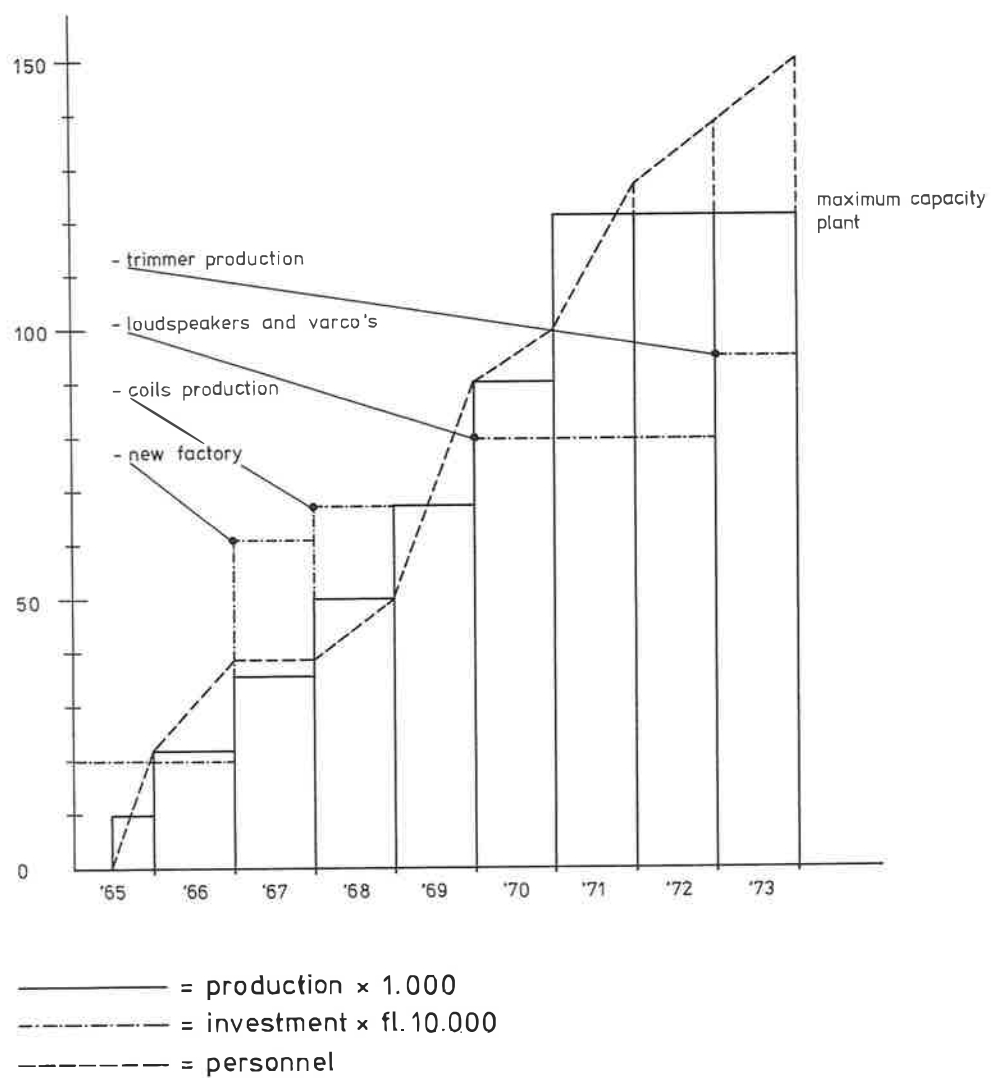
Yes, I know the phenomena, but I cannot answer your question. The easy way out would be to say that even managers seem to be human, but that rather begs the question. And I think that lack of communication is a very important cause, as that usually prevents the development of team spirit. But things seem to have changed in the last years, I think, and there seems to be less room in large organisations than a number of years ago for people who are difficult just for the sake of being difficult. In any organisation, large or small, it is extremely important that everyone concerned with a problem, should know exactly what the problem is and why it should be solved. That may take away at least some of the bloody-mindedness you mentioned.

Question

I have a question about the project co-ordinator. Some maintain that it should be the man on the team of the highest staff level, others say you should take the man with the best technological know-how, or the person who came up with the idea, as he will act as a promotor. What is your opinion?

Answer

I think that your criteria are wrong. The project co-ordinator must be the man with the best managerial capacities to bring the project to a successful close. This is of first importance, everything else, like technological know-how, inventiveness or level, is of secondary importance.



Development of a production-unit in Arusha for which transfer of technology was completed via the Pilot Plant in Utrecht

Cases of technology transfer within an international company

Ir. A.J. Huart
Deputy-director N.V. Philips Gloeilampenfabrieken
Eindhoven
The Netherlands

At the International TNO-Conference on "Acquisition of Technology for Innovation; technology transfer versus R & D", Mr. A.J. Huart, Deputy Director of the Factory Relations Department of the Product Division "Electronic Components and Materials" (Elcoma) of N.V. Philips' Gloeilampenfabrieken, discussed two different cases of horizontal transfer, i.e. the transfer from one manufacturing centre to another abroad. In the first case, he described such a transfer with adaptation to the local conditions in the developing country concerned; in the second case he dealt with the transfer of a complete operation without technology adaptation to another developing country.

Case 1: Technology transfer with adaptation

Transfer of know-how from a large scale operation in a developed country to a very small production unit in a developing country is impossible without adaptation of technology. Where the large factory thinks in terms of hundreds, of thousands or even millions, the younger overseas countries may think in terms of tens, or thousands. Experience has taught us that this scaling down cannot be done by the mass producing unit, which is the supplier of the know-how. It has to be done with a frame of mind which exists at the receiving end. For this purpose, the Radio-, Grammophone- and Television Division of Philips set up a special organization to study the specific problems associated with small series production and all other aspects of small plant management. This organization in Utrecht - called the "Pilot Plant" - was sited away from the large factories and technology sources. Communication regarding projects and pilot production has to be done by letter for the obvious reason that one finds the same conditions abroad. The Pilot Plant is a self contained unit, looking after its own personnel affairs, its own accounts and its own purchasing. Above all: it stands on its own technical resources. Summarized: it operates under carefully chosen artificial constraints to simulate local conditions in a developing country.

Case 1 describes the development of a production-unit in Arusha (Tanzania) for which transfer of technology was completed via the Pilot Plant in Utrecht. In 1965 it was decided to set up a portable radio production unit in Arusha. An old soap factory was initially rented to be used as factory building. In the Pilot Plant in Utrecht three people were prepared to run the project: the future manager, a specialist for the installation and start of the production and one man in charge of store-keeping and planning. They set up a pilot line and moved the whole lot to Arusha a few months after they started in Utrecht.

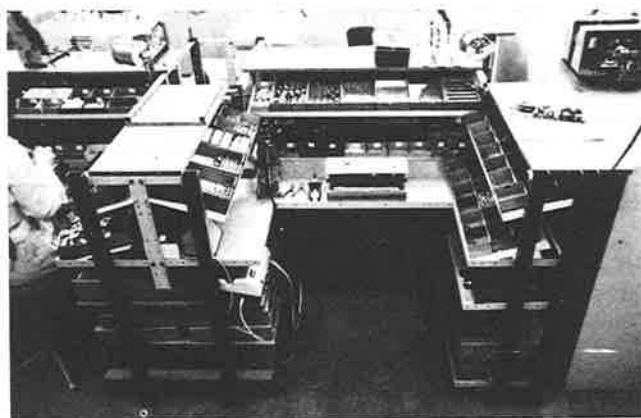
In Utrecht they had chosen the product, adapted it to local requirements and they had adapted the assembly methods to local conditions. The three Dutchmen started production in Arusha within six months after the decision had been taken to set up a production unit in that place. In the meantime an African manager, qualified and expected to be capable to run the operation, got the opportunity in the Pilot Plant to gain specialized experience and when he returned in Arusha, two of the three Dutch specialists left Tanzania.

Time went on and the increasing demand for Philips products initiated the decision to diversify the production and to manufacture also record-players and more sophisticated radiosets. The expansion of the production made a larger factory necessary and therefore it was decided to build new premises. Two and a half years after the start of the whole operation the activity was moved to a new factory, while meanwhile production had increased to 50.000 sets. By that time the first step towards integration was taken.



The factory in Arusha.

Ergonomically designed working bench, universally applicable for different operations. Can be adapted in height and number of shelves to match human physical dimensions and type of product. Note teaching recorder with taped training programme on lower left hand shelf.



An important step, because integration helps building up technological skill in the country, means more labour and thus greater added value. The graph shows the results of the integration step: a flawless increase in activity and in personnel.

Now, the plant operates at its maximum capacity. Further expansion is dependent on the development of the relationship between Tanzania and its neighbouring countries.

Case 2:

Technology transfer without adaptation

Case 2 describes the development of a production-unit in a middle East Country by means of the transfer of a complete operation without technology adaptation.

Due to a number of reasons, two small factories - set up in the country the middle sixties to manufacture television picture tubes - did not succeed and became insolvent. One of the two factories was kept alive and a few television-setmakers became shareholders of a new company which had to get technical assistance from an advanced international company. For that purpose, tenders were floated in 1969. Of the companies quoted, Philips was selected. After long negotiations on terms, a basic agreement was signed, involving a management and a technical assistance contract. A governmental condition was that the existing factory and the equipment of both the original factories should be incorporated in the new operation to the maximum extent.

Under the general management contract the general manager had to be a Dutchman, responsible to and controlled by a Board of Directors, consisting of representatives of the shareholders in the company in which Philips had only a minority shareholding.

A lot of problems arose due to a wrong estimation of local conditions. First of all - the general manager's authority was severely restricted and interfered by the Board. Secondly, the original available equipment, which was to be used, was not good and mixed up with equipment of different origin and thirdly: a mix of piece parts of different origin had to be used because quite a few parts were left over from the old days of the two starting factories. All this resulted in a high percentage of rejects in such a poor state that they could not be repaired.

Attempts were made to increase output by shift work, but although the capacity was good enough for 10.000 tubes, the output in the first year was only 1.350. The reason for this dramatic development was briefly a lack of motivation of all people involved.

An alternative course of action was needed as everybody agreed on. The first step was to go back to one shift only, to reduce the number of process phases, to use Dutch materials and to overhaul the equipment. In the meantime a plan was prepared for a completely new factory with a know-how package. The general management contract was deleted and replaced by a technical management contract only, under which the Dutch technical manager became responsible for the entire industrial operation and the Dutch managing director was replaced by a local man. It was a double headed monster, but it appeared to work.

In the next phase a feasibility study was made to evaluate conditions required for profitable operation. The study, which was approved by the Board, contained the following conditions:

- Philips guarantee a minimum output of 20.000 tubes within six months after the start of the new factory
- the local Board apply for protectionary measures.

The implementation of the plant was done under the supervision on the spot of a Dutch

plant engineer. He spent nearly a year to scrutinize the equipment. Dutch experts came over to run production on the floor and to carry out the mechanical maintenance tasks. Locals were trained in The Netherlands to eventually take over the management.

At long last the company got somewhere. Due to a delay because of local conditions the output in the first three months was only 9.000 but in six months it was 41.000 tubes. Then followed the decision to integrate production and after starting them, total production grew to the number of 150.000 tubes per year.

It took four years to come from a very poor position to a satisfactory operation. Four years in which a lot of time and possibilities were wasted.

Conclusions:

- the right production processes have to be chosen
- staff which is responsible for technology transfer, should be experienced in local conditions and have faith in the success of the project they work for
- expatriates should have adequate authority to carry out their duties
- good planning of the projects, good communication with and assistance from the know-how-centre should be ensured
- local staff selection should be done with care

OR IN SHORT: TECHNOLOGY TRANSFER CAN ONLY BECOME A SUCCESS WHEN IT IS DONE BY MOTIVATED PEOPLE THAT FORM A TEAM.

TECHNOLOGY TRANSFER WITHOUT ADAPTATION

CASE 2

Development of a production-unit by means of the transfer of a complete operation without technology adaptation

PHASE 0 (6 months)

- joined tender for collaboration with existing company
- condition: incorporate existing factory
- negotiations to settle collaboration agreement

PHASE 1 (8 months)

- agreement signed consisting of:
 - general management contract
 - engineering contract
 - technical assistance contract
- Dutch managing director appointed
- Dutch production manager appointed
- Engineer visits factory and assesses available equipment
- balancing equipment listed, drawn up, ordered and shipped

PHASE 2 (12 months)

- Production started in old factory. The following problems arise:
 - mix of equipments of different origin
 - mix of pieceparts of different origin
 - this results in:
 - high reject percentage
 - rejects not repairable
 - result: stocks of rejects
- To safeguard liquidity attempts to increase output by shiftwork.
 - capacity in 3 shifts: 10.000 tubes
 - however, actual output first year: only 1.350 tubes

PHASE 3 (3 months)

- General recognition that alternative course of action is needed.
New decisions and measures:
 - a. in old factory (to act as training centre)
 - back to one shift
 - number of process steps reduced
 - general overhaul of equipment
 - b. Plan for new factory with complete know-how package
 - c. Changes in company structure
 - general management contract deleted and replaced by:
 - technical management contract
 - managing director to be repatriated
 - general management taken over by local man
 - production manager to be repatriated. His function to be incorporated in that of (Dutch) technical manager

PHASE 4 (3 months)

- New feasibility study, made to evaluate conditions required for profitable operation in new factory, approved by the Board:
 - Philips guarantees minimum output of 20.000 tubes within 6 months after start
 - Board commits to apply for protectionary measures

PHASE 5 (7 months)

Implementation of the plan:

- premises, services and equipment installed under supervision of Dutch plant engineer
- equipment scrutinized for local content under supervision of Dutch technical manager
- production manager and plant & mechanical maintenance engineer (both Dutch) appointed
- old factory closed and operators selected to help installing of new factory
- three locals for training to The Netherlands
- specialists support from The Netherlands.

PHASE 6 (4 months)

- Start of production. Output in first 3 months 9.000 tubes, in next 6 months 41.000 tubes
- Decision taken to integrate production process further

After 48 months of preparation present output 150.000 tubes per annum in two shifts

DISCUSSION

Question

When discussing your second case, you said that you made a number of mistakes. I wonder whether you did not express yourself too strongly, for I think that your difficulties were of a psychological nature. It would have been far easier for your company to start transferring technology to that country directly, but for psychological reasons that was not acceptable to the government. So you had to go along with their ideas till it was absolutely clear that it did not work. Then, you must have had a very strong case for insisting on the organisational changes you described. So I am not convinced that you made mistakes, I think it was a logical outcome of a difficult psychological situation.

Answer

Well, I think you made a valid point here, and the psychological side of our difficulties should not be overlooked. I maintain, however, that we too made some serious mistakes. We did not realise that we never could get away with this project. First, we accepted the condition to use existing equipment as fully as possible, although we knew it came from different manufacturers. All our experience has taught us that then it is very difficult and sometimes wholly impossible to solve the compatibility problem. Secondly, we seriously underestimated the difficulties inherent in local conditions and the original organisational set-up. The project really got underway only after we had rectified these two mistakes. We should have refused these conditions, although I realise that this would have made the negotiations very difficult. But I do agree that there was a psychological side to all this.

Question

When talking about the Pilot Plant near Utrecht, you said that all communication is by letter. What language do you use, English, Dutch, Swahili or something else?

Answer

All communication is in English, even between Dutchmen. This is a question of principle. I would like to add that this restraint on communication is operative only for trainees. The management and staff of the Pilot Plant have normal communications with Eindhoven. As I said the whole point of these artificial constraints is to force the trainees to solve their problems locally, just as they have to do when they are on their own far from Eindhoven. So if a trainee discovers that part of his equipment does not work and goes to the manager of the Pilot Plant, he invariably will be told that he should not contact Eindhoven but should try to solve the problem locally. Quite often, the trainee goes to the town of Utrecht and tries to buy some spare parts.

Question

This paper is, I think, very timely. In the next few years we can expect that many developing countries, and especially the oil producing ones, will start to press for transfer of technology from the developed countries. And we can be fairly certain that in many cases this will be arranged between governments over the heads of the commercial enterprises concerned.

Answer

Well, thank you. I did not mention it, but actually there was strong pressure from the government in the last case I presented. After our initial failure, we got a second chance only because the government was committed by taking the initiative for this

project. And the State Bank had put in quite a lot of money. So they did not want to draw back, they wanted to see the whole thing through. The motivation of governments is another important aspect of this type of technology transfer.

J. Klevering
Enraf-Nonius
Delft
Holland

In the last fifteen years Enraf-Nonius has specialized in spin-off products of laboratories and other scientific institutions. Figure 1 gives the organisation of the group: Five production companies in Holland and six sales and service companies in Europe and the United States. The turn-over was about 50 million guilders last year. Our main shareholders are AKZO Chemical Company and DSM, the National Dutch Coalmines, each with 20 %, 25 % has been placed with some insurance companies and the remainder of 35 % is divided over many shareholders. AKZO and DSM are interested in commercializing their spin-off products and we have exclusive arrangements with these firms to the effect that, if their research leads to a new instrument, the development of it will be given to Enraf-Nonius. The research organisations of the two companies are large, together they have more than 7000 employees in research. So we like to say that Enraf-Nonius with a personnel of 850, has a research background of more than 7000. We also have close contacts and arrangements with other institutes where research is done, like universities in Holland, Europe and the United States and, of course, TNO. Our own research and development group has more than 120 people, and four fifth of their time is spent on application work, to make specialized instruments out of prototypes evolved at the research centres.

Fifteen years ago Enraf-Nonius was a very small company, with about 100 employees and a turn-over of less than 1 million guilders. Its production program was very limited and consisted mainly of medical X-ray equipment. The research group consisted of four people, including a young boy who cleaned the incredibly small research laboratory. Then, we started to think about the future of the company and very soon decided that the best policy would be to diversify and to try and build up a range of scientific instruments going far beyond medical X-ray equipment only. As we then were far too small to go in for research in a big way, we also decided to turn to the places where new ideas occurred and where we knew prototypes of new instruments were actually in use, e.g. the laboratories and institutions for scientific research. The growth of our firm since then shows that this program has met with reasonable success.

We still had to learn a lot in those early years and I remember two attempts at diversification that ended in near disaster. The first occurred when a famous Dutch baseball player showed us his design of a training device for pitching. You could train yourself all alone; you just set up this device on the lawn and started pitching. You did not need a catcher, and the inventor claimed that his device enabled one to become a quite accurate pitcher. He then pointed out that he had been to the United States, that there baseball is a national sport and that with some luck we probably could sell untold thousands of these devices to American kids. Now this looked quite promising, the design of the device was good, and we made a dozen prototypes and shipped them to the States. That are the only ones we have ever made. It turned out that the device did everything its inventor claimed, you could become an accurate pitcher by using it. And it is equally true that most American youngsters dream about becoming accurate pitchers. But for us it was a sad fact of life that American kids do not like to play baseball alone, they want to play it with their friends. So they did not have any use for this device and it turned out that we had overlooked that there is a social side to every sport. Our optimism had been great, but our market research very bad.

In the same year we had another sobering experience of the same kind. We came into contact with a technician who had worked in that part of Holland between The Hague and Rotterdam where there are many thousands of greenhouses. The farmers cultivate all kinds of fruits and vegetables, and tomatoes is very important crop. The flowers of tomatoes have to be pollinated artificially and this is done by hand. It is rather labour intensive, and in the process quite a number of flowers break off and never set fruit. Our

ENRAF-NONIUS GROUP

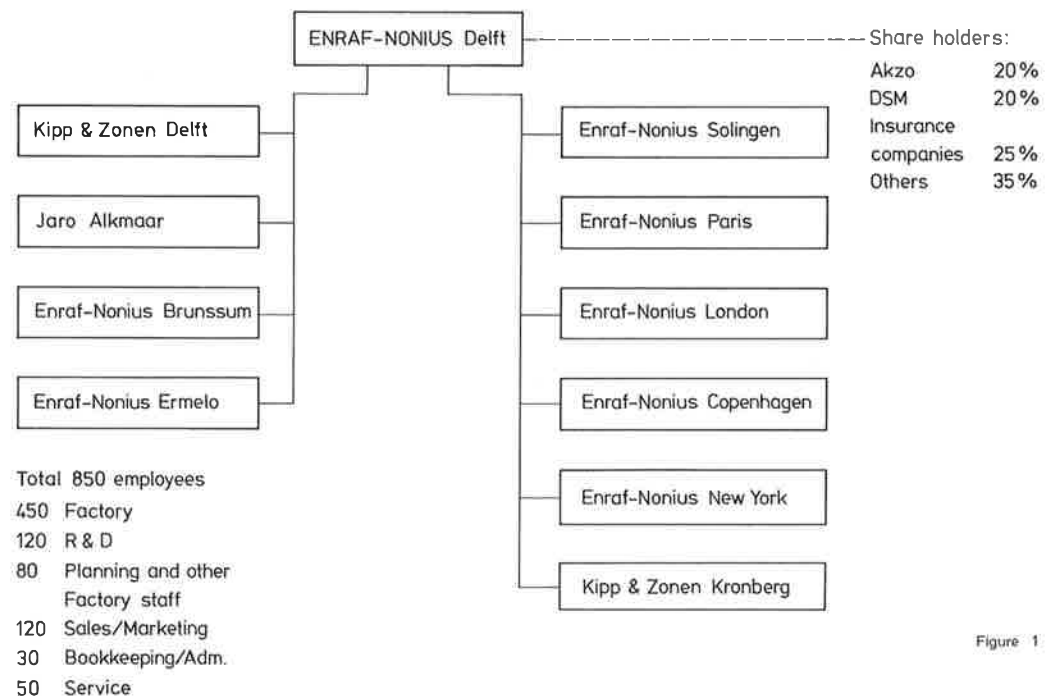


Figure 1

inventor proposed to blow the pollen all around the greenhouse with a small, hand-held instrument. It was a simple design, just a battery holder with a switch in the bottom, a small electric motor on top, driving a plastic fan. We made a prototype and our inventor departed, saying something about more orders next week. These never materialized. For in the moist heat of the greenhouse the plastic weakened and the fan enlarged itself to about ten times its original size under centrifugal force. On top of that, the electric motor and the batteries were not adapted to each other at all, because the batteries became flat within minutes.

It was the same story as with the pitching device: an interesting idea, in this case a very good market, but killed by bad design. By now we know, of course, that in these two early attempts at diversification our approach was incomplete. With the pitching device we had a good and well tested design but neglected to do market research, the pollinator, however, was a very good commercial proposition with a great market potential but we forgot to check the design.

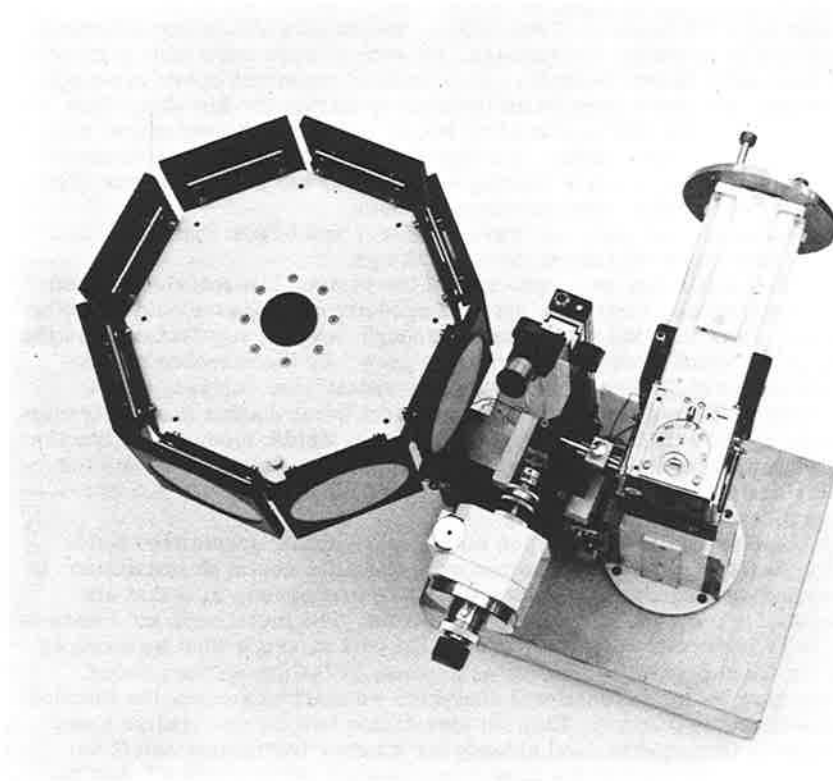
These failures taught us a few lessons. First that we should stay within our own specialism, which was and is scientific instruments. We simply don't know enough about other fields to be successful there. Secondly, we promised ourselves never to accept the claim of an inventor that there must be an interesting market for his idea. This may be perfectly true, but such claims should be based, not on the boasts of one man, but on very good market research. Lastly, our experience with the tomato pollinator drove home that we should always aim at making our instruments robust, so that they will work satisfactorily even under adverse circumstances.

These rules are of course neither new, nor revolutionary, and I think that at the last TNO Conference Dr. Robertson said about the same things.

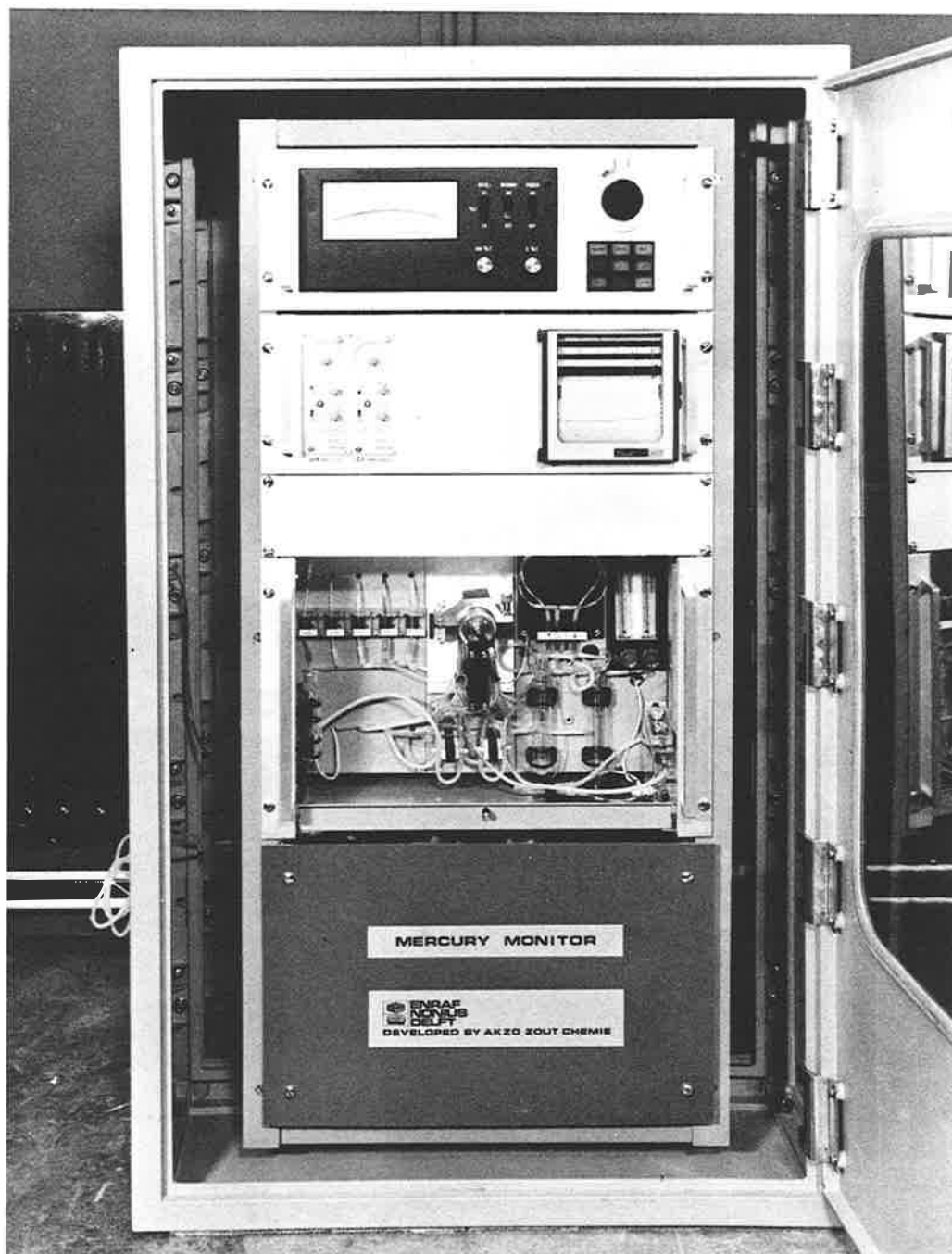
After this, we appointed a scouting man, who toured the various laboratories, talked with the research scientists and looked for spin-off products or ideas we could develop. In fact it soon became clear that one scout was not enough, and his appointment was the start of a scouting group which grew as our turnover grew. By these means we succeeded in transforming Enraf-Nonius from a narrowly specialized company into a broadly based instrument making firm with a strong basis in mechanics and electronics. We now have a range of more than 200 instruments in many fields: medical, diffraction, X-ray of course, general laboratory instrumentation and measuring instruments for the process industry and for monitoring pollution. Figure 2 - 7 give a number of examples of the instruments we have developed.

Let us now turn to some special problems you meet in this rather specialized field. The first fact of life is that a prototype, evolved at a scientific research institution, is almost never ready for production. Sometimes there are components in it that are either very expensive, or not easily bought on the market. The inventor is not interested in cost-price, he is interested in an instrument that will measure what he wants to measure. But for us, cost-price may determine success or failure on the market. So the first thing we have to do, is functional analysis; we start to analyse the function of the various parts of the instrument. Then we investigate how we can realize these functions. Can we put in components used already for another instrument and if the answer is in the negative, can we buy the needed components on the market? And you also have to bear in mind that the new instrument will somehow have to fit into your existing production program. All this is done in close co-operation with the external research group, not only because that saves a lot of time and money, but also because in the end the instrument will be used by research scientists and must be well adapted to their wishes and requirements.

At the same time you have to do your market analysis and this is a very important step. (Fig. 8). Before you start production, you must know whether the new instrument is a good commercial proposition, for if it is not, you will be saddled with an instrument that won't sell in enough numbers to ever earn back your investments. If the new instrument isn't a good commercial proposition, then you have to say no to the inventor, and this can be very hard, especially if it is a really inspired instrument. This may sound strange, but it sometimes happens that even an inspired instrument isn't a good commercial proposition, and then you have to shelve it and cut your losses. In many cases we start just with a simple leaflet or small brochure, and start to find



Arndt-Wonacott camera for structural analysis of proteins and other organic molecules. Develop in association with MRC Laboratory of Molecular Biology, Cambridge.
Figure 2



Mercury monitor for continuous measurement of traces of mercury in water.
Developed by AKZO Zout Chemie .

Figure 3



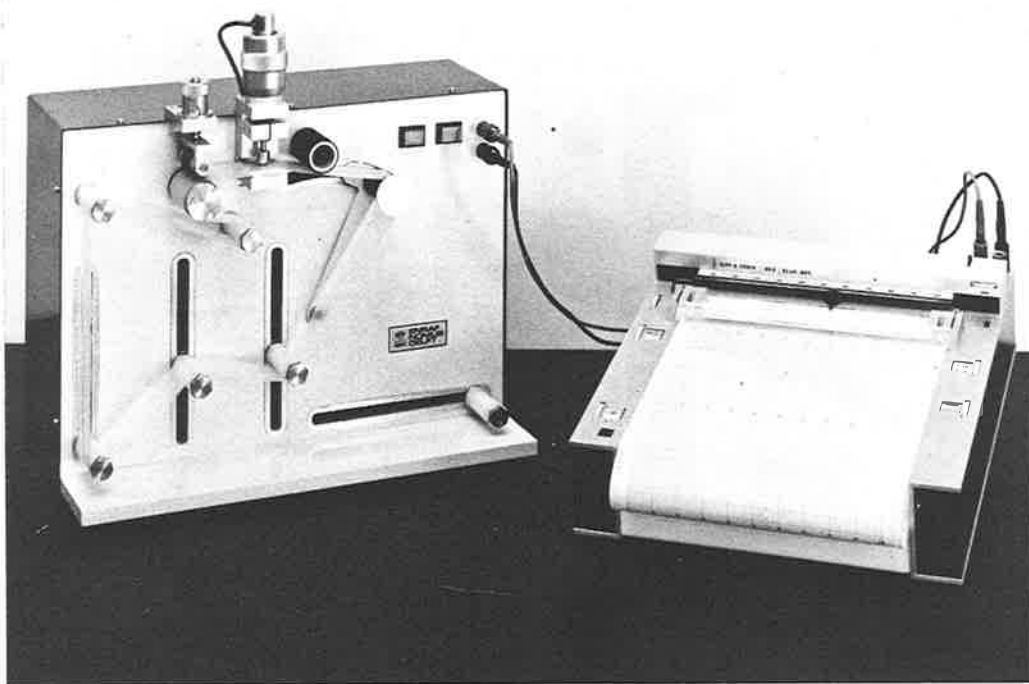
Complete Kappa four circle single crystal diffractometer, developed in association with the Universities of Groningen and Utrecht.

Figure 4



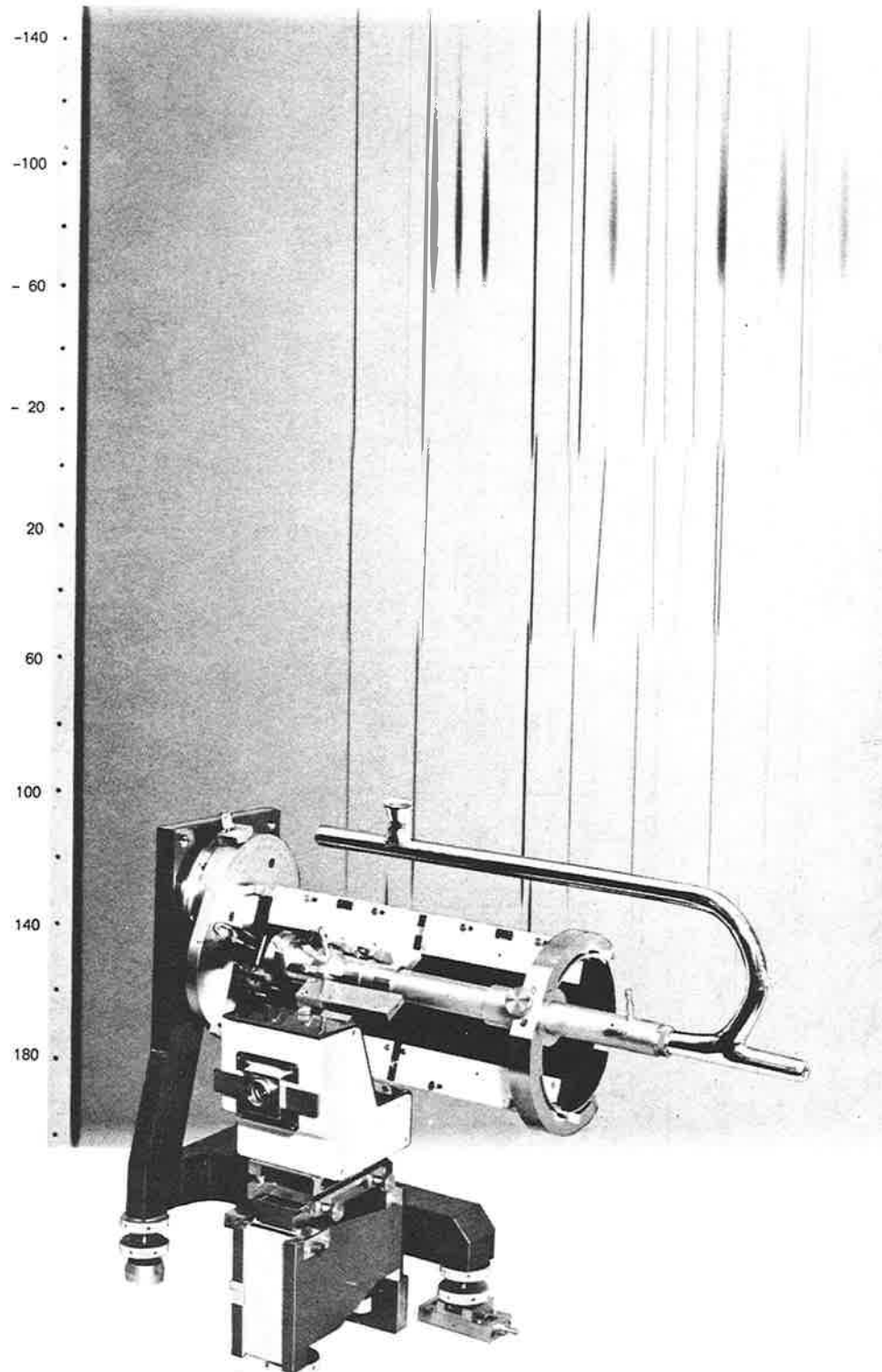
Part of the interior of a Enraf-Nonius Mobile monitoring station. At left four TNO Air monitors for NO-NO₂-SO₂- and O₃.

Figure 5



At left a DSM film thickness gage. At right a Flatbed recorder designed by Kipp & Zonen.

Figure 6



A Guinier-Simon camera for X-ray analysis of crystalline powders, developed in association with Prof. Simon, München.

Figure 7

INNOVATION-PROCESS IN THE INSTRUMENT-INDUSTRY

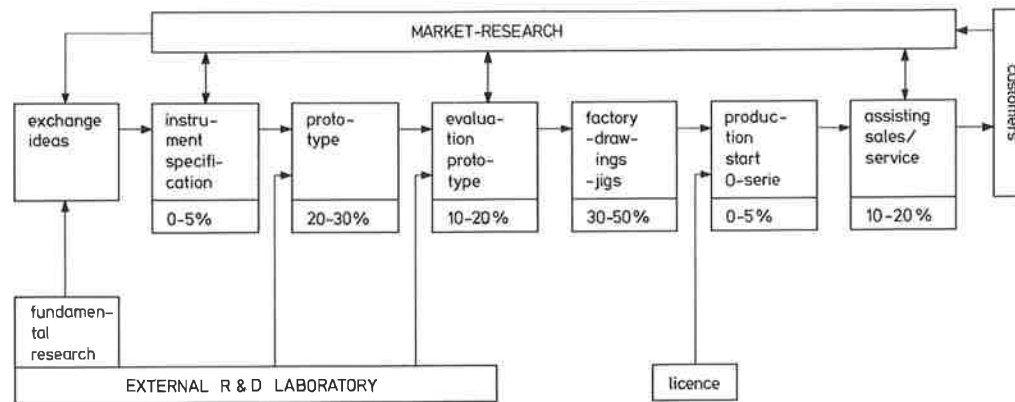


Figure 8

out how many scientists are really waiting for this instrument. We go to exhibitions and talk with future customers. In some cases we also make a wooden model of the instrument and travel around with that. For one of our most successful productions, a diffractometer, we toured one hundred universities in Europe and the United States with the wooden model, and after that we had a very good idea of the state of the market and of the specifications the new instrument would have to meet. We designed the diffractometer to meet the most exacting specifications and arrived at an instrument of high quality which had a fine market possibility from the start.

The next step is the prototype, which is used mainly for demonstration purposes, and this is done again in close co-operation with the original external research group. The demonstration of the prototype may lead to suggestions for new uses, and if we wish to include these, alterations in the design may be necessary. It goes without saying that the whole process of functional analysis, market research and evaluation of the prototype is very costly, it simply eats capital. And I have not even mentioned other aspects of your evaluation, like safety and service under adverse circumstances (which should be investigated carefully), and tooling up for production, steps that are costly. After you have started production, you have to assist sales and provide service, and this can be costly too.

By now, you will understand that I regarded with sympathy the curve of investments versus time Dr. Altenpohl gave yesterday in his paper, because we know too that it takes a heavy investment before you reach the break-even point. But in scientific instruments the situation may be more adverse than Dr. Altenpohl sketched, as the life-time of a scientific instrument seems to be smaller generally than the life-time of an industrial process.

Licensing is, of course, much easier, for you have not the steps of design and evaluation. But, as Dr. Thrush pointed out yesterday, you just shift your risk. As a licensee you face competition, and you must be very sure of the share of the market you will get eventually. This calls for extremely good market research, and that, of course, is expensive. Still, we prefer licensing to developing our own instruments whenever that is possible.

Let us now turn somewhat more to the business side. Sales and profitability are very important, and of course, your existing sales organization must be able to handle your new product. The implications of this are often underestimated. It means that your sales organization must be able to handle the new product, and you have to instruct people in sales quite carefully. And you should look at these things quite early in the development, so that you can either adapt your sales organization if that is necessary, or stop the development of the product. Profitability and expected sales volume are, of course, closely connected. If you have an exclusive instrument without competitors, you usually can put the profit margin rather high and you will have earned back your investments after you have sold a rather small number. But in this respect, I cannot stress enough that in the field of scientific instruments a good estimate of your expected sales is of the utmost importance. In scientific instruments it is very unusual to have a model that will sell for years on end without improvements or only with minor improvements. If you have such an instrument in your production program, that is selling well, you should nurse it, because then you have a money spinner that you will meet only once in your life. The usual situation is that the instruments of today will have become obsolete in three to five years hence. This means that you must have either an improved model or something totally new three to five years from now, if you want to stay in the market. It is this terrific time pressure that makes it so extremely important to estimate your expected sales volume very well. It means that you have always to be on the tip of your toes, and that calls, I think, for total integration of research, development, market research, production and sales.

Here I want to digress somewhat and mention two aspects I have touched already, namely safety and serviceability. We sell instruments, but actually we are not selling that, but service, service to the research scientists. In fact, we are saying to research scientists: 'If you buy this instrument, you will be able to measure with ease what you could only measure with difficulty last week, and you will be able to measure tomorrow what you could not yesterday.' I have changed the situation somewhat, but not overly

How to investigate a new idea ?

- Sales: short term and long term outlook? Is the existing sales organization able to handle the new product ?
- Profitability: an exclusive or specialized product, or a patent will give larger profit margins.
- How large is the sum to be invested before commercial production can start ?
- How large is the internal technical know-how and the know-how external partners can provide?
- To what extent does the new product fit into existing production facilities?
- Is it possible to take a licence for an existing similar product?

much. As all customers of service, research scientists like good and easy service, not only during installation, but also back-up service. In our field of work the concept of service is of crucial importance. Every successful sale of an instrument depends for 50 % on the features you have in the hardware and for the other half on the service you provide. So you should see to it that serviceability and safety of your instruments are excellent. There is, however, another good reason for this policy. You can live as long as Methuselah, but even then you will not be able to predict the uses your customers will find for your instruments, and it is simply good policy to build in redundancy with regard to safety and serviceability.

To return to my main theme. We are dependent for our ideas and prototypes on external research groups. It takes some ten years of hard labour to be an overnight success as a manufacturer of scientific instruments. This gives one a certain managerial philosophy. You should never sacrifice quality for an easy commercial success. If you have made your name in the difficult field of scientific instruments, you will have done so on the quality of your products, and that should never be sacrificed for whatever else.

The relation to your external providers of ideas and prototypes should be clear and clean. You must have the right of refusal. Whenever we are presented with a new idea or a new prototype of an instrument, we always have to ask ourselves: Is this so new and advanced that there is nothing else on the market, or is it proposed because nobody was interested in making it? And when you have found the answer to that question, you must be able to refuse to develop the idea or the instrument, even if it is an inspired idea or an inspired instrument. Market research will give you the answer.

Of course we have been very fortunate with our external research groups. Our main shareholders - AKZO and DSM - TNO and many others gave us service and a backing that we tend to see as unusual. And we do not only appreciate the freedom in development we have been given, we also think that this contributed considerably to the success of this kind of co-operation between research and instrument manufacture.

There have been some recent developments. In an agreement with Organon, one of the subsidiaries of AKZO, it was agreed that the excellent sales organization of Organon would sell specific medical instruments made by Enraf-Nonius.

The co-operation with DSM has changed too. In the beginning we thought that their spin-off would enable us to build general purpose instruments without much development from our side, but that expectation turned out to be false. We are wiser now and recognize that their developments in instruments are very often tailored to the specific needs of their laboratories and their factories. It is up to us to turn their ideas and developments into an instrument for general use.

Ladies and gentlemen, I have tried to give you an impression of the problems you meet when handling spin-off from laboratories and institutions. I thank you for your attention.

DISCUSSION

Question

(Chairman) When you have an instrument, do you plan for second and third generation models?

Answer

Yes, we do. Generally the life-time of an instrument is about three to five years, and then you must bring out a modified or a new model.

Question

(Chairman) And you do plan for that just from the start?

Answer

Yes, we know that it is absolutely necessary.

Question

(Huart) You said that you are allowed to reject ideas from the outside research laboratories. But if you have accepted an idea and if you have developed it, how often is it a failure? What percentage of the ideas used by you do not come up to expectations?

Answer

That is a straightforward question. When we started our diversification program, about half of our new instruments were good sellers, and the other half were more or less disappointing commercially. But at that time we tended to listen too much to the ideas of saleability the inventors had. After we gained experience in market analysis, the percentage of successful developments began to go up; by now about 70 % of our instruments are doing quite well, and about 30 % do not wholly come up to expectations.

Question

In your paper you mentioned contacts with industry, universities and organizations like TNO. Are there differences in the relations you have with these three different institutions?

Answer

Yes, there are. Industrial laboratories have more market feeling, and that makes it rather easy for us to work with them. I have great respect for TNO and I know that they are trying to acquire more of an industrial way of thinking. But it would be quite good, I think, if TNO set up a marketing organization to check on new ideas and to do market analyses and market surveys.

Comment

(Chairman) As a former member of the Board, may I point out that TNO is doing exactly that at the moment?

Effect of the EEC on technology transfer

Prof. Dr. M. Castagné

Staff-member of the 'Département Gestion des Entreprises'
Économie Appliquée de l'Institut National Polytechnique de Nancy
Nancy
France

and

Marc Müller

Staff-member of the 'Service d'Etude de l'Activité Économique de la Fondation Nationale des Sciences Politiques'
Paris
France

Mr. Chairman, ladies and gentlemen,

It is a great pleasure for Prof. Dr. Castagné and myself to present this paper on the "Effect of the EEC on Technology Transfer".

Technology transfer is a set of ways for interchanging technology. It needs a certain number of channels which are more or less formalized by senders and receivers. It involves either the simple diffusion of technology, or the start of a new technology (entering for example the initial phase of the industrial innovation process).

Among the channels of technology transfer, we distinguish first:

- those related to the acquisition of scientific and technical information;

and secondly:

- those related to the purchase of a technology. (Table 1).

In the light of this definition, it seems that the EEC, by its existence and by its action, should be one of the most important instruments for developing and accelerating technology transfer, within the Community and to countries outside it. On a micro-economic level, the EEC should foster closer relations between both economic and technological entities and interests. On a macro-economic level, the will to integrate the R & D potentials of the member countries, leads to an apparently favourable climate for efficient technology transfer in the EEC.

To analyze this effect of the EEC, we will adopt the point of view of the firm.

We will follow Table 1 and start with the analysis of the channels of technology transfer related to the acquisition of scientific and technical information. Later on we shall analyze the channels related to the purchase of a technology.

Impact of the EEC on the channels of access to scientific and technical information

- Scientific and technical literature

In 1970 one hundred firms in five industrial sectors in the EEC answered a questionnaire about the sources of information they used. Table 2 gives an idea of their quantitative importance. One can see that documentation is the most abundant in the sector of chemistry, a result of the great number of innovations in this sector. The abundance of patents is a consequence of the policy of chemical firms to deposit patents systematically. In the other sectors the problem of management of documentation seems to be less acute.

Table 3 shows the relative importance of the different sources of the information that came into the firm. The figures are in per cent., they are qualitative and mean that out of one hundred pieces of information that came into the firm, X % came through such or such a channel.

In certain sectors (electronics, aerospace and steel) there is a shift from the channel of technical documentation to the channel of 'personal contact'. In electronics, one can expect that contacts with the USA are relatively important, but there seems to be an impact of the EEC in the sectors aerospace and steel.

The two processes of technology transfer

1. Information transfer

- Literature
- Patents
- Market information
- Personal contacts

2. Acquisition of new technologies

- Licences / know-how
 - Co-operation between firms
-

Table 1

	Number of reviews acquired per <u>month</u> (related to the size of the firm)	Number of patents examined per <u>year</u> (related to the size of the firm)
Chemicals	200 to 2000	20 000 to 30 000
Electronics	50 to 300	500 to 2 000
Aerospace	100 to 500	smaller than 100
Steel	100 to 300	few
NC machine tools	50 to 250	very few

Table 2

CHANNEL INDUSTRIES	Technical documents	Patent documentation	Market information	Personal contacts
Chemicals	35	20	20	25
Electronics	30	5	25	40
Aerospace	30	5	20	45
Steel	30	10	10	50
NC machine tools	50	5	25	20

Table 3 (numbers in %)

YEAR	France	United Kingdom	Italy	Netherlands	Japan	USA
1960	4.0 %	5.6 %	1.5 %	2.0 %	0.8 %	12.8 %
		No growth in this period				
1970	4.6 %	5.5 %	1.7 %	2.0 %	5.8 %	19.1 %
	Constant				× 7	× 1 $\frac{1}{2}$

Origin of patent deposits in Germany
(% of all foreign patent deposits)

Table 4

Source of information leading to successful innovation in the European firm

	Transfer of knowledge by engaging a new employee	20%
	Internal transfer from R & D centre	24%
EEC impact (important in the future)	Literature, documentation and patents (external)	9%
	Market information (external)	12%
EEC impact (slight)	Personal contacts (conferences, visits to other countries etc.) (external)	35%

Technological transfer leading to an innovation

Table 5

The Commission of the European Communities is busy to enlarge the diffusion of knowledge contained in the scientific and technical literature. In fact it is trying to set up an automatic European network of information and documentation (a so called DATA BANK). The 'Comité de l'Information et de la Documentation Scientifique et Technique' (CIDST) is doing the preliminary work for the foundation of such a Data Bank. Furthermore, there are the:

- SDIM (Système d'Information et de Documentation Technique)
- ENDS (European Nuclear Documentation Service)
- CID (Centre d'Information et de Documentation de l'Euratom).

But it is obvious that the impact of the EEC in this field has not been sufficiently heavy and that undoubtedly there exist unsatisfied needs for documentation. So it is not surprising that European private industry has stepped in to create:

- EIRNA (European Industrial Research Management Association)
- IDC (Internationale Dokumentationsgesellschaft für Chemie)
- PDG (Patent Dokumentation Gruppe)
- DERWENT.

These private associations are rather exclusive and mostly have only large European firms as members.

All this permits of some conclusions:

The need for documentation seems to be different in the different sectors of industry. In the sectors of iron and steel, aerospace and nuclear energy, the EEC has had some impact, and the chemical and pharmaceutical industry organized itself.

But in electronics and scientific instruments, in non-ferrous metals and in the food industry, the need for documentation still is for a large part unsatisfied.

What wishes do the future users of the European Data Bank have? There are five:

- the important point of secrecy, as no competitor must be able to discover that kind of information a certain firm did get from the Data Bank;
- a frame larger than the EEC only;
- division in sectors;
- trilingual;
- integration of economic and technical-economic data.

When the European Data Bank is founded, it will have to face a number of important problems:

1. The relation between the European Data Bank and the existing national documentation centres; -,
2. The relation between the European Data Bank and the private associations for documentation;
3. The kind of documentation at the disposal of individual firms;
4. The price that can be asked for the documentation service;
5. The fact that the ask of the European Data Bank will not be the same for all sectors of industry.

- Patents as holders of information

Table 4 shows that in Germany, to take this country as an example, patent deposits coming from Europe have not increased over the years, but that those from the United States and Japan have. The other countries of the EEC show the same pattern.

After the constitution of the EEC its member countries saw that it would be necessary to design a 'European Patent System'. The EEC set up a group of experts on 'Community Patents', which has finished its work in March 1973. The unified European Patent System was designed to remedy some serious shortcomings of the existing national patent systems:

- national patent systems are not adapted anymore to the needs of industry and society (the systems are more of a hindrance than a stimulus to modern technological innovation; the delays in publication are too long in relation to the life-time of modern products and there is a general drop in quality due to a too great number of demands)
- national patent systems are difficult to use as documentation systems and in this there are also differences between the various sectors of industry.

We think that the decision of the EEC on the European Patent System will improve the protection of industrial property.

- Market information

Here we have two different processes:

1. Customer - supplier - subcontractor,
2. Technology transfer by product.

With regard to the relation between customers and suppliers, one may say that, although the Common Market gave rise to an increase in intercommunitary exchanges, it did not change the habits of the industries in technology transfer in the same proportion. According to the European industrials themselves the system of exchange still falls short of some kind of unification, and one cannot deny that in this way Europe loses considerable benefit from technology. The same goes for sub-contracting, which is little developed within the EEC, and which, however, should be the spear-head of technological development, as it is in the USA.

One has to conclude with regret that the impact of the EEC in the field of customer - supplier - subcontractor has been very weak.

In 'Technology transfer by product' the situation is almost the same. International trade is rather heavily linked to this kind of transmission of technology, because generally the sale of manufactured products is the attribute of societies that are pioneers of technological progress. This is certainly true for developed countries and emerging countries.

But between the EEC countries, one does not note a strong stream of technology transfer by products of leading technology. There are of course some checks to this:

- norms, which are generally different in each country, although there is a tendency for normalization on an EEC basis;
- disguised protection, practiced by some EEC countries.

Anti-pollution norms and telecommunication are, perhaps, a few useful examples.

- Personal contacts and professional mobility

There is a well documented lack of contact between research people in the EEC countries, and the professional mobility is small and far smaller than in the USA. There are barriers of language and culture, as between Angl-Saxon and Latin countries, and these barriers are important. We have to conclude, however, that the impact of the EEC on these barriers has been slight. (Table 5).

Impact of the EEC on the channels for purchase of new technology

Here we follow the second part of Table 1:

- Licences and know-how;
- Co-operation between firms.

We will first analyze licences and know-how contracts.

- Licences and know-how

The impact of the EEC on this channel of technology transfer has been limited. At present, licencing and know-how contracts are mostly concluded on an exclusive basis (including export restrictions and other clauses). In this way the members countries of the EEC waste part of the sum paid for royalties, because each country imports the same process separately. In 1965 and 1966 55 % of all technological processes imported by Japan, were on a non-exclusive basis and could be applied by more than one firm. The European emphasis on exclusivity in these kinds of contracts has its dangers. It might even lead to a quite harmful distortion of the market by suppressing competition, and that is against article 85 of the Treaty of Rome. But on the whole, European industry is in favour of these exclusivity clauses, and it has fought every attempt of the European Commission to restrict the scope of exclusivity in these contracts.

- Co-operation between firms

Here the EEC has had two effects:

- a. By its mere existence, it tends to harmonize the technological and commercial interest of the various industries. This is an extremely slow process.
- b. By its jurisdictional activities, the EEC has had an impact on technological agreements between European firms. The most important result so far may look a bit negative: European anti-trust legislation.

Co-operation between European firms is listed schematically in Table 6. There, we distinguish four types of co-operation: joint venture, agreement for technological exchange, co-operation on large European public programs and creation of common subsidiaries (technologically based). One look at the Table shows that in some sectors joint ventures and agreements for technological exchange do exist (chemical and electronic industries, non-ferrous metals and steel). The EEC has had either only a slight, or absolutely no effect in the five other sectors. This may be so for historical reasons and there are of course barriers, like norms and, perhaps, article 85 of the Treaty of Rome.

The third column of Table 6 shows that only the aerospace industry has co-operated on large European public programs. All the other sectors have refused to play the EEC game. That the aerospace industry is the exception, can be explained by the large US technical transfer programs of the years 1960 - 1964 (HAWK, F 104 and so on). From the start, production of these planes was planned on a European scale. After the US had withdrawn, the European aerospace industry continued to think supranationally; some results of this collaboration are: the Bréguet Atlantic 1150, the French-German TRANSALL, and the French-British JAGUAR and CONCORDE. The example of the European aerospace industry has failed so far to convince the other sectors of industry that these collaborative, supranational projects are worthwhile and profitable.

This may seem baffling, because it is rather well known that the results of supranational collaboration are valued highly by the European aerospace firms. There is a good flow of information, mainly through personal contacts between scientists, and this ensures that relevant new facts are digested and assimilated into the various firms almost immediately.

We think that the lack of supranational collaboration in the other sectors of industry is for a large part based on a lack of mutual trust. Furthermore, the goal of this kind of co-operation quite often is not the creation of large intra-european firms, but specific productions only. Governments still tend to guarantee the home market to national firms. In most sectors of industry there is no really intercommunitary public market, based on governmental demand.

This explains too why in Europe the creation of common subsidiaries is a very rare event. Here the lack of suitable European legislation for the 'European firm' only tends to reinforce this lack of enthusiasm. At present, the Commission engages itself in slow elaboration of tactical programs. These actions are mostly limited to a few sectors only, and often lack continuity, so that European industry has found it very difficult to include the EEC effect in its R & D forecasts.

All this is the basis for our conclusion that, with regard to technology transfer, the member countries of the EEC have benefited less than they could have done or hoped to do, and that actually some countries outside the EEC, as Japan and USA, have reaped where they did not sow.

In the EEC one can distinguish four different barriers to effective technology transfer:

- On the level of institutions mutual trust is on the increase, but communication is neither easy nor fluid;
- On the level of organizations, exactly the same situation exists;
- On the level of governments, it seems that mutual trust is rather rare and communication is sparse and slow;
- On a cultural level, the EEC has not brought any striking modifications. At European meetings English is often the only official language, and even then the participants don't understand each other because of cultural differences.

We sincerely regret that the conclusions of our paper have to be somewhat negative, but we do think that the situation of the EEC is grave and rather alarming. The recent crises in energy and raw materials should spur on all countries of the EEC to work together to develop the new technologies that will help us to solve our problems. Of course, national programs are not bad in themselves, but they should be part and parcel of, or tally with a unified European program, if only because no European country can go it alone to develop all necessary new technologies. For if we don't act in concert, the flywheel of the European economy will slow down and may even come to a stop.

Types of agreement	Joint ventures	Agreement of technology exchange	Co-operation on large European public programs	Creation of common subsidiaries
Chemicals	Yes	Yes	No	Yes
Electronics	Yes	Yes	No	Few
Aerospace	Few	Few	Yes	Few
Machine tools	No	No	No	No
Non-ferrous metals	Yes	Yes	No	No
Scientific instruments	No	Few	No	No
Steel	Yes	Yes	No	No
Food industry	No	Few	No	No
Data processing	No	No	No	No

Technological co-operation between European firms

Table 6

DISCUSSION

Question

Mr. Müller mentioned that the EEC has made an effort to build up some data-banks. I would like to know whether the EEC has also made an effort to create dictionaries of key-words, for without such dictionaries no data bank can be used efficiently. Only a good system of key-words can ensure that a customer is not swamped with irrelevant data, but gets the 10 or 12 documents he really needs.

Answer

(Müller) These dictionaries have been compiled, I think, in the fields of ferrous and non-ferrous metals.

Question

Yes, I know. But they were not compiled or commissioned by the EEC. In my opinion there are other fields where the compilation of these dictionaries is rather urgent.

Answer

(Müller) The ferrous and non-ferrous thing is a good example of the point we wanted to make in our paper. The EEC should not try to do everything and certainly should stimulate private initiatives. And what was the second part of your remark?

Question

I said that the compilation of these dictionaries of key-words is urgent in other fields too and I think that the EEC as such has not anything to show at the moment.

Answer

(Müller) Yes, that is true.

Question

In your paper you mentioned efficiency of transfer of information and you showed a table where this efficiency was rather accurately given in percentages. I would like to ask two questions about it. First, how do you define efficiency of transfer of information, and, secondly, how do you measure it?

Answer

(Castagné) Je vais répondre en français. Le tableau que nous avons montré, issu d'une étude britannique récente, montre, parmi toutes les informations qui arrivent dans une entreprise et que nous avons montré dans la table 3, celles qui ont été efficaces, c'est à dire, celles qui ont été vraiment incluses dans un processus d'innovation. Nous pouvons remarquer que les informations qui pénètrent dans la firme par les contacts personnels sont en général responsables de 35 % du total des informations efficaces. C'est à dire, que l'on distingue, si vous voulez, deux catégories d'information, les informations qui arrivent dans une entreprise, et les informations qui sont réellement utilisées dans un processus d'innovation. Lorsque vous avez cent informations utilisées dans un processus d'innovation, par exemple, trente cinq proviennent de contacts personnels et neuf seulement proviennent de la documentation scientifique et technique ou de la lecture de brevets. Or, le Marché Commun jusqu'à maintenant, a surtout cherché avoir un impact au niveau de l'acquisition de documentation technique et un certain progrès dans le système Européen des brevets avec l'élaboration des brevets

Européens, cet effort n'aura donc pas une grande efficacité sur le transfert technologique efficace. Voilà pour répondre à votre première question.

La deuxième question, quant à la mesure exacte de l'efficacité d'une information dans un processus d'innovation; évidemment une mesure quantitative est toujours difficile, mais je pense que par un sondage auprès des entreprises et des cadres concernés, des ingénieurs concernés, on arrive, grosso modo, à déterminer pour une innovation donnée les grands canaux d'information qui ont été efficaces.

(I would like to answer in French. The table we have shown, stems from a recent British study. In table 3 we have given the sources of all information coming into the firm, and the other table is about effective information, i.e. information that really has been used in an innovation process. The last table shows that, generally, of all effective information, 35 per cent. comes into the firm by the way of personal contacts. So one can distinguish two kinds of information: all information coming into a firm and information that has been used in an innovation process. If you take, for example, one hundred pieces of information that have been used in an innovation process, you will see that about 35 did come in by personal contacts, and only nine from scientific and technical documentation and patents. Up till now, the Common Market tried to have an impact in the field of technical documentation and has progressed towards European Patents and a European Patent System. But this effort will not have a great impact on the efficacy of technology transfer. I think that this answers your first question. In your second question you asked about the exact measurement of efficacy of information in an innovation process. Of course, quantitative measurement is always difficult, but by sounding firms and their staffs about particular innovations one may determine the most important channels of information that have been efficacious.)

(Chairman) Does that answer your questions?

Question

Not wholly, I fear. I didn't ask for the sources of information, but for a definition of efficiency of transfer of information. How do you know whether a certain item of information has been efficient?

In his answer, Professor Castagné has used the French term 'efficacité'. Although there may be a difference between the English efficiency and the French efficacité, I would like to hear a definition of efficacité.

Answer

(Castagné) Une information est reconnue comme efficace si elle est comptabilisée par l'équipe qui gère un projet de recherche et de développement comme étant vraiment une information qui a servi dans un processus d'innovation donnée. Donc, on mesure l'efficacité des informations par type d'innovation, par projets de recherche qui sont conduits dans l'organisation. On ne la mesure pas vis à vis du total de l'organisation, mais pour une innovation donnée. Quand on fait des moyennes, par exemple, on étudie cent processus d'innovation et on fait la moyenne, on constate que 35 fois sur 100 ces informations qui ont effectivement servies dans un processus d'innovation, proviennent de contacts personnels et neuf pour cent de cas proviennent de la lecture de brevets ou de la documentation scientifique et technique. L'efficacité est mesurée par le fait que elles sont liées au fait d'avoir fait avancer vraiment un processus d'innovation dans l'entreprise.

(A piece of information is considered to have been efficacious, when the R & D team shows that it has been used in a particular innovation. So, one does not measure efficacy in relation to an organization as a whole, but only in relation to a particular innovation or a particular research project. When one takes one hundred innovation processes, one sees that on the average 35 % of the informations that were efficacious came in through personal contacts and only nine out of one hundred by studying scientific and

technical literature or patents. Efficacy is measured by determining whether an information has helped to advance an innovation process in the firm, or not.)

Question

Since the six members of the EEC joined Great Britain, Denmark and Ireland, I feel that there is a danger that at a symposium like this, it is a done thing always to introduce what has been the effect of Le Marché Commun upon this, that or the other. In fact, I wonder whether there has been any effect whatsoever on communication that has not been brought about by the mere existence of this group of nine nations, who have been trying with various degrees of success to work together for a rather long time. Surely, even before the Six joined with the other Three, there was a great deal of communication occurring already. Even today there are some people in this room who are from misguided nations who don't belong to this select club. I have been lunching with two Swiss gentlemen and we communicated extremely well. Therefore I do wonder whether our speakers have in fact made a case that there has been any increase in communication of technological data by the EEC or whether we are really chasing a red herring.

Remark

It is, of course, quite good to poke fun at situations sometimes, but we should not take, I think, the previous speaker too utterly seriously.

It is true that on the surface very little appears to have happened as a result of the formation of the large Community last year. But a great many companies, for example in Great Britain, have been preparing for this for a long time, and new information flows have started perhaps as long as five or six years ago. The primary stimulus comes, I think, from the legalistic framework our French friends have mentioned and which enables companies within the EEC to build up commercial corporations of a particular kind. This reacts on technical information and also on commercial policy in fields as, for example, defence against foreign competition. This has been going on for quite a long time already, but it will take a good many years, I think, before our experts will be able to measure precisely what has been happening.

May I comment briefly on the discussion about efficacy of information? It is impossible to say that, because you had a particular piece of information, you advanced, because information comes from very many quarters and the particular success cannot be laid down to any one thing. Advance is an organic process generating its own logic and its own information flow. However, it is sometimes possible to say it negatively: if you had had something then you would not have failed, if you had known then what you know now you might have acted differently and prevented someone getting there before you or prevented a scientific failure of some kind. It is the monitoring of the lack of information in specific instances that will either show the gaps in a service or indeed its efficacy.

Answer

(Castagné) Je veux répondre à la question très rapidement. Je pense que l'action, l'impact du Marché Commun pourra se mesurer dans une future proche, probablement dans le domaine des "Data Banks", ou dans le domaine du Brevet Européen, et fera peut-être également faire de progrès au système Européen de brevets. Mais pour le reste c'est essentiellement une question de développement de la confiance au niveau des individus et peut-être au niveau des organisations. Au niveau des individus la confiance a beaucoup pour augmenter entre les années de 1960 et 1970. Au niveau des organisations, il a un peu augmenté, au niveau évidemment des États, c'est tout un autre problème.

(I would like to answer very briefly. I think that the impact of the Common Market might start to show itself in the near future, probably in the field of the "Data Banks" or in the field of the European Patent. And also, there may be progress with the Euro-

pean Patent System. For the rest, it all depends on the growth of mutual trust between individuals and, perhaps, organizations. On the individual level there has been a distinct growth of mutual trust between 1960 and 1970. Organizations have shown some growth in this respect, national states are, of course, quite another subject.)

Dr. Ir. A.J. Bogers
Staff-member of the Industrial Liaison Department TNO
Apeldoorn
the Netherlands

Though under heavy attack, or at least subject to an extensive discussion, science and technology are still the prime movers of progress. For many, progress means economic growth, the benefit of which is also being questioned at the present time. Now you may wonder whether I did not prepare a paper for the wrong TNO Conference, as the main aspects of the generally felt disillusionment with technological progress has already been treated in an excellent way by Professor Freeman at last year's Conference. I would like to defend, however, that the change in attitude towards science and technology, and towards alleged results like economic growth, has much to do with the present attitude towards research and development; and here again we have a subject that has drawn the fire of many critics. Their critique is not altogether unjustified. There certainly is some evidence that our concepts of the role of R & D for the benefit of society, if not wrong, have at least been too simple.

To see these very important issues in their proper perspective one can turn to some statements in the Dahrendorf programme of the European Economic Community, as: "Economic expansion is not an end in itself, but it will continue to be an important task in the future, it calls among other things for continuous improvement in research. However, growth must be at the service of mankind and quality of life, and science and education play a special role in this."

The Council of the Organisation for Economic Co-operation and Development has expressed about the same train of thought in a report on social concerns and indicators, and this will be treated in more detail later on.

The Dahrendorf programme also distinguishes two central themes for R & D:

- Innovation in response to social requirements to meet the needs of protecting the environment, health, education, urban development or in general improving the quality of life;
- Innovation in industry to maintain and increase capacity and to raise the level of technology.

Also according to the Dahrendorf programme:

"Priority should be given to the syndrome of problems that the Club of Rome called 'problem areas', these are population growth, energy supply, preservation of the environment, conditions of urban and rural life, resources for man and industry, recycling and questions of human behaviour. But at the same time care must be taken to avoid taking over the pessimism by extrapolation that characterizes the approach used in the studies of Meadows and others."

Those quotations from the Dahrendorf programme do put the problem in a clear perspective. Moreover, they help to introduce a concept that is crucial to the role of R & D and the institutions engaged in it: the concept of innovation. Technology Review published an excellent article on the concept of innovation by E. Haefner in its 1973 March/April issue. Haefner discusses industrial innovation only, but his way of reasoning can also be applied to innovation in general.

Innovation in its most simple definition is the successful introduction of something new, and the successful introduction may be even more important than the fact that this 'something' is really new. Technical progress is based on this kind of innovation. It once seemed almost axiomatic that more research should lead to more technical progress, since the natural sciences are at the foundation of our industrial civilization. But no statistical evidence or systematic empirical observations support the allegation that there is a close correlation between the volume of research and the number of innovations in an industry. Some even point to inventions originating outside research establishments as a major cause of industrial progress. Basic to the overestimation of the role of organized R & D is the concept of the innovation chain. Here, the process of

innovation is seen as a chain of successive steps from basic research to research results, then to technical development work, to new products, processes and methods and thereby to economic growth. (Figure 1).

This concept suggests that new knowledge leads more or less automatically to new useful products. If this were correct, one should find a strong correlation between the R & D effort and the output of technical progress. We have seen however, that such a correlation simply does not exist. There is still another reason why the concept of the innovation chain is highly improbable. It presupposes that the intensity of technical development does not depend on the economic situation of, or the prospects for a branch of industry. But the incentive to innovate lies mainly in the expectation of some kind of profit, and on the other hand only a firm in a sound economic position can provide the means for a development effort.

From this, Haeffner draws two basic conclusions:

- Research and Development appears to be an often needed, but in itself insufficient condition for invention, innovation and industrial economic growth;
- Economic conditions in, and future prospects of an industrial sector largely determine investments in invention activities and thereby the frequency of innovation.

Haeffner combines these conclusions in an operational model of innovation, in which innovative activities - and thereby also technical progress - are motivated by the expected profit, which in turn is determined by the state of development of, and the economic conditions in the industry. Haeffner's model contains two streams, or better still, two loops that are more or less separate and coupled rather weakly. The first, or research loop starts with the total of accumulated scientific knowledge, giving rise to scientific problems and research fields in the second step. The next step involves the scientists working on these problems and in the research fields, and they are motivated by their wish to acquire distinction in the academic world. Their activities lead to research results that add to the total of accumulated scientific knowledge and so close the loop.

The second, or innovation loop starts with the state of development and economic conditions of the industry, which determine the decision to start a process of innovation, a decision that is motivated by expected profits. This leads to innovation activities and from there to new products, methods and processes, and they create industrial development and economic growth. In their turn, these add to the state of development and economic conditions of the industry and close the loop.

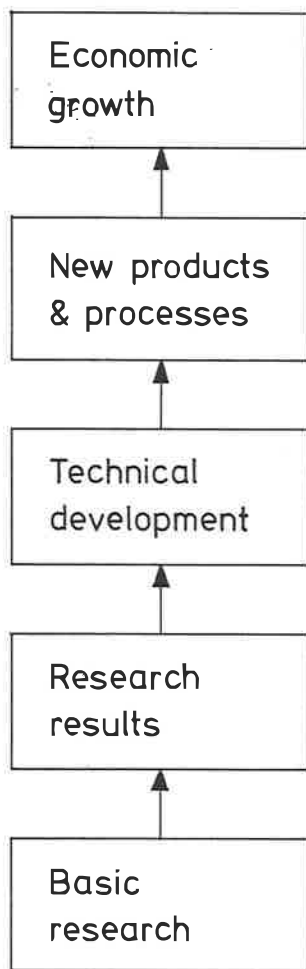
These two loops are coupled indirectly, and thus rather weakly, by the fact that the total of accumulated scientific knowledge in the first loop influences the innovative activities in the second loop by way of direct information transfer and educational activities. (Figure 2).

This model explains quite a number of questions that have been worrying governments and industry. Whereas scientists still add daily to the total of accumulated scientific knowledge, only a small fraction of the new knowledge is used in innovation, leading to the famous dictum that research and crime have in common that they don't pay.

Haeffner's model, however, states that progress stems from innovation directly and comes from R & D only indirectly. The innovation process is essential, and a more detailed knowledge of this process, especially of the factors that either hamper or promote innovations, or better still, a policy based on this knowledge, may help us to solve these problems. In fact, quite a number of things have become known from empirical studies.

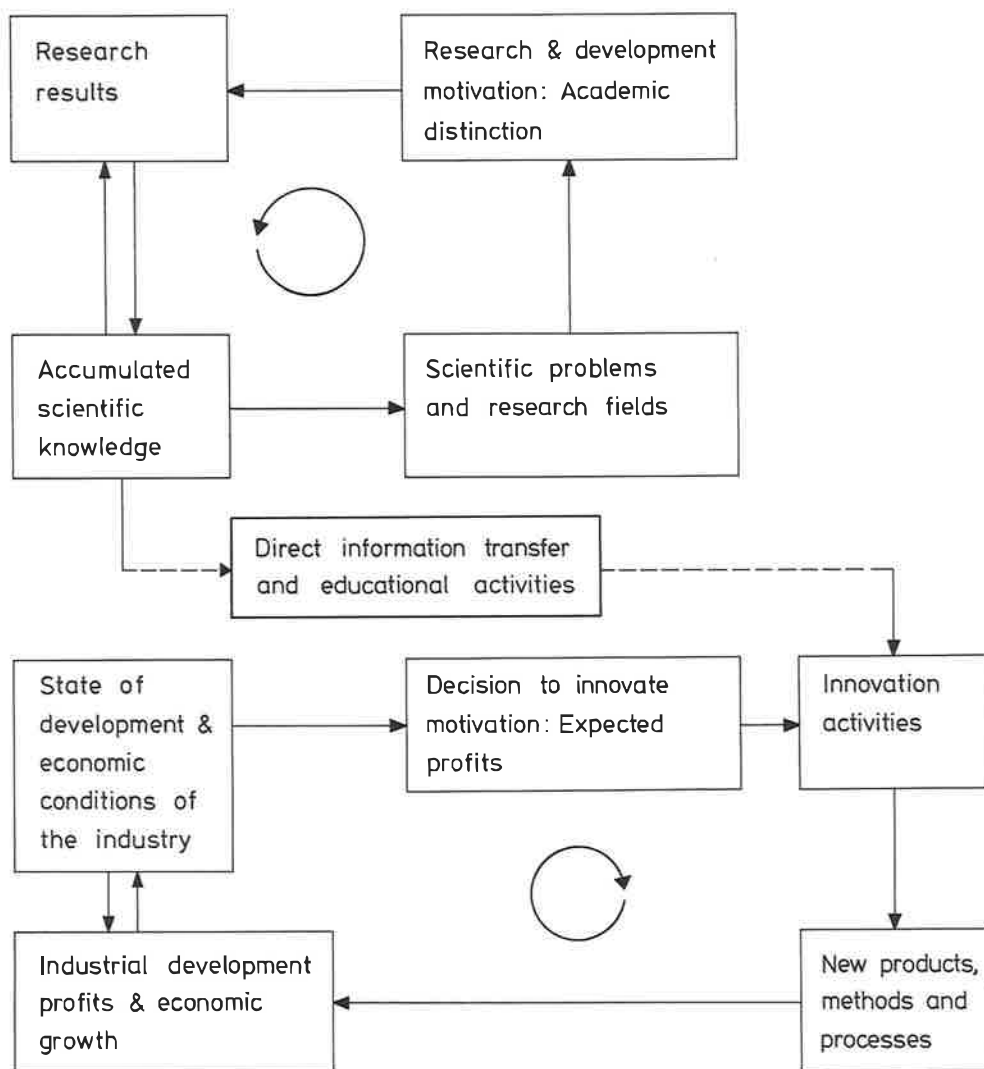
For many, innovation means the big things involving highly advanced technology, as television, jet engines or computers. This view is not incorrect, but it certainly is incomplete. There is a multitude of minor, or incremental innovations that have great significance for economic development. Often the components of a new product or method are well known and not new at all; it is only the combination that makes it something new.

One of the major results of the empirical studies on innovation is the undeniable evidence that an innovative activity starting from a well identified need, whether social or in the market, has a far greater chance of success than an activity starting from a technical possibility. In short: Need-pull is far more effective than technology push - in rough



The false concept of the “innovation chain”

Figure 1



Haeffner's model, with a research and an innovation loop, both self-contained and only weakly coupled

Figure 2

figures the ratio is 4 to 1.

Another interesting result touches the sources of information innovators use. Not all investigators agree on this quantitatively, but their results indicate that innovation is mainly due to the utilization of generally disseminated and easily accessible knowledge by creative individuals.

This unavoidably leads us to the concept of technology transfer. Simply defined, transfer of technology is the process of employing a technology for a purpose other than for which it was developed. While 'normal' R & D tends to emphasize creative laboratory work, technology transfer focusses on the utilization of previous research. Of course there is no clear demarcation between the two, just as there isn't between basic and applied research, as technical development involves aspects of both. The changing role of R & D institutions, mentioned in the title of this paper, is closely connected with the shift of emphasis towards technology transfer. By now it will be clear that this has to be seen against the background of what we now know to be essential in the innovation progress.

Probably the most important barriers to technology transfer and in consequence to utilization of existing technological knowledge, is the fact that those who generate or possess the knowledge and those that are or should be interested in its utilization, are completely different. Not only their motivation, but also their approach is different. Strangely enough, it seems that we have been getting fully aware of this only recently. This fact has been touched upon in the Innovation Advice of the Dutch Advisory Council on Science Policy, and the Science Council of Canada has said in its report 'Innovation in a cold climate':

"There has been an over-emphasis on producing generators of information and not enough stress on putting existing information to work."

To find a solution to this problem is of the utmost importance for governments, because usually they fund a major part of the national research effort. The Dutch Advisory Council on Science Policy has suggested that knowledgeable people should be appointed in each Department involved in R & D and innovation, as a kind of senior scientific officers. In Great Britain, a number of these civil servants, called Science Advisers, have already been appointed.

In the first half of this paper a number of aspects of complex subjects like R & D, technology transfer and science policy have been discussed. The second half will give a number of examples about how these concepts can be, and are being used to solve pressing problems of society.

But first, let us sum up the most important conclusions we have reached so far:

- We remain interested in progress, if not in economic growth, than more in improvement of the general quality of life.
- Science and technology should lead to innovation through R & D, but this is far from an automatically acting process. Generation of new knowledge does not lead by itself to utilization of that knowledge.
- The motivation of people engaged in innovative activities differs markedly from that of people engaged in R & D. Lack of effective communication between generators and users of knowledge acts as a major barrier to reasonably fast application of new scientific knowledge.
- Empirical studies on the process of innovation tell us that need-pull is much more effective than technology-push.

We have seen that the Dahrendorf programme mentions two principal areas where R & D should lead to innovation:

- In response to social requirements;
- In industry.

With respect to the first area, the OECD has issued a report which is very interesting. It contains a list of social concerns and indicators that are common to most countries of OECD. This list is a first step towards a kind of 'social marketing' and it is extremely useful for the identification and specification of social needs that have everything to do with the quality of life.

The list of OECD contains 24 'social concerns' and is far too long to be presented here

in detail. But the 24 'social concerns' are split up into 8 groups that give a very good impression of the kind of subjects and problems singled out by the OECD:

1. Health
2. The individual development through learning
3. Employment and the quality of working life
with subdivisions like:
The availability of gainful employment for those who desire it
The quality of working life
Individual satisfaction with the experience of working life
4. Time and leisure
5. Command over goods and services
6. Physical environment
with subdivisions like:
Housing conditions
Population exposure to harmful or unpleasant pollutants
The benefit derived by the population from the use and management of the environment
7. Personal safety and the administration of justice
8. Social opportunity and participation
with subdivisions like:
The degree of social inequality
The extent of opportunity for participation in community life, institutions and decision making.

Of course, these are large subjects, but in its report the OECD tries to break them down still further to more specific and less abstract items, and the complete list can be most helpful as a guide for actual R & D programmes. It is an attempt to operate the need-pull mechanism in fields of R & D of a more social nature, hence the use of the term 'social marketing'.

Apart from international organizations like the EEC and the OECD, other institutions of a more individual or national nature have started activities in the field of public technology. In the United States the Technology Utilization Office of NASA joined forces with the International City Management Association and founded Public Technology Inc. with the specific object of: The application of aerospace technologies and expertise to the solution of selected municipal problems.

The first thing this organization did was to bring physically together the people who grappled with municipal problems with the people who might have the technological answers or solutions. This was done to minimise the lack of communication between both parties and to obtain workable formulations of the various problems. This approach resulted in a list of clearly specified problems confronting local authorities that may be solved by existing technology, this time based on aerospace research. Some items on the list are: self-contained breathing apparatus and protective clothing for firemen, short range communication systems, a locator for underground pipes and conduits, body armour for policemen, disposal of toxic and inflammable wastes and emergency patient monitoring.

In Germany the same type of problems is studied by Systemplan at Heidelberg and by the Institut für Systemtechnik und Innovationsforschung at Karlsruhe.

A completely different aspect of the interaction of technology and society is risk, or rather risk analysis. For a long time the central government of the Netherlands saw as its prime responsibilities traffic and civil engineering (flood prevention), and it did not show overly much interest in other risk areas. But as the country is getting more and more industrialized and the population is still growing, quite a number of other risks have to be studied and assessed carefully.

It was TNO which started the systematic approach on this subject and recently created a risk analysis group. But before doing this, TNO deeply investigated the needs of central government, of local authorities - especially in industrial areas like Rijnmond, IJmond and Moerdijk - industry itself and the insurance companies. Risk involves both the chance that an accident will occur and the damage as a consequence of the accident,

and it has to be assessed for many other aspects than purely technological ones only. But the latter remain very important in risk analysis, and that is the reason why TNO took the initiative. To my opinion it is a good example of social marketing: first the identification of a social need and then the opening of communication channels for the transfer of the broad technological knowledge of TNO.

Although the number of examples in the field of public technology could be multiplied with ease, we will leave it at this and turn to a related subject: The importance of new approaches for the changing role of R & D institutions. Here I will draw my examples from our own work at the Industrial Research Organization TNO. In 1973 we investigated innovation in the field of transport over short distance and of handling of materials. This study corroborated the result of others that need-pull is far stronger than technology-push. Around 80 to 90 per cent. of all innovations had their origin in a need recognized in the market, and only 10 to 20 per cent. were based on the availability of certain technologies. But the main purpose of the study was to find out how innovation in industry could be enhanced and accelerated. Using our own results and those of others we could conclude that assistance to industry, in order to be effective, should involve more than R & D alone. The results of the study of 1973 fully confirmed our experiences of many years with the provision of assistance to the Dutch foundry and metal-working industry: Effective communication is crucial and maintaining it is extremely labour intensive. Communication channels tend to become blocked sooner or later, and so they should be inspected regularly and cleaned whenever necessary, activities that may be time consuming.

The other example I want to give is what we call 'product development'. In our view this involves a number of steps like:

- Definition of the product.
- Specification of the new product, which shapes it during the development phase.
- Conceiving of a method for manufacture and optimization of the product to be.
- Decision on the method of manufacture and preparation for commercial production.

Innovation carried out in this way calls for an integrated approach which includes research, development, market analysis and economic feasibility studies.

Another important aspect of innovations is finance. A number of countries have established special organizations for the provision of capital to industry whenever the risks are exceptionally high, like the National Research and Development Corporation (NRDC) in the United Kingdom and ANVAR in France. At last year's Conference the NRDC and some of its problems were mentioned in the paper of Professor Freeman, and the activities of ANVAR were discussed by Professor Saint Paul. It is remarkable that the NRDC was created as early as 1948. When a firm or an individual has an innovative idea, but lacks the capability to translate it into a new product or process, these institutions can be called to assistance. Of course, an important part of their task is to promote the introduction in industry and society of results of research sponsored by government. They carry out a number of activities, as:

- collection of new ideas and inventions
- evaluation and feasibility studies
- market research and marketing
- patenting
- bringing together generator and user, often through personal contacts
- and last, but not least: finance.

These institutions act as mediators, they do not carry out research and they often participate financially in new projects. It is quite interesting that in these institutions ideas have evolved considerably. For example, when the NRDC was created, it was thought in the UK that there were quite a number of good ideas and inventions lying around and just waiting to be applied; that they could not find application for lack of research, development facilities, capital and so on. This reflected typically the attitude of technology push. But by now the NRDC has become convinced that need-pull is the stronger mechanism.

Here too, the examples can be multiplied with ease, but it was only the intention to give an impression of some of the new approaches used to introduce results of research into

industry and society. Integrated assistance to industry is especially important for small and medium sized industries, and there problems often are of a more general nature than technological only:

- financial risks of innovative activities are simply too high in many cases
- management is concentrated on day-to-day problems and lacks time to look into new things
- there usually is not enough staff to do market research, to extend the administration and so on
- and lastly, high risk capital is very costly.

Let us try to sum up. Although the concept of the innovation chain is a highly improbable model and actually has been refuted by the facts, it still exerts a great influence on our way of thinking about research, development, technology transfer, innovation and so on. More realistic models, like Haeffner's one, have given us a quite different view of the matter. The two loops in this model, the research loop and the innovation loop, are both self-contained, and they are coupled by an information flow which only provides a weak link. As soon as research institutions try to change this, then by doing so, they change their own role. Strengthening of the information flow can have surprising results, and for my last example I will draw from our own experience again. About four years ago the Netherlands Reactor Centre and TNO started the publication of a joint quarterly, called *Innovatie*. It is distributed as widely as possible among interested parties and it contains rather short articles on new processes, products or instruments developed at the one or the other research institution; why they were developed and how you can use them. The facts are provided by the research scientists, but the editing is done by an experienced science writer. The publication consistently aims at the sphere of interest of the manager. If we may judge by the high response rate, this quarterly fills an important and deeply felt need. But as short as five or six years ago, this way of shopping for potential users would have met with furious resistance, as then the concept of the innovation chain still ruled supreme. Research was one thing, an activity that would lead eventually to innovation, and popularization of research results was quite another thing, and never the twain should meet. Research institutions that have strengthened communication with their potential users, have changed their role by adding another activity to their programme. Although it is manifestly impossible to predict the future, one may discern, even if somewhat dimly, a few trends that could affect the role of research institutions in the future.

In their paper, Professor Castagné and Mr. Müller maintained that since the creation of the EEC most industries have refused to play the European game. But sooner or later the advantages will become obvious and then the transition from a national to a truly European science policy will have important consequences for the role of existing research institutions.

A second point is the time lag between the publication of new knowledge and its application in an innovation. Yesterday, Dr. Altenpohl projected a graph showing that there is a considerable time-lag between the generation of new knowledge and its application. His slide also indicated that the speed with which new knowledge is applied usually falls short of expectations. In view of the steadily rising costs of research this is causing concern, and many countries are trying to change the situation. The Technology Utilization Office of NASA is an example of a way the USA follows to solve this problem. Intimately related to all this is the modern insight that need-pull is a far more effective mechanism than technology-push. Correct identification of needs determines success or failure in about 80 per cent. of all cases studied. Whether one uses known technology or known research results to satisfy a need is rather immaterial, and in this respect technology transfer and R & D are not enemies or competitors, but complements and allies. However, to use existing knowledge effectively one should know rather exactly what is known about a certain subject at a certain time. Returning to Haeffner's model, this calls for an enhancement of the information flow between the research loop and the innovation loop. For this, we can turn to last year's Conference, to the paper of Professor Shapero who discussed the importance of the "high communicator".

American and European experience has shown that hiring and, of course, stimulating high communicators can pay important dividends, if only by avoiding duplication of effort. Whether these people should be inside or outside research can only be decided in each case, but their mere existence certainly will influence the role of research institutions.

Each trend that has been discussed just now may not cause in itself big changes in the role of research institutions, but joined together they might do so.

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