12th INTERNATIONAL TNO CONFERENCE

Industrial Innovation in a Changing Society; Opportunities and Limitations

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Opening address

Dr. L. B. J. Stuyt
President of the Netherlands Organization for Applied Scientific Research TNO

Ladies and Gentlemen,

It is a pleasure and a privilege for me as President of the Netherlands Organization for Applied Scientific Research TNO, to welcome you at the 12th International TNO Conference.
This year the theme of the Conference is:
Industrial Innovation in a Changing Society; Opportunities and Limitations.

Innovation itself is not a very original subject for a conference such as this one. Although innovation is as old as mankind, it were the economic circumstances of the early seventies that brought home to many that technological change is a very important power behind economic growth. Then the mass media discovered it as an interesting subject and innovation, or its absence, became the talk of the town.

So we can ask ourselves: has not innovation been discussed widely enough? Perhaps it has and therefore we added to the title of the Conference "in a changing society", to emphasize the mutual interaction between technological change and society. As a number of speakers will point out here today we know many things about the innovation process, but we certainly do not know everything about it. We know that there is feedback between technological change and society, but the interactions are very complex and there is still a large amount of research to be done before we can state that we understand the innovation process. A good example is the influence of education. Universities turn out those who will become top executives in industry or the civil service and who by their influence may affect the kind of education later generations will receive.
Government provides the means to do fundamental research at universities and its results often are a basis for technological innovation, which on its turn gives research new and better instruments.
This is the famous science-technology spiral described by Professor Casimir, at the same time it is a clear example of a feed-back system.
Education, however, is not an island but a part of society and if ideas and ideals in society change, one can see that the views of pupils and students shift too. There are indications that in many countries of Western Europe one can distinguish three generations of engineers after 1900. Those educated between 1900 and 1950 think purely technically. The second generation, from 1950 to 1970, is also interested in economic factors, especially costs. The generation which appeared after 1970 has discovered the social side as a third element.
They recognize the importance of notions such as energy, raw materials, pollution and ecology as a supplement to a purely technical and economic way of thinking.
There still is another important word in the title of this Conference: the limitations to innovation. We should never forget that in any society the velocity of change is not only finite, but also rather low.
It takes some time before a new product has established itself on the market and the introduction of a new and better process in industry may even take tens of years.
There are sound economic reasons for this phenomenon, but some of the resistance to change has a psychological basis. Trying to force the pace of innovation is always self defeating and can give rise to violent reactions from the public that seem irrational to the supporters of fast changes.
On the other hand one concept has won general consensus: effective innovation, effective technology transfer or effective technology acquisition requires an appropriate scientific and technical infrastructure at the user's end. Many efforts towards innovation have failed through lack of this essential condition.

One most often repeated and recognized mechanism is people. Successful innovation always occur through people, and personal interaction is indispensable for assuring the effectiveness of innovation. Failures of successful innovation are ofte due to lack of real personal interest both at the source and user's end.
These and other limitations to innovation will crop up in a number of papers at this Conference.

In conclusion I would like to touch upon the role of TNO in industrial innovation in our country. Its main task is to assist at the maintenance of prosperity and welfare and we think that in this respect assistance to small and medium-sized firms is of special importance.
This too is a subject that will be discussed in one of the papers. To provide these firms with new ideas is but one side of the problem, assistance in managerial and financial matters often is of equal importance. For that reason TNO is in contact with financial and other institutions, providing risk-capital for innovation projects. Nearly everywhere it is realized that governments have an important role to play too. In modern societies a range of problems such as pollution and energy, to name but two, calls for governmental intervention and that leads to new solutions and innovation.
It is encouraging that recent studies in the U.S.A. seem to show that governmental measures for example for the protection of the environment are economically advantageous in the long run and do not lower employment.
On request of the government TNO is engaged in finding solutions for problems of tomorrow. This part of its work is carried out in close cooperation with industry, as industry will have to carry out the solutions that result from these studies.
Finally, TNO is also active in the field of policy analysis. Here TNO participates in studies about the role of governments in industrial innovation, for example in the Six Countries Programme on Government Policies towards Technological Innovation and Industry.
This too will be mentioned in the next two days.

Ladies and Gentlemen, these examples illustrate of course only a part of the work of TNO. This Conference will give us more information about the possibilities of industrial innovation in a changing society, which we shall be discussing for the next two days.
I hope to meet you again at the Conference dinner tonight.
I now declare this Conference open and I would like to ask Professor Van der Kerk to start the proceedings.

The role of the Netherlands Government in respect of Innovation

Drs. M. W. J. M. Peijnenburg
Minister of Science Policy
The Hague
The Netherlands

Ladies and gentlemen,

One of the most striking features of our times is their increasingly international character. More and more countries are being drawn into the worldwide economic system and more and more economic activities have international aspects and repercussions. Also, more and more enterprises are seeking international markets or a broader international base for their activities, or are feeling the pressure of competition from hitherto unexpected parts of the world. Technology has brought about the great advances in transport and communications which are responsible for the changes I just described.
This same technology is one of the sectors towards which government action in the field of innovation is directed everywhere in the world. One almost gets the impression that governments are racing one another to see who can be first to draw up an innovation policy. In the United States, those who fear that their country is in danger of losing its lead in the field of technology often point to Japan and West Germany as competitors. In spite of this, many people in Europe still envy the United Sattes on account of its capacity for innovation, especially in the field of technology, and on account of the features of American society which are thought to be responsible for this. The growing series of memoranda on innovation bears silent witness to all this.

As many of you will know, we in the Netherlands do not hang back in this respect, and I hope to show in the coming summer together with the Minister for Economic Affairs, that we have understood the signs of the times.

I do not say this lightly. On the contrary. I would like to put three main ideas to you, the first of which concerns understanding the signs of the times. It is my conviction that a good policy on innovation van only be achieved if a country views its economy quite rationally in the ligth of the numerous technological, economic and social developments which sometimes take place over a considerable period of time. I should add that a good innovation policy as I see it means a policy which is effective from the economic angle but which at the same time takes account of the social repercussions, desirable or otherwise, of innovation.

The second important point I wish to make is that an innovation policy also because it is not an end in itself, has something in common with an octopus. Its tentacles reach into almost every sphere of government policy. This in practice means two things. First, many people in the governmental sector must become aware of the importance of innovation and the points of contact between it and their own sphere of activities; and secondly, it will generally be most effective if a combination of steps is taken in different spheres of policy.

Finally, I propose to discuss the research and development potential in the Netherlands and policy on science and technology, which is only one of the areas of policy concerned with innovation, but an important one. I intend to show that in this research and development potential the Netherlands possesses something of great importance, with its own distinct character differing from that of other countries but also presenting a number of problems which will have to be solved by science and technology policy directed towards innovation.
I now come to my first subject, I shall briefly discuss a few important developments all of which demonstrate that the social, economic and technological context of innova-

tion policy is far from simple. Let me begin by mentioning the international division of labour, which is partly based upon objective economic factors. The Netherlands became great through among other things trade and its favourable location, whereas the economies of many other countries are to a large extent determined by the availability of raw materials or the fact that wages are low. A more dynamic factor in this respect are the abilities that people developed on the basis or opportunities that circumstances offered. But what interests me is not so much the phenomenon per se as the changes in this international division of labour, many of which are brought about by the emergence of new technologies or the diffusion of existing ones. In my introduction I mentioned advances in transport and communications technology. But the technology embodied in products and production processes is also increasingly becoming available to the newly industrialized countries and is now even to some extent being developed by them. The first answer which we are inclined to give to this challenge from the 'new Japans' - and the challenge could in time become a far more formidable one than the American one of the mid-Sixties - is that we should aim at more knowledge-intensive products. This answer is correct in principle, but it is oversimplified and incomplete. It is oversimplified because existing technology is being taken over and modified by newly industrialized countries increasingly rapidly, so that with all our efforts the technology gap will be closed in many fields within 10 or 15 years. The answer is also too simple because the product range of, say, the Scandinavian countries, Switzerland and West Germany shows that products with high added value (as I think we can reasonably expect our products to be in the future) need not be knowledge-intensive products.

Both these arguments lead me to emphasize the fact that Dutch society will increasingly have to ask itself where the real possibilities lie. Consideration of technological, economic and social developments against the background of our traditional goods and services industries must provide the impulse for selectivity, such as choosing products which are environmentally acceptable and processes which are economical on energy as well as deciding which goods and services and which markets are appropriate for a country like the Netherlands; as far as the products are concerned, I have already mentioned products with high added value being suitable; another, and now negative specimen, would perhaps be mass-produced products.

It is clear that such choices are made against the background of very different social and cultural attitudes to work and economic activity. Attitudes vary great between the United States, Europe (if it is permissible to generalize for the whole continent), Japan and the new generation of industrialized countries; moreover, they are attitudes which are more or less constant factors and thus do not lend themselves readily to change. Hence, however much one may sometimes deplore a certain risk aversion or low esteem for outstanding cleverness or achievements in our societies, they are to some extent facts of life not very well amenable to government influence.

By what kind of considerations must we or can we be guided in our choice. I shall mention one or two. Some people believe they detect a technological recession or saturation at present. I remember, for example, speaking at a symposium at the end of last year where Mr. Wack of Shell Planning spoke along these lines and gave arguments to support his view. His main point was that the transformation of knowledge into economic progress via applied technology will not proceed at the same rate in coming years as in the last 25 years. Questions which we shall have to put ourselves are: if there is such a recession what are its causes? Does it affect all areas of technology and the economy? And above all, how permanent is it? Wack also mentioned one obvious way out, the rise of micro-electronics, although he was certainly not optimistic about its effects on employment in the initial period, especially in the services sector.

This brings me to a second consideration. Innovation policy must not be restricted to industrial innovation. Manufacturing and service industries are becoming increasingly interrelated, and it is an interesting question whether in a country like the Netherlands there may not be possibilities precisely at this interface. The service industries are

also increasingly affected by technological developments. Banking and insurance are spoken of in connection with the introduction of micro-electronics, and examples can easily be found in transport, health care, education and even retail trade. Surveys of developments and potential in these service industries will also have to assist us in mapping out innovation policy.
Now a third consideration, which I see primarily as calling for action from ourselves, by which I mean the government. All kinds of indications suggest that new firms, including small firms, should have a special place in government policy. In the United States it is certainly the case that there is a positive correlation between employment and the number of new or rapidly growing small businesses; Mr. Wack gave some figures in support of this. On the other hand there are signs there too of a slump in the setting up of new firms and especially technologically advanced ones. We are primarily interested in gaining insight into this phenomenon as it applies to the Netherlands, and a study of it is currently being conducted for the Ministry of Economic Affairs. Firms of this kind do not have an easy time of it, as has been shown by various studies on the subject of venture capital for example.

I would like to end the first part of my speech with two concluding remarks. Firstly, we do not have any forecasting agency in the Netherlands which could assist industry, the government and society in surveying and assessing technological, economic and social developments. The second conclusion I have already implicitly stated: I certainly do not think that it is for the government to make the choices which will ultimately be necessary. It will help the government to decide its policy if people give thought to the questions I have raised about the future, and if industry and other groups in society make their views known. And certainly representatives of labour ought to take part in these discussions. I really hope that a full-grown dialogue (or trilogue?) on the rate and direction of technological change in the various sectors of our economy, and on the degrees of freedom left to us, will turn out to be possible. Now I come to the government's possible role in promoting innovation. This role is a many-sided one.

Looking at the various fields of government policy, one sees that many of them influence ability and readiness to innovate in trade and industry.

For the purposes of promoting innovation, I would like to divide the various fields of policy into three general groups: firstly the supply side - assistance and advice to individual firms; secondly, policies affecting the background against which firms must function - industrial policy, financial and economic policy and also, I would like to emphasize, social and cultural policy; and thirdly the demand side - fields of policy in which the requirements of the collective sector are formulated.

Before saying any more about the importance of these various fields of government policy for innovation, I would mention that although better utilisation of science and technology are central themes of the forthcoming innovation memorandum, I attach equal importance to its catalytic effect on other spheres of governments policy and its capacity to promote awareness about innovation.

As to supply this side, I shall return later on to science and technology policy.

The second point here is education policy. Our country's valuable knowledge potential, from which we can expect important contributions towards innovation, is rooted in our educational system and the policy on which it is based. But our high level of knowledge should not make us complacent. As I said in my introduction, the division of labour and the demand for certain kinds of qualified labour are changing rapidly. These developments obviously call for alertness in educational policy. In particular, retraining and refresher course facilities must be developed much further. In addition, in order to stimulate innovation awareness, consideration could be given to including a management component in some scientific and technical training courses and to increasing the opportunities for in-service training, alternating with formal courses etc.

I'll mention another area:
In view of the fact that innovation is bound up with many aspects of running a business,

In view of the fact that innovation is bound up with many aspects of running a business, a good information and advisory system is of great importance for promoting innovation. As is the case with the various R & D-institutions a certain demarcation of the respective spheres of activity of the advisory bodies seems possible and desirable.

I shall now turn to the government as a source of demand for as having influence over demand. The relevant policy areas are the procurement of goods and services, regulations as to products and industrial processes, and finally a balanced growth.

First the procurement policies. It is important to stress that such a policy is more than simply buying nationally produced ready made goods. I consider the interaction between the consumer - in this case the government - and the producer to be of great importance in product development. Only then will new opportunities arise. The well-known U.S. example of the development of semi-conductor technology shows to what extent government contract allocation policy can stimulate innovation.

In the Netherlands we have simular examples in the fields of telecommunications and public works. At the same time, cancer research is an example which shows that no matter how urgent demand may be, scientific and technical development imposes limitations on the possibilities of innovation. For this reason effective interaction between the government, industry and science is necessary for a succesful procurement policy to be developed on the basis of collective insight into needs and technical and commercial possibilities. As for the government's part in this, I do not think that it should be restricted to central government alone. Lower echelons of the administration can also stimulate innovation by means of contracts. It is desirable that these authorities should come to some kind of agreement and if possible to a common formulation of their needs. Recently the Minister of Finance has established a committee on government procurement. I am represented on that Committee and I consider it my task to take initiatives there from the point of view of innovation policies.

I shall now say something about the importance of a balanced growth policy for innovation. The Netherlands is being confronted with new scarcities at an early stage due to its population and its situation as regards energy and raw materials, and it will have to find an answer to these problems sooner than other countries. I have said on other occasions that this gives us a unique opportunity to take the lead in technology and develop attractive export products in such fields as environmental technology and substitutes for raw materials. As an illustration I would point to hydraulic engineering, where the Netherlands has succeeded in converting a comparative disadvantage - the essential and increasing battle against the sea - into a comparative advantage as regards experience and expertize in this branche of engineering.

We must make systematic efforts to discover what opportunities a balanced growth policy presents for innovation. Fortunately work is already being done in this field, particularly by the Ministry of Public Health and Environmental Protection and the Ministry of Economic Affairs. As an example I would mention the Committee on Industry and the Environment. But it seems to me that the work already in progress can certainly be extended. Procurement policy could also be more closely attuned to balanced growth policy, while closer ties should be created with the world of research in order to gain more insight into the possibilities and limitations of science and technology. This latter point is of particular importance for the relationship between regulations and innovation policy. Good phasing is necessary to ensure that requirements are such that technology can reasonably keep pace with them. Experience in America shows that excessively demanding regulations can be counter-productive.

However, if reasonably phasing is adhered to and the international aspects are borne in

mind, regulations can be used to guide and stimulate the interaction of balanced growth policy and innovation policy.
In this context I would also particularly like to mention the humanization of labour. The creation of clean and enjoyable work should be one of the principle aims of a socially responsible innovation policy.

Insight in the possibilities opened up by science and technology, and insight in the needs expressed in the marketplace or in the political process are essential here. This requires that government, industry and society can call upon the country's research and development potential. In my capacity as Minister for Science Policy I shall now turn my attention to the availability and effectiveness of this research and development potential in the Netherlands which is both substantial and many-sided. Generally speaking, one can say that the quality of research and development work here is high, although there is some danger of erosion through among other things lack of mobility, the ageing process, and an increase in administrative commitments.

Government support for research and development of importance to the manufacturing and services industries is mostly indirect. This can be historically explained, at least in part, by the dominant position of the multinationals, which can provide their own research and development. But there are also many small and medium-sized firms in the Netherlands without research and development departments of their own. Hence the establishment of an organization like TNO. Another example of indirect aid on a substantial scale is the National Aerospace Laboratory, which is chiefly of importance for the Dutch aircraft industry. I mention these examples in order to show that the Dutch Government does indeed give appreciable research and development aid to industry, albeit indirectly, Increasing its effectiveness now is the catchword, and a greater orientation towards needs for example by binding government subsidies to more or less explicitly stated opinions of trade and industry.

Certainly a lot can be imporved if we take as a criterion the ability of the R & D-infrastructure to provide usable solutions to social and industrial problems.
Research establishments are often not suffiently orientated towards outside problems. A strategic effort for determining the appropriate reasearch areas is only slow to develop. Cooperation between the various institutions on the basis of a clear definition of their respective tasks in promoting innovation could also be considerably improved, for instance between the TNO and universities of technology and between universities and industry.

I would now like to consider in greater detail the position of TNO within the research and development infrastructure. It is a unique instrument which, if properly used, could become an important driving force in the whole innovation process.
Innovation-oriented activities are already carried on in many parts of TNO much to the benefit of some manufacturing and services industries - not only in its Agency for Industrial Reasearch, but also in the other Agencies for food, defense and health research. In principle this broad spectrum is a good thing but the variations call for a differentiated policy. It seems to me essential that TNO should create for itself and the outside world a clearly defined pattern of innovation tasks or functions, research areas and client groups. Based on such a pattern it could then improve its market orientation, for this must be an essential characteristic of TNO operations. Only then can TNO succesfully counter the accusations which can be heard now and then of too academic an orientation. For this to be achieved it is necessary not only to create new interface mechanisms and improve existing ones, but also to bring about a change of mentality. In my view the time for talking is just about over. It is high time for experiences which have proved successful to be extended and utilized in other parts of TNO. A strategy for improving the market orientation must be developed. Moreover, TNO will not be able to avoid establishing priorities and making choices with regard to the research areas. Quick and effective action must be taken to correct the present state of unreadiness in this respect.

My words should not be misunderstood: I remain convinced of the great value of TNO as I am convinced of TNO's own determination to enhance its effectiveness for the support of innovation in industry and service sector. I will support efforts in this direction as far as possible.

In a similar vein it is my view that the Dutch R & D-potential as a whole is capable of initiating and stimulating innovatory action. For this reason, the innovation promotion programme which is being worked out by the government takes the existing research and development potential as its point of departure. The aim of the programme is to design the instruments and measures needed to bring research and development establishments into closer harmony with the needs of industry and society. Individuals and establishments concerned are continually called upon to cooperate in developing the programme. I will mention later on a few examples of such involvement.

In addition to this I find it important that the measures and instruments which are being prepared should for the time being be of an experimental nature. Rigid structures must be avoided at all costs; flexibility must remain a central concern.

The innovation promotion programme will also make use of the possibilities opened up by cooperation. Where different sectors of the research and development potential naturally supplement each other there are excellent opportunities for effective cooperation, for example in the chain between pure and applied research or at the interface of two or more disciplines, such as technology and the environment. I would like to conclude by giving a few details of the initiatives which are to be developed within the framework of our innovation policy.

A broadly-based working party is examining the possibilities of a programmatic approach. The universities, TNO, the major research organizations such as the Netherlands Energy Research Centre and Industrial laboratories would have to join forces to carry out a programme of this kind. I also see a role for professional associations in drawing up such programmes, for instances the Royal Netherlands Chemical Association and the Royal Institute of Engineers. Especially when one considers that associations of this kind view problems from a variety of angles - from the point of view of industry and of the universities for example - it is evident that their assistance can be fruitful for the forming of ideas.

As regards the transfer of knowledge, a working party in which the universities of technology, TNO and the Government Industrial Advisory Service are represented, among others, is working on a proposal concerning the promotion of transfer of knowledge to small and medium-sized firms.
People carry knowledge with them wherever they go. Thus when considering the subject of transfer of knowledge we must not overlook the very complex structural mobility problem. One of the best ways of tackling this problem will be to experiment with the secondment of staff.

The transfer of knowledge also includes the diffusion of knowledge. I hope that we will succeed in finding ways of giving information to small firms about the use of micro-electronics. The Advisory Group for micro-electronics as well a recent initiatives of the Ministry of Economic Affairs certainly will be instrumental in this respect.
I attach great importance to future activities aimed at discovering and articulating individual and social needs. The coordination and mutual reinforcement of policies relating to procurement, balanced growth and innovation to which I referred earlier will have to be based on these activities. Problems connected with raw materials, environmental technology and energy savings are or will hopefully be attacked by means of pilot projects.
Finally and this really refers to the first part of my talk I would like to mention technology surveys, which will be intended not only to increase general insight but also to indicate areas where productive work can be done.

To summarise, the innovation promotion programme has the following three aims:
- to articulate the demand for and supply of knowledge;
- to orientate research and development potential towards the demand for technology; and to stimulate the exploitation of technology and:
- to create and reinforce cooperation both in the sphere of government policy and in the world of research.

Ladies and gentlemen: I have now come to the end of my speech. I have described the role of the Dutch Government in innovation as I see it. I would like to close with a warning and a word of encouragement.

The government can stimulate as much as it likes. But if industry does not respond to such encouragement, innovation policy is doomed to failure. I call upon those of you working in the Dutch context not to let such a state of affairs arise but to do everything within your power to support the innovation which this country so badly needs.
Thank you.

Significance and Function of Innovation in Present and Future Society

Mr. K. L. R. Pavitt
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Brighton
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In this presentation, I shall look at three interrelated factors industrial innovation, international competitiveness and economic welfare, and shall try to identify some of the problems that you may wish to discuss over the next two days. I shall argue that industrial innovation has been important for competitiveness in the past, that it will be equally - if not more - important in the future. The requirements and consequences of innovation will pose difficult problems for industry, for government, for the economics profession, and for those who want to see a more united Europe.

1. Past Studies

Those who work in specific firms are well aware of the nature and the importance of the innovations (in the form of new and improved products and production processes, and related services) necessary for competitiveness in specific product areas. Over the past twenty yeras, a considerable body of empirical evidence has begun to accumulate to show that innovation is a necessary ingredient in competitive success in a number of industrial sectors, in particular, in the aircraft, chemicals and electrical and electronics sectors. [1)]

This evidence has had some effect in economics on the theory of international trade, with the development of the so-called 'technology gap' theories that explain the export pattern of the industrially advanced countries (and particularly the USA) in terms of the temporary advantage given to US firms by the pressures on them to introduce innovations before firms in other countries. Thus, the industrially advanced countries (and particularly the USA) have their comparative export advantage in the R&D intensive industries, where there are relatively more opportunities for innovation. [2)]

At the same time, detailed empirical studies have identified some of the factors that strongly affect the degree of success and failure of innovations in firms and that can be influenced by deliberate policies by management: continuing commitment of resources and managerial attention to innovation; balance amongst the many inputs into innovation, attention to marketing, user needs and after-sales servicing; efficient design and development work; good internal and external communication; high quality professional management. [3)]

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1) See, in particular, C. Freeman, The Economics of Industrial Innovation, Penguin, London, 1974; R. Miller and D. Sawers, The Technical Development of Modern Aviation, Routledge and Kegan Paul, London, 1968.

2) See, for example, W. Gruber, D. Mehta and R. Vernon in "The R and D Factor in International Trade and International Investment of United States Industries", Journal of Political Economy, Vol. 57, February, 1967.

3) For a recent review of these studies, see R. Rothwell, "The Characteristics of Successful Innovators and Technically Progressive Firms", R and D Management, Vol. 7, 1977.

In spite of this progress, some gaps in our understanding have remained. There has been very little detailed and systematic analysis over the whole of the industrial spectrum of the degree to which competitive performance in the industrially advanced world depends on a capacity for industrial innovation. In particular, there have been few studies of the nature and competitive effects of industrial innovation outside the 'science based' industries (chemicals, electrical and electronic, aircraft): - in, for example, non-electrical machinery and the durable consumers goods.
In addition, there has been little detailed and concrete discussion and analysis of the role of R and D activities and innovation in the strategy and behaviour of industrial firms in responding to competitive threats and opportunities.

For reasons that I hope will become clear by the end of this talk, filling these gaps in our knowledge is necessary if we are to be better able to understand and respond to the requirements for innovation in the 1980's. In the meantime, I shall briefly present some of the results of studies that, we think, begin to fill the gaps. They have been done in the Science Policy Research Unit and will be published at the end of 1979. [1)]

2. Exports, Prices and Technical Quality

But beforehand I should mention two other British studies by Saunders [2)] and Stout [3)], both of whom have made comparisons of the exports of engineering goods in the 1970s of Britain, France and F.R. Germany. Both show that German export performance is stronger than that of Britain and France in most product areas. Both also show that the Unit Values (total monetary value of exports divided by total units exported, in each of the product areas) are higher for German than for British and French goods. In other words, German engineering goods on the whole are relatively more expensive, yet they sell better, which is not what most economics text books say should happen.

One possible explanation emerges from the detailed studies of innovation in specific sectors that we have undertaken in the Science Policy Research Unit: German engineering goods are technically of higher quality, incorporating design features and performance characteristics that make them more economic to users than cheaper and technically simpler machines. When making purchasing decisions, users of machinery consider total life-time cost in addition to initial purchase price, and - given the physical interdependance of many industrial operations - they put a strong premium on reliability. Some preliminary evidence suggests that individual consumers may sometimes have the same behaviour when buying durable goods (white goods, electronic consumer goods, automobiles), where technical quality and performance might be becoming an important factor in competitiveness, in addition to price and to after-sales service.

3. Innovative activities and Export Shares

These arguments, although persuasive, are not entirely convincing (especially not to economists) since they are based on studies of only a few (perhaps unrepresentative) product groups in industry. Convincing evidence must explore systematically in all

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1) K. Pavitt (Ed.), Technical Innovation and British Economic Performance, Macmillan (London), to be published in 1979.

2) C. Saunders, Engineering in Britain, West Germany and France, Sussex European Research Centre, University of Sussex, 1979.

3) D. Stout, International Price Competitiveness, Non-Price Factors and Economic Performance, National Economic Development Office, London, 1977.

product groups the degree to which differences amongst firms and countries in competitive performance can be statistically explianed by differences in the level of innovative activities.

Until recently, the difficulty in doing this has been to find a sufficiently disaggregated and reliable proxy measure for comparing different countries' innovative activities. R and D statistics, although very useful, cannot be used yet, since they enable comparisons of only six broad sectors in manufacturing industry. However, the US Department of Commerce now has data on US patenting between 1963 and 1976, broken down into forty industrial sectors, and by country of origin. In spite of the many limitations of patent statistics, the number of patents awarded in the USA to OECD countries other than the USA, is at least as good a measure of innovative activities as R and D statistics, in all sectors except aircraft. [1)]

Our statistical analysis of forty industrial sectors, where we plotted each country's exports against its US patenting shows a very strong statistical relationship between export performance and innovative activities (measured through US patenting) in nearly all capital goods (including mechanical engineering), in nearly all chemicals, and in many durable consumers goods. In other words, innovation has been critical in the 1970s to competitiveness in product groups that make up at least two-thirds of the manufacturing exports of the advanced OECD.

4. Future Trends in Industrial Innovation

But will the requirement for technical innovation be as strong in the 1980s as it has been in the 1970s? I have argued elsewhere that it will be at least as strong, if not stronger. [2)] Pressure of competition from the newly industrialising countries in standard goods will continue to grow; patterns of consumers' tastes and expenditures will continue to change; energy and environment will continue to be scarce and expensive resources; and the opportunities for rapid technical change will remain considerable in electronics, and may become so in biochemistry.

Successful innovators will be those who respond to these trends. They will probably be those with a strong capacity for innovation in capital goods, processing engineering, fine chemicals, or durable consumers goods. This capacity will probably depend increasingly on formally established activities in research, development and design, and on the ability to mobilise and assimilate technologies from a wide range of sectors.

If this view of the past and the future role of innovation is correct, then it will pose a number of problems to industrial firms, to governments, to the economics profession and to those who wish to see Europe united.

5. Innovation and Firm Strategy

The nature of the problems and possibilities of adaption and innovation facing individual firms will clearly depend to a considerable extent on the types of products that they make and sell: coping with the future in textile products will be very different in many ways from coping with electronic products. Nonetheless, one can perhaps detect three classes of response of the firm to the changes and requirements described in section 4 above.

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1) See K. Pavitt and L. Soete, "Innovative Activities and Export Performance", in K. Pavitt (Ed.), Op. Cit.

2) K. Pavitt, "Technical change: the prospects for manufacturing", Futures, Vol. 10, No. 4, 1978.

The first response can be described as more of the same. It consists of trying to produce more or less the same products, in more or less the same way, in more or less the same place. Depending on the products in question, the policy consists of a strong marketing (for example, more advertising, price cutting) to try to keep up the sales of existing products; a resistance to environmental legislation and to high energy prices; a pressure for tarrif protection against foreign competition. In the sort term, it is the easiest and most comfortable policy. In the long term, it could be disastrous if it does not succeed in stopping economic and political change.

The second response can be described as a movement off-shore. It consists of producing more of the same in those parts of the world where labour, energy and environmental costs are lower. Profits will more easibly be maintained than in the first response. But it has three potential shortcomings. First, if carried too far, it will lead to resistance by the trade unions in the advanced countries. Second, it will be resisted by the countries receiving the investment, unless the firm helps build up local skills (which create new and independent sources of competition). Third, it could lead to undue emphasis on the search for even cheaper factor inputs, to the neglect of product and process innovation.

The third response is that of innovation. It has the disadvantage of being risky and uncomfortable, and of requiring a continuing and long-term commitment. It has the advantage of keeping the firm in emerging growth areas, and of ensuring highly qualified and highly paid employment in the industrially advanced countries.

6. Government Policies for Innovation

Given the importance of industrial innovation to competitiveness, employment, the balance of payments and levels of income per head, government policies to stimulate innovation have been a subject of growing attention in the 1970s as a part of industrial policy. [1] Previous efforts to promote innovation had been concentrated to a large extent on big and sophisticated R and D projects which often reflected the needs of particular lobbies rather than opportunities of changing markets. It is now recognised that a wider battery of policy instruments than R and D need to be used, that they must be adapted to, and applied over, a wider range of sectors, and that the policies should be clearly aimed at assisting change rather than stopping it.

Nonetheless, a number of important questions in innovation policy remain unanswered or only partially answered. What are the nature and effectiveness of the various instruments of government policies for innovation? How can government ensure that it has access to the varied competences necessary to formulate and execute policies in a wide range of sectors? Indeed, in many countries, how can government ensure that the necessary degree of competence exists amongst the managers, engineers and other workers in industrial firms?

7. Industrial Innovation and Economic Analyses

In spite of recent progress, the full implications of industrial innovation for economic analysis and economic policy are not yet fully understood. In a world where firms and countries in the OECD area compete through searching, selecting and exploiting new and improved products and processes, the following questions must be asked.

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1) See The Current International Economic Climate and Policies for Technical Innovation, report prepared by the Science Policy Research Unit, Sussex, and Staffgroup Strategic Surveys, TNO, Netherlands, 1977. C. Stoffeas, La Grande Menace Industrielle, Calmann-Levy, Paris, 1978. Boston Consulting Group, A Framework for Swedish Industrial Policy, October, 1978.

First, it is useful to assume that all firms automatically make optimum decisions on the basis of perfect information? In a world of uncertainty and rapid change, should not a firm's capacity to search, select and adopt new things be recognised as an independent variable in analysis and policy?

Second, can we expect exchange rate policy to be effective in national policy and in international adjustment when non-price factors (like technical quality) are of major importance in competitiveness? Is there any evidence of this in exchange rate adjustment processes of the 1970s?

Third, is it enough in innovation policy to stimulate effective demand and a favourable investment climate, thereby (it is argued) ensuring a high level of R and D expenditures and of diffusion of new technology? Although such a policy may be relevant to large-scale process industries (where most innovations are process rather than product innovations), is it relevant to capital goods and (to a certain extent) durable consumers goods industries, where most innovation is in products rather than processes, and where it can therefore be argued that investment is a consequence, rather than a cause of successful innovation?

Fourth, do the assumptions about convergence of levels of income per head in the OECD area that were prevalent in the 1950s and 1960s, [1] hold in the 1970s? In this earlier period, it was assumed that, given the gap in efficiency of production technology between richer and poorer countries, high and steady rates of investment would enable the poorer countries to close the productivity gap. But things have changed in the 1970s. The production technologies for standard goods have spread beyond the OECD area to Eastern Europe, Latin America and South East Asia, and the markets in the OECD area for these standard goods could soon be reaching saturation.

To use a sporting metaphor, industrial 'first division' countries could in the future depend on their capacity for innovation (in capital goods, fine materials, process technologies, and novel consumers goods), those in the 'second division' on their capacity for investment (in standard durable consumers goods and process industries), and those in the 'third division' on cheap labour (in textiles, footwear and other consumer goods).

8. Innovation and European Integration

If this view of the world is correct, there could be considerable problems in the process of European integration over the next ten years. Our statistical work and industrial enquiries at Sussex [2] give a reasonably clear and unambiguous picture of the countries in the First and Second Divisions. In the First, there are the USA and Japan, accompanied by F.R. Germany, the Netherlands, Sweden and Switzerland. In the Second Division there are France and Italy (moving up), and the UK (moving down). Second Division countries feel under threat from those in the Third Division (E. Europe, Latin America, S.E. Asia), since the gap between the Second and Third Divisions is not big; Spain, for example, has just been promoted to the Second Division. On the other hand, the gap between the Second and the First Divisions is big; only Japan has been promoted since the Second World War, and France expects to take twenty years to join it.

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1) See, for example, John Cornwall, Modern Capitalism: Its Growth and Determinants, Martin Robertson, 1977.

2) K. Pavitt (Ed.), Op. Cit.

Thus, problems will come in future from European Second Division countries threatened by new entrants from the Third Division, yet unable to make the structural transformations and innovations to join the First. This will be reflected in relatively poor competitiveness and relatively low income per head. It will result in conflicts with the richer EEC countries over regional and agricultural policies, and will hinder new initiatives. It could eventually lead to national protectionism and the collapse of the Common Market.

A European policy for innovation should therefore have as one of its major objectives the promotion of Europe's Second Division countries to the First.

I hope that this brief and inevitable superficial discussion of innovation shows, there is plenty to discuss, plenty to study, and plenty to do.

Innovation in the Dutch Metal Industry - Challenges and Constraints

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This paper is based on the experiences of the Rhine-Schelde-Verolme group, which is part of the Dutch Metal Industry.
The RSV group is fairly representative of Dutch heavy industry in the metal sector, as its main activities are:
- shipbuilding and ship repair
- off-shore
- naval shipbuilding
- power division
- industrial equipment
- process systems and equipment
- electrical systems and equipment.

The theme of this Conference is 'Industrial Innovation in a Changing Society', and as such clearly consists of two items: the changing society and industrial innovation. Nowadays many reports and articles state that, maybe as a result of changes and trends in society, the economic outlook is rather grim.

Another important issue in these reports and articles is industrial innovation, and often the question is posed whether industrial innovation will or can be the answer to the problems of present society.
In our type of industry the answer is a clear yes: innovation is an absolute necessity. One can put it even more stronger: a firm that does not innovate, gives up its chances for survival.
In fact, it seems justified to add innovation to the factors capital and labour as another basis factor for the survival of a firm. However, in our type of industry innovation is not the only answer, it is only an answer, and this will be discussed more fully later on.
However, a company seeking to develop an innovation meets constraints every day.
First, it sometimes seems that society has become somewhat hostile to innovations. It is true, of course, that the introduction of an innovation may cause the demand for certain goods to fall behind production, and that can lead to more unemployment. It is also true that, especially in the past, industry was a polluter of the environment and wasted scarce resources, such as energy and raw materials. So it is not wholly surprising that some public resistance to the introduction of new industrial developments exists. But society can only proceed by experimenting, by introducing new things, by making mistakes and learning from these mistakes. There is no other way if we want to avoid stagnation.
Another constraint on innovation might be our relatively weak competitive position compared with other countries - i.e. the high costs per unit in the Netherlands - and protectional tendencies in European and other countries. These constraints must be kept firmly in mind, even when one is certain that there exists a market for a new product.
Another important point, and it is distressing to have to make it, is the low productivity and motivation of the labour force. The consequences are serious: often the quality of Dutch products is too low and its costs are too high. It means that the introduction of wage intensitive new products should be considered very carefully as there is the risk of competition from cheaper countries. It sometimes seems to me that on the whole we are getting less vital, less creative, less optimistic and less inventive than we were formerly. The general increase in wellfare and social security have made most people more complacent about their incomes. People today are interested in the

quality of life and personal well-being, but they expect that their material wellfare will remain on the same level. Many people do not seem to realize that their expectations are linked directly to maintaining the competitive position of their country.
It might not be out of place here to say something about education in our schools and universities. One has the feeling sometimes that the need for innovation and new developments is not stressed sufficiently heavily in our educational system. On the other hand it might be that the average Dutchman - if he exists - is less innovative than people in other countries. Maybe we still have too much the trading mentality, which in itself is of course a good quality. But even a trader needs goods that are competitive if he wants to trade successfully!
It is a fact that, for instance, in England and France some remarkable new inventions have been developed successfully, and in the introduction of innovations countries such as Germany, Switzerland, the U.S.A. and Sweden certainly score higher than Holland.
It should be mentioned here that the tendency in our country to level incomes and to eliminate wage differences does not have a positive influence.
One can state generally that in a reasonably high developed society innovation can flourish on a sufficient scale, but that its influence on employment should be watched carefully.
On the whole innovation in consumer goods means more jobs, whereas innovation in the capital goods sector may lead to a loss of jobs.

The role of innovation

When we have accepted all these constraints on innovation, there remains the question of what are the challenges.
The first point arising is our definition of innovation. There are many, but the one that fits our situation best is:
The application of technological and economic developments to market directed products and production methods.
The next question, of course, is how we are going to realize this goal.
To begin with, innovation itself is very important, but it is not the only instrument in the innovation strategy of an industrial company. Acquisition of the necessary technology can also be realised by licences and by co-operation with others, stretching from ad hoc joint ventures to complete mergers. A good innovation strategy may also lead to the decision that certain industrial processes which use a technology that fits the market no longer, should be desinvested.

In choosing an innovation strategy for a company, we have the following main options:
- be the leader
- follow the leader
- the 'me too' strategy.

The be the leader strategy has a number of consequences: it can only be carried out successfully if the company disposes of highly qualified staff, costs and risks are high and it is long term. Normally this strategy can only be realised by very well organised, financially very strong groups, which in most cases will have their own research facilities that have easy access to the results of fundamental scientific research.

In the 'me too' strategy, technologies developed by others are bought or copied. Companies following this strategy usually are able to produce at relatively low costs and leave the development of new technologies to others.

The last opinion for an acceptable innovation strategy is follow the leader. This strategy does not put too heavy a strain on the financial resources of the company, but it has some other consequences that deserve close attention. It calls for continuous analysis of the circumstances in which the company is operating and for regular scouting for new developments of products/market combinations that are introduced successfully by others.

Thus in the 'follow the leader' strategy a company has to look continuously at:
- who is doing what and where in the world;
- can the company, on the basis of careful strength/weakness analyses hook in with a product or market conception of its own?

If we now look at Dutch heavy industry in the metal sector, one sees that it has not introduced many new products in the recent past. Rather, it sought to maintain its position by sophisticated jobbing, meaning that it acquired single orders from others, that design and construction were carefully worked out - so called application engineering - and that then the constructions were built in its own workshops. However, in the seventies the costs if the Dutch product went up through inflation and accompanying wage raises. Combined with the hardness of the currency this meant that even careful application engineering did not lead to costs that were low enough and this caused an erosion of the international competitive position of the Dutch metal industry. In these circumstances the industry had only one option for an innovation strategy and that is the 'follow the leader' strategy. I hope it will be clear that RSV has chosen this strategy, although in practice there is a mix of some kind, as in some areas we try to be the leader and in others we have to accept the 'me too' attitude, because we are too far behind on developments.
This leads to the question of how RSV applies its chosen strategy and which role the government can play in it.

In general, RSV distinguishes three promising areas for innovation:

1. Product innovation:
   - the development of unique and advanced products, preferably for series production;
2. Production innovation:
   - reduction of labour costs per unit by, for instance:
   - efficiency improvement by better engineering, and investments,
   - efficiency improvement by better organization,
   - efficiency improvement by better motivation of the employees,
   - development of new technologies and their application.
3. Management innovation:
   - this includes, for instance:
   - reorganization by restructuring potentially profitable activities or closing down structurally loosing branches,
   - co-operation with other companies.

To meet the challenges, especially in product and product innovation, in a rather diversified company such as RSV, it was decided to overhaul the existing organization for innovation and efficiency.

A member of the Board was charged to activate and direct the innovation and efficiency programs in accordance with the company's strategy. On the innovation side - and I'll restrict myself to this for the purpose of this Conference - this member of the Board was given a staff group, called the Steering Group for Innovation, which is the key-point for all innovation activities in the company. Its task is threefold. It has to prepare the innovation strategy, it checks and controlls progress and quality of all innovation activities, and it decides on the setting of priorities for new, strategic innovation schemes and for innovation projects proposed by the divisions.
To assist the Steering Group in this complicated field a Corporate Business Intelligence Group was formed with the task to search and scout worldwide for technological and economic developments that may be of interest for RSV. Attention is focussed on selected areas, such as maritime and naval technology, energy, the chemical and petrochemical process industries and the industrial equipment industry. In these activities, patent searches are an important instrument. Besides screening medium-term and long-term trends on their impact on future activities of RSV, the Group assists when necessary in the development of specific innovation projects. To guide and stimulate the innovation activities, there is in each division a 'division innovator', who reports

directly to the division manager. In practice he often acts as a delegate from the division manager by collaborating directly with the Corporate Business Intelligence Group or the Steering Group.
It is expected that he will guide all innovation projects in his division and that he will ensure that the sums earmarked for innovations are spent optimally. Another important task of the division innovator is to look for new ideas and to generate a general climate in which new ideas are born, and to stimulate and organize the capabilities of the various engineering groups in his division.

Although we would like all our innovation projects and ideas to be market oriented, we have recognized that this is an impossible ideal and that there is an area that could be called the area of free innovation. Therefore we formed a Central Research and Development Group whose main fields of interest are special welding technology, technology of difficult materials and highly advanced methods for scientific and technical computations. The first task of this Group is to keep abreast of new developments elsewhere and to start and direct our own development projects in these fields. Its second task is the co-ordination of these activities in the company in such a way that the spin-off for RSV is the best possible. The organisational set-up just described has been created to improve the information flow within the company. Good ideas and suggestions must not stay bottled up in their place of origin, but should reach the appropriate levels of management - the bottom-up flow.
Also the policies and strategies formulated on the executive level should permeate downward in the company - the top-down flow.

Perhaps this is the moment to ask what kind of support the government can give to innovation in a company such as ours.
The strong importance attached to innovation at present has led to the happy result that RSV is earmarking more funds for this purpose than formerly. However, compared with, for instance, the electro technical industry, the absolute amount is still rather low. So the government stepped in and gave development credits to RSV for a number of innovation projects. One could wonder, however, whether the government should not follow the example of the USA and use other specific instruments for the stimulation of innovation, for example by placing direct orders with industry. Many studies have shown that generally medium-sized companies are better at innovation than larger ones, but that these companies often lack the financial strength to take big risks. In such cases the government should help, but in my opinion, preferably not with straight subsidies, but more indirectly.
A good example of close co-operation between government and industry is the American space program. The direct economic benefits have been small, but the spin-off in technological know-how in communication, metallurgy, high-grade fuels, dietetics, alternative energy etcetera can hardly be overestimated.
Normally one uses cost-benefit analysis as the method for the assessment of results, but in my opinion this method cannot be used for even an approximate quantification of the effects of the technological change caused by the American space program.
Such a policy seems to work well in the USA but is unthinkable in the Netherlands. Holland is entirely committed to European co-operation, and in this respect the Kalkar project is a good example. Still it is often difficult for Dutch industry to obtain its rightful share of the innovations for reasons of the national interest of the participating countries and the relative smallness of the Dutch companies.

Possibilities for innovation

To illustrate the possibilities for the Dutch metal industry, I will give some examples from the innovation program of RSV for 1979.

Maritime industry

In the opinion of RSV shipowners nowadays prefer mostly vessel types with proven records of operational and economic qualities. However, as in the eighties prospects

will improve sooner or later, the industry should prepare itself to meet the future requirements of new and diversified trade flows and the requirements of environmental protection by appropriate vessel types.
In its product innovation the shipbuilding division of RSV concentrates on the design of new vessels or on the updating of existing ones. At the same time the industry has recognized the urgent need of the national shipowners for a reduction of operational costs.

- Manning costs. It certainly is a challenge to reduce the crew cost by, for example, rational integration of functions, and by automation on board using micro-processors. Automation has not only invaded the engine room, also nautical control procedures and cargo control procedures are automated more and more.
- Fuel costs. It is encouraging to learn that the Netherlands Maritime Institute, in close co-operation with government, universities, shipowners and shipbuilders, has embarked on a program in which fuel consumption will at last receive the attention it deserves.
- Maintenance cost. It is felt strongly that a further shift from repair to scheduled maintenance will check costs and improve the ship's operational availability. Condition monitoring of essential vessel components is coming into use and this will have a substantial impact on maintenance procedures and the functioning of repair yards. RSV is fully aware of the transition and concentrates in its innovation program on meeting the requirements of the shipowners. A typical example is our project for highly effective and efficient tank inspection installations.

Offshore industry
In the offshore industry attention is focussed more and more on the reduction of cost and risk. Major examples are ways to convert marginal oil fields into profit contributors and ways to widen the weather window for sophisticated capital intensive servicing and maintenance equipment. These subjects rank high in the priorities of the industry. Subsea completions, floating production structures, modular systems, automated inspection devices are already available in a number of versions, but still need further development to achieve maximum performance in a number of cases. In RSV a major part of the funds available for offshore innovation is applied in this direction.

Naval construction
Another maritime field where a continued innovation effort is necessary, is naval construction. The high technological product standards require very specialized design and engineering capabilities. There is a close and very effective co-operation with the Royal Dutch Navy as principal and with suppliers of sub-systems and components. For the medium term future of RSV the building of naval vessels is very important. It is obvious that for RSV to maintain its prominent position, its innovation activities have to be continued and extended vigorously. International acceptance of the 200-miles zone may open new prospects here.

Electronical equipment
In this field our innovative efforts will be directed somewhat more towards applications on land and to a lesser degree towards maritime activities. In both areas costs are high and development times are long and to keep these reasonable, co-operation with well established companies - mostly American - seems to give the best opportunities. In this kind of co-operation the possibility of acquiring our own know-how and experience is a very important aspect. Our point of view is that arrangements about joint development and innovation programs should be incorporated in such arrangements.
In this field we see opportunities, for example, in:

- the aircraft industry
- power generation supply
- defense
- microprocessors.

Industrial equipment
This is a diversified area which is important for RSV, with many opportunities for in-

novation. Some examples are:
- Installations which can be used as oil tank inspection platforms.
- Components for industrial systems, such as vacuum belt filters - of which the prototype was developed originally with TNO - packaging equipment and racks for compact storage of nuclear spent fuel elements.

The Industrial Equipment Division concentrates also on what might become the fastest growing energy market in the eighties: Coal.
One of the most important items in the innovation budget is a thin seam miner for the exploitation of high grade and near the surface coal seams. This project is now in its engineering phase and it has received already close attention from the US mining industry, as it may contribute to efficient coal mining with a minimal impact on the environment.

Defense material
For most innovation projects in this division the strategy of 'be the leader' has been chosen. For a number of projects RSV received development credits from the government, and this means that the government is prepared to support innovations which are thought to be promising.

Power
This is an important area, both for RSV and the Dutch heavy metal industry as a whole. We can make a list of options the Netherlands have for meeting its future energy requirements:

- Natural gas	Huge own resources, used on a large scale a fuel, clean and mature technology, supply limited to middle-term.
- Mineral oil	Mainly imported from OPEC, used as a fuel and a chemical feed stock, mature technology, supply limited to middle-term.
- Coal	Own resources that are however difficult to mine, can be used as a fuel and a chemical feed stock.
- Nuclear fission	Without breeders limited, with breeders unlimited supply, resource waste disposal system still to be developed.
- Nuclear fusion	Still under development, might supply energy on a large scale, long term supply expected to be unlimited.
- Solar energy	Still under development, might supply energy on a small scale, limited contribution at high costs, suitable for areas that are not too densely populated.
- Wind power	Still under development, might supply energy on a large scale, suitable for coastal areas, mature technology for small scale applications that is suitable for rural areas, limited contribution at high costs.
- Geothermal	Feasibility not yet proven, probably only limited contribution, environmental impact unknown.

There is no doubt that only coal and nuclear fission are the best options and should be developed to meet the future energy requirements of the Netherlands. In spite of intensive research, energy saving would only help to delay the moment when ultimate decisions have to be taken; energy saving is not an option, but a must.
In my opinion RSV has to use its resources to develop both options, but cannot ignore the others as subjects for investigations. The first thing to be done here, is to carry out optimization studies to find the conditions that have to be met for economic and social feasibility.
My personal conclusions are that nuclear energy should have the first priority for electricity generation, that combined cycle using fossil energy will necome important in the near future and that the use of coal in energy systems is a subject for strong innovative efforts. RSV is active on a number of subjects, of which some could lead to applications rather soon whereas the others are expected to lead to applications on a medium-term time scale.
For large capacity heating systems the fluid-bed combuster will be a strong candidate,

but innovation will be largely of market development. Sulphur containing waste materials will be the main problem, and we think this should have the full attention of science and engineering.

Many of our problems stem from the regulations for environmental protection. In most cases their necessity is beyond any doubt, but the problem is caused by economic factors, especially cost increases. When, for example, coal fired power plants have to be provided with flue gas desulphurization equipment, the cost of electricity would increase by some 30 per cent, and the cost difference between coal fired and nuclear electricity would increase too.
The challenge is to discover a process of desulphurization for which investment is lower, or to develop equipment that can be built at lower cost. Again economic factors will be the driving force behind particular developments, unless external factors would dictate what has to be done. Such a factor could be the rationing of supplies by Energy Producing and Exporting Countries, and we know from experience that this is not just hypothetical. This might be an additional reason to give serious attention to methanol as a fuel for transportation.

Proces systems and equipment
It is an open secret that the prospects for the hydrocarbon integrated jobbing industry are rather gloomy. The high cost level in the Netherlands and strong competition, notably from Japan, will keep new activities in the Netherlands at a low level. In this sector the innovative efforts should be concentrated mainly on production and management. There seem to be more promising opportunities in the field of floating or modulized chemical or petro-chemical plants. RSV is in an unique position to assess both concepts and is seriously involved in these new market possibilities. In industrial power supply, the drive for energy saving is opening up markets for waste heat boilers and regenerators for gas turbines.
A major effort of RSV is the development of a gas/gas tubular regenerator for gas turbines with superior thermal shock features. With government support RSV started recently a project for a new type of gas turbine with certain promising aspects.

Conclusion

It will be clear by now that RSV is active in the field of innovation and we like to think that we are fully alive to the various challenges we meet every day. However, apart from the constraints I did mention earlier, there are two more which worry us: money and people. The second is more important than the first, because normally money can be raised if a project is good. But even if you have money, you need brains to spend it properly and therefore we lay much emphasis on strengthening our engineering force. As I said before, the education people get in schools and universities is not much of a help, so we have to educate them ourselves or we have to buy know-how externally. This is not only important for innovation, but also for the process of making our present products better and cheaper.
Lastly, we often do not find it easy to convince many enthousiastic technical specialists that technically bright ideas often cannot be realized from a commercial point if view. Here, we often come across remarkable differences between technical people from other countries, for instance the United States, and their Dutch colleagues. Again I suspect that the education and training people have received in their youth will explain most of the differences, which shows that the educational system has an influence far beyond mere tuition and that the education people receive should be well adapted to the demands which will made upon them.
It is clear that the present state of our industry puts an enormous challenge to our flexibility and inventiveness. But to my conviction sufficient strength is still available to meet this challenge.

The importance of innovation promotion for industry, particularly for small and medium-sized enterprises

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1. The importance of technological innovation for industrial growth is undisputed. In the USA, for example, the television, giant aircraft and computer industries today employ almost one million staff, who earn approx. US $ 13 billion with the help of technologies for which the basic innovation work was carried out during the thirties and the fourties. Between 1969 and 1974, the firms in the USA devoting the most effort to innovation achieved a growth in sales and workplaces amounting to 43 % and 41% respectively, whereas the "mature" US companies increased their sales by only 11 % and the number of workplaces by a mere 1 %.
   The considerable extent to which innovation determines the chances of survival of an enterprise or of a branch of industry and of the workplaces available is apparent from estimates according to which between 30 % and 40% of the goods both produced and marketed today were not in the market ten years ago.

2. On the other hand, technical innovations are being heatedly discussed today by the general public. Whereas technical progress has up to now been regarded in general as someting positive, to be welcomed, more and more criticism is now being voiced.

   Slogans such as "rationalization-induced unemployment", "a chip which devours workplaces", "job-killer" and "technology-induced unemployment" sway public discussion to an increasing degree. A wave of innovation - triggered off by microprocessors and their wholesale application - threatens to revolutionize our production and manufacturing methods and to lead to the loss of workplaces to an as yet unforeseeable extent. By concluding agreements to protect workers from the consequences of rationalization measures, management and the unions are endeavouring to moderate the social implications for workers resulting from the radical switch to new manufacturing methods.

   So, is innovation moving ahead too fast? Have we too many innovations?

   The change of opinion now evident in the public's assessment of technical progress is closely related to the current unsatisfactory employment situation. This throws a new light on the loss of workplaces, in as far as this unhappy development is connected with technical innovations.

   If, in times of growth, the loss of workplaces in any one branch of industry is usually compensated for immediately by the provision of new workplaces in other expanding sectors usually requiring similar qualifications, this "mechanism" does not work when economic growth is on the wane.

3. The present unfavourable employment situation in my country does, however, by no means stem from technological progress. The causes are to be sought elsewhere:
   - First, we are currently experiencing in the Federal Republic of Germany continuous fluctuations in the number of those employed on the one hand - which is growing - and the number of consumers on the other hand - which is decreasing - the consequences being that increasing production possibilities will be confronted more and more by a decline in demand.

- Second, the menace of a gap in demand in many sectors will be intensified by changed requirements structures. Households are already equipped to a large extent with furniture, refrigerators, and other material goods. More importance will be attached to the satisfaction of immaterial needs with regard to self-actualization in our dealings with our fellow-men and social commitment.

- Third, the pressure from competitors on the supply side is increasing on domestic markets. Goods which are less complicated to manufacture can already be produced both cheaper and better in countries of the Third World. At the same time, competition is fiercer on foreign markets because most industrialized countries will attempt to stabilize employment by stepping up exports. In addition, the Deutsch Mark had been undervalued for many years - a fact which made it appear that many enterprises had an advantage in being located in the Federal Republic of Germany, though in actual fact this was no longer the case. With the transition to floating exchange rates, the pent-up need for adaption to changed structures became suddenly apparent.

  The present situation of underemployment is, therefore, primarily a structural crisis generated by shifts in demoscopy, in global requirements and in competition on the international markets.

  Once we have grasped this fact, we shall better be able to find the appropriate ways and means of coping successfully with this difficult situation.

4. It would surely be wrong to turn our backs on new technologies and to prevent the application of new technical solutions. Such a course would only make things worse.

   The importance of new technologies for our economy can be seen from the way in which the various production sectors were able to hold their own in the face of international competition during the past few years. Branches of industry manufacturing standardized goods were particularly affected by developments on the world and domestic markets. On the other hand, those production sectors employing highly-developed manufacturing techniques, highly-qualified manpower and producing high-quality demand-oriented goods, were able to maintain their position. At the national and international level, commercial success will depend to an ever greater degree than hitherto upon the use of superior technologies.

   In our economy, which is based on the principle of competition, the management of any enterprise is hardly free to choose between embarking on a labour-saving innovation and ignoring the opportunity of doing so because the lack of innovation activity in national and international competition is sooner or later followed by the loss of a footing on the market, thus entailing the loss of more workplaces than would be the result of steady endeavours in the competitive sector of innovation.

5. Innovation in industry is prompted by market requirements. It has recently been maintained in several quarters that the willingness of enterprises to break new and unfamiliar ground in order to increase the attractiveness of their range of goods has decreased noticeably. A pessimistic outlook on growth seems to gain ground in industry - brought about by the slow rate of economic growth during past years, by the drop in profits and by the foreseeable decline in population. The desire to "play safe" has the result that work is concentrated primarily on improving existing products and is not devoted to the development of new ones while R&D efforts are showing little or no increase. This suggests that the innovation strategy pursued by many enterprises is a rather defensive one, i.e. it aims to keep a firm grip on existing markets. However, slackening R&D efforts will in the long run jeopardize the innovation capacity of industry and thus satisfactory economic growth as well.

In international competition the Federal Republic of Germany will not be able to hold its own unless it concentrates even more than before on research-intensive and technologically sophisticated products. The Federal Government is therefore endeavouring to further research and innovation in industry all along the line by introducing a package of measures.

One approach is that of direct government grants for company R&D. Other approaches and tools are, for example, tax incentives, the provision of loans on attractive terms or advisory services enjoying government support. These instruments will be discussed in detail later on.

By far the major portion of funds spent on the direct support of company R&D is now provided by the Federal Ministry for Research and Technology (BMFT). In 1977, DM 1.377 million were spent in this sector, that is, approx. 86 % of the total amount of government funds provided for civil industrial research and approx. one third of the total promotion funds made available by the BMFT.

The BMFT does not support the entire range of industrial R&D but particularly future-oriented key areas and projects. The projects concerned are those

- intended to shift industry's range of activities in the direction of those technologies which - on account of their complexity and scientific roots - cannot (or at least not for a long time to come) be mastered by those countries which are still in the process of becoming industrialized;

- leading to technologies which entail neither the disadvantages nor unfavourable properties of some production techniques used so far, which reduce environmental pollution in particular or which conserve both energy and raw materials;

- contributing to the fulfilment of public duties and to the improvement of the infrastructure.

The BMFT is not a technological research association for furthering the entire range of technologies, but rather concentrates its funds on selected promotion programmes, for example, on energy technology, data processing and electronics, or on the humanization of working conditions.

Government funds are granted to firms by the BMFT under such programmes if

- the scientific and technical risk involved is particularly considerable and large funds are required;

- developments will take a very long time, so that profits cannot be expected in the forseeable future;

- the market underrates more advanced technological solutions because it is oriented closely to present, rather than to future, demand and shortages or because it underrates solutions which are chiefly for the common good.

The recipients of grants are expected to contribute to R&D outlay themselves, in order to ensure that the activities promoted are selected on the basis of real need and in order to stimulate the rapid commercialization of the results obtained.

In principle, companies are to shoulder 50 % of the costs involved. Their contribution may, however, be less if the projects concerned are of considerable public interest or - in exceptional cases - if their execution would be jeopardized by the limited financial means of the firms willing to launch them.

6. The Federal Ministry for Research and Technology promotes enterprises which generate advanced technologies, particularly in those fields of considerable importance for the national economy.

   These include the opening-up and utilization of new sources of energy and raw materials, research activities in the sectors of ecology, biology and medicine, the development of information technologies and the promotion of electronics, to name only a few examples.

   Today we hold a leading position in several fields, for example, nuclear energy, plant construction, modern coal technologies, metrology, optics and laser technology as well as modern recycling techniques and sea water desalination.

   These technological sectors receiving promotion from the Federal Ministry of Research and Technology also create new workplaces: the promotion of nuclear energy has undoubtedly resulted in the provision of more than 100,000 additional workplaces, whereas approx. 4,000 newly-created workplaces have been added in the sector of electronics as a consequence of government support.

7. Many production possibilities in our economic system have been virtually ignored in the past.

   Let us think for a moment of sectors such as the humanization of the working environment, town and country planning, environmental control and investments to improve the infrastructure - all fields with almost unlimited potential requirements.

   A considerable need for innovation and investment still exists, for example, in the sector of energy supply and utilization. In this connection the following fields in particular lend themselves to innovation: the wider commercial use of solar energy, the improvement of advanced coal technology (coal gasification and coal liquefraction), the broader application of the total-energy concept (combined heat and power generation) in district heating systems as well as the development of improved techniques for insulating and heat recovery.

   Sizable potential markets are waiting to be opened up not only in the public sector but also to private-sector demand.

   Of course it is not enough to offer potential buyers at ever shorter intervals marginal product improvements and exaggerated sales propaganda which only increase both their irritation and reluctance to buy. The range of goods currently on offer seems to be less oriented to changed requirements rather than to conform with them. We must realize that demand has become more flexible where quality is concerned. Buyers' decisions are increasingly influenced by the criteria of guaranteed usefulness, durability, service and maintainability.

   This is why the design of new products must take account of changed requirements corresponding to the increasing appreciation of the necessity of protecting the environment and of conserving natural resources.

8. Opportunities for qualitative growth are, therefore, to be seized both in the public sector as well as in the business and private customers' sector.

   But qualitative growth relies on new technologies, on inventions and on successful innovations.

   The Federal Government is therefor endeavouring to create on a broad basis the prerequisited required in order to ensure the success of innovation projects.

A vital condition for the success of such technological innovation projects is first the execution of broad-based scientific and technological research work. In the field of basic research such activities are carried out for two purposes: firstly, in order to acquire new knowledge and findings, and secondly, in order to train highly-qualified staff who will be able to command and apply this knowledge and whose training has equipped them to tackle, handle and utilize future findings from fundamental research. At the same time, research is a vital - but not in itself adequate - prerequisite for technological innovation. The ability to master a technology, to find commercial applications for knowledge and to introduce products on the market at the time when they are in demand is also required.

If the aim is that of increasing the probability of the successful development and commercialization of technical products and of reducing the obstacles and barriers in the path of innovation, then a start must be made at the individual enterprises. It is they who shoulder the difficult and risky task of converting technological concepts and results into marketable goods.

The risks incurred by both companies and industrialists engaged in technological innovation are first and foremost encountered in terms of technological uncertainties. These will always occur when new ground is being broken and when it is still open to doubt whether or not the desired technological solution to any one problem can be realized at all. One example of this is provided by reactor development. On the other hand, commercial risks are entailed, and sometimes even risks involving international policy. As far as future marketing prospects are concerned, major investments often appear questionable or insecure even when they are being considered in connection with established technologies already mastered.

The promotion of innovation by the government means that

a) factors which tend to arrest the innovation process must be identified,

b) instruments must be designed for the removal of such obstacles,

c) the risks to be borne by the enterprises themselves must be reduced appropriately.

9. The most recent addition to the list of measures for the promotion of innovation was approved by the Federal Government in April 1978 - namely, an overall concept for research and technology policy geared to the needs of small and medium-sized enterprises and intended particularly to strengthen the innovation potential in these firms while at the same time encouraging its wide application.

This concept coherently described for the first time the existing instruments for the promotion of research and technology, improving them with an eye to the needs of small and medium-sized enterprises, and supplementing and extending them by adding new measures.

I should now like to discuss this concept in greater detail.

10. The specialized major programmes promoted by the Federal Ministry for Research and Technology which now envisage numerous possibilities for promotion for the benefit of small and medium-sized enterprises (mention should be made in this connection of the following areas, for example: microelectronics, optics, metrology, data processing and solar technology) aim to expand further the number of small and medium-sized enterprises receiving promotion funds.

Thus administrative obstacles will be removed as far as possible by simplifying application and fund allocation procedures, existing financial barriers will be re-

moved in their turn by giving special consideration in each case to the financial capacity of small and medium-sized enterprises when fixing promotion quotas, by improving the prerequisites for the participation of sub-contractors in R&D projects by providing information on large-scale projects and finally by the speedy and widespread publicizing of new promotion measures.

11. In the meantime, the concept has been extended and supplemented by additional promotion measures which are taking effect at the beginning of 1979 and which date back to the decisions concerning budgetary matters and growth policy which were taken in the summer of 1978 in connection with the World Economic Summit. Promotion will now be granted also for the in-house expenditure incurred by small and medium-sized enterprises for R&D manpower. The Federal Government has appropriated DM 300 million for this purpose in 1979, the sum to be distributed in the form of grants. Above and beyond this, long-term investment loans at low interest rates are being provided for the first time in 1979 under the extended ERP (European Recovery Programme) scheme, the aim being to assist the financing of capital expenditure in the sector of the production and introduction on the market of completely new products. This means that promotion now covers capital investment focussed on the differentiation and diversification of the range of products offered on the market.

    The global, expenditure-related promotion of R&D personnel is directed particularly to the large number of small and medium-sized firms whose main chances lie in the application and innovation of new technologies. Comparatively modest financial incentives suffice to compensate for the commercialization and materialization risk involved.

    Moreover, the managements of small and medium-sized enterprises tend to cut back staff to the number required for carrying out current operations. Particularly when business is not so brisk as it might be, they prefer to do without staff who could be employed on development tasks. In consequence, new technological trends and changed marketing conditions are concentrating their attention on routine work. The meagre staff capacity prevents the rapid inclusion of new and advanced developments in the production programme, even when the necessity of an appropriate re-orientation of activities to new subjects has been clearly recognized. For this reason, staff-oriented R&D promotion is directed particularly to this structural disadvantage at small and medium-sized companies and aims to bring about the employment of larger numbers of scientific and technical staff even at such firms.

12. During the last few years, additional instruments for promoting company R&D have been created alongside the specialized major programmes of the BMFT. Among these tools are the programme for the promotion of primary innovation and the programme for technical development in Berlin's industry, both drawn up by the Federal Ministry of Economics, which further in particular the development projects - regardless of the specialized field involved - initiated by small and medium-sized firms, as well as tax reliefs for the purpose of easing investment financing. All of these instruments largely contribute to the improvement of the financial constraints governing the development and equipment of company R&D facilities.

13. Cooperation with external research agencies is often the only way open to many small and medium-sized enterprises for gaining access to improved products or manufacturing techniques which will increase both their competitiveness and efficiency. These companies must therefore award a greater number of R&D contracts to private or government-supported research institutions or to other enterprises. Under a new programme, the Federal Government is supporting such contract research by providing a grant of up to 30 % of the contractual sum, but not

exceeding DM 120,000 per year for each enterprise. Those firms with a turnover of up to approx. DM 200 million receive grants for R&D contracts governing the development of new or improved products and techniques which will help raise the level of their efficiency.

The 26 institutes comprising the Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.V. (FhG) (Fraunhofer Society for the Advancement of Applied Research) provide both industry and government with a diversified research capacity for executing application-oriented contract research and development. A major task for the FhG is that of providing both contract research facilities for small and medium-sized firms and advice on the use of new technologies as well as on the marketing prospects for new products. R&D contracts from companies with a turnover of up to DM 200 million can be supported by funds from the Federal Ministry for Research and Technology amounting to between 40 % and 60 % of the contract value. The respective allocation procedure is both rapid and unbureaucratic.

In addition to contract research geared to the specific requirements of one or several enterprises, cooperative research institutions are required to handle application-oriented technological problems of interest to all firms in a particular branch of industry. Industrial cooperative research is sponsored by research associations in related disciplines which have joined forces to form the Study Group of Industrial Research Associations (Arbeitsgemeinschaft Industrieller Forschungsvereinigungen = AIF) in Cologne. This group is supported by the Federal Ministry of Economics.

14. The big science institutions funded by the Federal and Länder governments, together with technical government authorities, federal research institutes, universities and technical institutions of higher education are important sources of know-how for many enterprises. Industry in particular benefits from the results of applied research and development carried out at big science centres within the framework of cooperation on large-scale projects and the awarding of contracts. The know-how at big science institutions can also be of extreme interest to those small and medium-sized enterprises which do not cooperate with such an institution and which desire to use research results for their own purposes. The big science institutions have set up special agencies which endeavour to find users for R&D results and which function as liaison offices providing information to small and medium-sized firms. R&D results of special interest are further developed and then made available to interested users in the form of product- or technique-related functional models.

15. After completion of their R&D activities, many small and medium-sized companies are often confronted with the crucial problem of introducing the newly-developed products and techniques on the market. They require funds for production facilities, for expanding sales outlets, for warehousing and for marketing activities.

In contrast to the capital market in the USA or in Great Britain, the established capital market in the Federal Republic of Germany provides hardly any loans for risk-bearing investments concerning the introduction of new products and techniques or for the establishment of new enterprises to engage in the commercial exploitation of inventions.

In the light of this fact, and at the suggestion and with the cooperation of the Federal Government, several companies in the banking sector set up in 1975 the Deutsche Wagnisfinanzierungs-Gesellschaft mbH (WFG), (German Venture Capital Company). This company invests in the equity of innovative firms, providing them with management aid and - in exceptional cases - also with additional loans. Its

investments are usually minority holdings in order to allow proprietors to continue running their businesses on their own responsibility and gives them a preferential right to buy back their share-holding if the venture is successful. The amount invested by the WFG in each project is currently in the region of between DM 400,000 and DM 2 million. The Federal Government supports the WFG by covering a proportion of the losses incurred during a 15-year start-up period by means of a conditionally-repayable loan. The Government's counterguarantee enables the WFG to engage in more hazardous investments than would be possible in normal bank business.

16. For years now the Federal Government has been supporting industry in its endeavour to organize qualified advisory services for the benefit of small and medium-sized enterprises. These advisory activities have to date focussed primarily on improving business management and organization.

With financial assistance from the Federal Government, pilot projects are being executed with various regional groups of the Rationalisierungs-Kuratorium der Deutschen Wirtschaft e.V. (RKW) (Rationalization Board for German Industry) and with several Chambers of Industry and Commerce. Within the framework of these projects technology-oriented consultations are held for the purpose of establishing the innovation requirements of interested small and medium-sized companies and to help them gain access to the relevant R&D findings and to establish contact with the appropriate institutions. Where necessary, transfer guidance is to be supplemented by innovation consultancy services subsidized by the Federal Government. Specially appointed experts will assess development requirements and elucidate the effects of the envisaged innovations from the aspects of organization, personnel and finance.

17. Progress in research and technological development depends largely on whether or not existing knowledge can be made available to interested users rapidly, in concentrated form and related to tasks, and subsequently put to practical commercial use. The Federal Government has created the prerequisites for better access to information with its programme for the promotion of information and documentation. Sixteen specialized information systems are being established together with specialized information centres for the fields of environmental control, patents, handbooks of technical regulations and research projects. Industry is particularly interested in the specialized information systems already set up for chemistry, energy, physics and mathematics and in those currently being planned or set up, e.g. in the fields of electrical engineering, metallurgy, regional planning, trade and industry, health and the social sciences.

The specialized information centres provide enquirers with information on the wealth of technical literature available in the field requested, and ensure the rapid supply of such literature, including translations. For the purpose of making the services provided by information centres more easily available to small and medium-sized enterprises, information clearinghouses are to be set up acting as intermediaries to facilitate the transfer of problem- and branch-oriented information between users and information centres.

18. The majority of technological innovations are oriented directly to the demand for, and supply of, relevant know-how. Precise knowledge of marketing conditions and of the developments to be expected both at home and abroad is, therefore, of essential importance when companies decide whether or not to tackle innovation. Studies of technological developments and their importance for process and product innovations likewise supply general data which can give some guidance to small and medium-sized enterprises in connection with management decisions. Government authorities, in particular the Federal Ministry for Research and Technology and the Federal Ministry of Economics, commission the preparation

of such studies. The advisory services then have to evaluate the findings of the studies and adapt them to the specific needs of enterprises.

19. The overall concept for research and technology policy with regard to small and medium-sized enterprises contains measures recently introduced with the aim of improving the opportunities for such enterprises to engage in research, development and innovation and of helping them to cope with financial, technical and organizational problems. The concept provides an appropriate basis on which to develop further improvements and to continue expanding the range of instruments for promoting technology policy.

20. In conclusion I should like to refer again to a question raised at the beginning of this paper, namely, whether or not we are trying to adapt to too much technological change. My answer to this is an unqualified "No". On the contrary, we have not put nearly enough technical progress to commercial use on a broad scale. Our employment problems cannot be solved by doing without innovations which would increase productivity. More workplaces and heavier investments can be achieved only if our society finds the courage to put the necessary structural changes into effect.

In this paper I have tried to make two things clear:
Firstly, in the Federal Republic of Germany we consider it a government task of high priority to help industry - particularly small and medium-sized enterprises - to cope with structural change by means of promoting technological innovation processes. At the same time, the government's aim is that of ensuring qualitative economic growth coupled with high employment figures.

Secondly, government aid in connection with this process of adjustment can be no more than an offer of assistance to industry - help as an incentive to self-help. There are no rules or regulations to this effect. Managements make their own independent decisions.

The Federal Ministry for Research and Technology by no means considers itself the possessor of a patent solution to all the issues involved in the broad-based promotion of both technological progress and innovation. In 1976 we exchanged views in detail with scientists and government representatives from the USA during a symposium on the possibilities of technology promotion and came to the conclusion that each country must consider - bearing in mind the requirements of its specific circumstances - what steps can be taken to cope with current problems in each case. In all countries without exception, technology promotion can be practised only on the basis of all-round scientific promotion, without which the training of scientists and engineers - which is one of the major prerequisites for innovation processes - cannot contribute to the establishment of solid foundations. The conviction prevails that growth cannot be made to continue quantitatively at will, but that intensified effeorts must be made to harmonize the quality of economic growth with natural resources and with the needs of the people.

I believe that we can put to good use the opportunities linked with technological progress to this end, and at the same time keep a watchful eye on the hazards also involved.

Procurement Policies of Governments and their Effects on Industrial Innovation: International Experience

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There are many ways in which governments influence the process of innovation in industry. One of the ways that has been receiving a great deal of attention recently is government procurement policy. By this I don't mean the procurement of existing goods, off the shelf, as is done by the central purchasing agency in most countries. What I am discussing today is the use of government buying power to provide an incentive to industry to produce better goods for the public and to improve its own technical competence. We should look not only at the central government but also at local government and at such public agencies as the PTT, hospitals and utilities.
Interesting policy initiatives have been taken in some countries. In the United States the Experimental Technology Incentives Programme has since 1973 been using procurement to stimulate innovation in such areas of national concern as energy conservation, health care and transportation systems.
In Canada, the Department of Supply and Services has a special group responsible for maximizing the positive effect on innovation of the purchasing power of the Federal Government. In Germany the Ministry for Science and Technology has made a study of the effects of government purchases in such areas as heat pump technology, fire protection, and equipment for the elderly and the disabled.
In Sweden the National Board of Technological Development (STU), an organization somewhat comparable to TNO in Holland, has been actively promoting, in cooperation with industry and civil servants, innovation oriented procurement activities at the level of local government.
This morning we heard that in the Netherlands a committee has been created in the department of Finance to promote innovation oriented procurement.

A recent meeting of the Six Countries Programme on innovation policy was devoted to the evaluation of such policy initiatives. My introductory report to you today is based largely on the research we undertook at TNO to support that evaluation.

I believe that the topic is particularly relevant to this TNO conference, because the Discussion on innovation is now moving from generalities to specifics. It is no longer sufficient to state that, in general, more innovation is necessary to combat economic stagnation and that the difficulties are great. Surely that is true, but we should now move on to discuss specific actions that government - in cooperation with industry - should take in response to specific technological opportunities and specific demands of society. "The time for talk is just about over", as Mr. Peijnenburg said this morning.

I believe that there are four important reasons that innovation oriented procurement policy has been receiving so much attention lately. The first of these reasons is the manifest success of the U.S. military in using procurement to promote the spectacular development in micro-electronics. In the fifties and sixties the U.S. government clearly articulated its interest in electronic improvements. This articulation was persistent, public, and punctuated by support of various candidate programmes which, in hindsight, not always succeeded, but contributed to the ground swell that ultimately materialized in the I.C. innovation. The government conveyed a sense of urgency for its projects. It was also willing to pay high premium prices for untried designs. It stressed reliability, miniturization of systems, and industrial preparedness. The military and space programmes were creative first users and purchased large quantities of components, directly or indirectly. In some years half of the industrial output of certain components was bought by the government.

Altogether, the U.S. government created a conductive environment for product innovations at the beginning of the product life cycle. Because of the quantity it purchased, it enabled industry to take advantage of the effects of the technological learning curve.

It is further of importance to note that any company that could produce a suitable component, fitting requirements, was a potential supplier. After a certain company had become the largest supplier, the Department of Defese (DOD) tended to turn to other, often smaller, companies. It encouraged new entries in the market and was willing to give anyone a chance. Often former employees of established companies took advantage of this attitude and founded their own "spin-off"-company. Often the small companies created innovations. DOD and NASA could give anyone a chance because they were highly competent purchasers with adequate testing facilities.

The second reason for the interest in innovation oriented procurement policies lies in the results of many recent studies on the process of innovation. The results stress the importance of "demand pull" rather than "technology push" as a critical factor in successful innovation.
With regard to government action in particular, retrospective studies carried out on both sides of the Atlantic have concluded that government has been more effective in influencing innovation by the articulation of demand than by such more traditional policies as subsidizing R & D. Innovation oriented procurement policy seems to be an essential element of any innovation policy that pretends to be more than a dressed up version of old R & D policies.

The third reason for the interest in procurement is more speculative and also political in nature. It relates to the present stage of technological development and the economic stagnation in the industrialized world. It has been argued that the present economic crisis has underlying causes related to the type of technological change thas has characterized the third quarter of the twentieth century. The spectacular increase in personal income in this period and the development of a number of technologies based on major innovations of the thirties, has led to a situation in which many individual needs are now much better fulfilled by industry than ever before. In fact a certain saturation of the market for many consumer goods can be pointed to, as well as a lack of recent major innovations in this area.
On the other hand, many public or collective needs go unfulfilled and the impact of innovation in this area seems to be much less. The modern industrial corporation, one might conclude, has found it much easier to respond innovatively to private than to public sector demand.
One can also use the concept of "natural trajectories" of technological change, "technological regimes" or "technological imperatives" to signal that perhaps industry and society are locked into a certain kind of behaviour and a given set of outmoded priorities in its present attitude toward innovation. New "trajectories" must be developed and one area that seems a natural candidate for providing the opportunity for technical change is the public sector.

In the Netherlands, as perhaps elsewhere, there has been a good deal of discussion about the "socialization of demand" as a way to combat the present economic stagnation. If it is true that the economic stagnation is closely tied to a lack of technological chance, a strong case can be made to focus attention on innovation in the public sector. Procurement policies that can contribute to this, as they seem not to have done in the past, take on added significance.

With the exception of military hardware, the public sector seems to have lagged behind technologically when compared to the private sector. Public transportation technology has developed much slower than the private automobile. The telephone system lags behind the development of computer terminals and other non-collective communication equipment. Block heating has lost out to the one-household central heating unit. Development in preventive medicine and productivity in the health system look pale

when compared to innovation in the pharmaceutical industry. You can go to a highly trained doctor for the latest miracle drug, but you still have to ask your grandmother about prevention.

In the U.S. there has been no talk of the socialization of demand. But there has been a somewhat parallel discussion about the "moon-ghetto" dilemma. If technology can put a man on the moon, why has it not been able to develop ways to improve the quality of life of people living in urban ghetto's. Or: if you can produce an instrument for playing table tennis on your television in colour, why do so many basic human needs go unfulfilled. In all these cases it is thought that a more effective use of government procurement could be at least part of the answer.
Finally, we should not forget the interest that industry, as the partner of government in the procurement process, has in improving the quality of articulation of public demand. The total amounts of government purchases are very great. Industry also knows that innovations are most likely to originate in the best developed markets. A government that contributes to the development of markets by improving its procurement process contributes also to the competitive ability of its national industry.

There is no time today to discuss at any length all the innovation oriented procurement programmes that we have studied in different countries. But I can give a few examples.

In the United States the Experimental Technology Incentives Program, or ETIP, was created in 1973. It aimed at improving government procurement by demonstrating in the civilian sector the use of advanced procurement techniques developed by the military. It also sought cooperation with Federal agencies and State and local purchasing officials in order to influence their procurement practices. Selected experiments were, for example, a low-cost blood analyser, a solar electric power plant, and an energy-efficient and low-noise air conditioner for households. None of the experiments of ETIP seem to have been particularly successful, but the programme is widely credited with the introduction into Federal and local procurement of such practices as performance specification, instead of design specification, the use of life cycle costing and the value incentive clause.

In Sweden, the National Board of Technological Development (STU) has a programme to promote innovation oriented procurement activities at the local level. The reason for this is that local authorities account for 85% of the 35 billion Swedish Crowns annually of public procurement. Programmes have been initiated in such areas as:
- Collection and treatment of household garbage,
- data processing systems for local government,
- public transportation,
- fire prevention and fire fighting.

The utilization of external competence by local and country governments is considered to be an important part of the programmes. For example STU will set up procurement courses, in which local procurement officers will be taught by procurement officers of the Swedish telephone company and the Department of Defense. Other activities include: Enhancement of the accessibility of expert knowledge by publishing lexicons with information concerning the purchasing of various urban technologies by local authorities; preparation of a list of the available expertise in the country; investigation of approaches concerning innovation oriented procurement policies abroad; development of STU's own competence on procurement matters; and initiation of procurement advisory committees within STU to assist local and county authorities.

Besides such programmes as sketched above, which aim to improve procurement practices in general, there are in many countries major - non-military - technological programmes in existence to which procurement - if handled correctly - can make a major contribution.

In France the "Plan Calcul" is the product of an industrial policy aimed at keeping French industry internationally competitive in computer technology. A secondary goal is to develop equipment that better fits the particular demand of French government and other French users.
One way French industry and the public sector are cooperating is as follows: Within the French central government every department has a data processing committee. Its members consist of civil servants of the particular ministry and a representative of the Central Council for data processing. The Council is in charge of the purchase of computer equipment from French industry and is part of the general directorate for industry. This means, that industry, through the Council, with its representatives in the Committees in every department, can have extensive knowledge of future demands of the public sector. Similar pattern can be descerned in other European countries.

A second example is that in Japan MITI is spending $ 20 m on an experimental Communication City, Higash-Ikoma. It is to be completely wired with optical fibres. The services to the population include rebroadcasting of TV and radio programmes, videophones, taking part in television discussion programmes from the home, community TV, medical information, and fire alarm. However futuristic all of this may sound, the immediate purpose is very down to earth. Japanese companies are using this government sponsored Communication City as a testbed for all sorts of industrial applications of optical fibres and new equipment.

It is of the greatest importance to note that such innovations could never be introduced by a single firm without the fullest cooperation from the government. It is my opinion that in telecommunications the future world leaders will not be the companies with the greatest technical competence but those companies that operate in countries where there is the willingness and the competence on the part of government and other parties involved such as the PTT and broadcasters, to cooperate in the process of demand articulation. This demand articulation should not be done in a narrow technocratic manner. It should be a political process, but probably cutting across traditional party lines and hopefully not dominated by special interest lobbies.

Having given a few examples - however brief - of government procurement being used to stimulate and direct industrial innovation in the civilian sector, it is now useful to go back to the original example of military procurement and micro-electronics.
We must ask ourselves what the critical differences are. Two types of differences seem to be of special importance, namely in government market power and in governmental organization.
Probably the most important difference in market power is that on the demand side of the market the U.S. military, was a large buyer in many cases the only buyer, or monopsonist. It had tremendous market power. In some years half of industrial output of certain electronic components was bought by the governement. In the 1950's government contract R & D accounted for about 60% of total R & D expenditures at IBM. On the supply side of the market, industry was characterized by strong competition but also by sufficient profit margins to finance independent research and develeopment. With regard to market power serious difficulties have to be overcome in civilian procurement. Politically difficult market aggregation has to be achieved before any market power can be brought to bear in such areas as urban technology or health equipment.

As in the case of the energy-efficient air conditioners, demand may be largely private and consumers may choose to buy a cheaper and better looking model rather than the one with the low life cycle costs purchased by the government. When the government has only a small fraction of total demand for a product, procurement can sometimes be successfully complemented by other measures such as regulation. But it can achieve little by itself.
Although it is not possible to generalize, producers in such areas as urban technology and health care often have profit margins that are too low to support independent R & D efforts. Total sales in any particular area are too low to encourage risk taking. In

Great Britain the development of a portable toilet which was seen to be of great importance for the elderly and disabled had to be undertaken commercially by the NRDC, which is a semi-government organization.
In other cases there may be not enough competition, or government may actually discourage it. It has happened too often that in a field of large scale, advanced technology such as telecommunications equipment or nuclear reactors a government has guaranteed large purchasing contracts to a particular firm only to keep it in business and regardless of technical competence.
The danger in such policies lies - apart from the harm done to free trade - in the fact that such a firm may loose its interest in remaining technologically competitive on the international market. Consequently it won't be. Larger countries with several large producers are in a more favourable position in this respect, because they can organize competition without making the politically difficult decision to purchase abroad. If market power is disregarded and government procurement is used to guarantee sales to a national firm, the public will loose and so - in the end - will that firm.

The second major difference between military and civilian procurement lies in the area of governmental organization. The military is tightly organized and the consensus as to its objectives is comparatively strong. What generals want from technology can be summed up by the American phrase: "a bigger bang for a buck". The consensus after the war was very strong indeed, that to deliver that "bang" miniturization and micro-electronics offered solutions.

Furthermore, in-house technical competence to evaluate competing bids from industry was available. This made it possible to bridge the R & D interface, which is too often a difficult to cross dividing line between people who know what is technically possible and people who know what the true needs are.

The organizational qualities of the military made it possible to decrease the effects of uncertainty to industry in the decision making on new technology. This uncertainty is greater if the technology is in a relatively early stage of development, as was the case with micro-electronics in the 1950's. Still one should observe that the conclusion from research on the development of micro-electronics after the war has been that the military in no case was directly responsible for major innovations such as the transistor or the integrated circuit. The real advantages were to be found in an acceleration of the development and diffusion process.

Let us now look at the organization of civilian procurement. Government organizational structures geared to clearly articulated tasks and with total responsibility for innovation in areas of national concern comparable to the military hardly exist. Such areas would be energy conservation, health care, and the abatement of pollution.
One exception that should be mentioned here is the Dutch department of Rijkswaterstaat, which has total responsibility for building and maintaining dikes at such a level that the risk of flooding is reduced to a minimum. This is truly a traditional and overriding national concern in Holland, comparable to national defense in other countries. It is interesting to note that Rijkswaterstaat has also succeeded in developing an innovation oriented procurement policy and that Dutch construction firms in this field are as a result probably the most advanced in the world.

But, in general, efforts to develop civilian innovation oriented procurement policies suffer from having to deal with many bureaucratic or political organizations and conflicting objectives. In addition these objectives are not constant over time and are subject to pressure from special interest lobbies. Government will usually not have its own technical in-house competence to evaluate different proposals. It is then at the mercy of these lobbies. The resulting uncertainty can be disastrous to the innovating producer. It is interesting to note that such cooperation between industry and government as does exist in, for example, the area of the computer or telecommunication industry is in a number of countries a direct descendent of defense oriented cooperative

activities in the Second World War.

Summing up the difference between military procurement of micro-electronics and civilian programmes now underway I could say that in the first case both market factors and organization were exceptionally favourable. This does not mean that innovation oriented civilian procurement should not be attempted. It does mean, however, that utmost care should be taken to operate in markets where competitive relationships are favourable.
In addition government should organize itself around technological decisions in such a way that uncertainty to producers is decreased. This means in some cases broad political discussions that lead to a reasonably stable consensus on technological choices. In other cases market aggregation must be achieved or new procurement techniques such as the use of performance specification must be introduced into government practice. These are not facile or utopian suggestions. A number of countries have initiated concrete programmes to achieve such ends. This can lead to a process of organizational learning that may seem slow at first but in the end can be an important factor in stimulating and directing innovative activity to the benefit of both industry and the public.

Summing up I believe the following recommendations can be put forward:

1. Procurement is an instrument that can both advance and give direction to innovation. As such, it should be one of the key instruments of Government innovation policy.
2. Especially outside the military sector there is still insufficient experience with innovation oriented procurement policy. With a few exceptions, governments have lagged in exploring its possibilities through experimentation. Experimentation within each national context is particularly important because the implementation techniques and effects depend strongly on the specific cultural and structural circumstances.
3. In the Netherlands procurement policy can contribute (in accordance with our "facettenbeleid") toward the development of technology aimed at the abatement of noise, air and water pollution, as well as at energy conservation.
4. Improved procurement practices can be achieved by market aggregation in such areas as care for the elderly, medical technology, fire protection, public transportation and block heating.
5. Government procurement should not lead to protectionism in the increasingly important public sector. However, it is probably acceptable and necessary to use procurement to aid the development of certain "infant technologies", especially when this is similarly done in other countries (see for example the Dutch "matching funds" policy).
6. The effectiveness of public procurement is greatly dependent on the way Government organizes itself, and the procedures it uses. A lack of in-house-competence, especially at the local level, is at present major limitation to the use of procurement for purposes of innovation. Experimentation and organizational learning should be started as soon as possible.

A Point of View from Industry

Dr. Ir. A. E. Pannenborg
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The theme discussed at this conference by Dr. Prakke and the author has received considerable attention in the last few years: the Science Policy Research Unit of the University of Sussex has devoted studies to this subject area, the Six Countries Programme on Government Policies towards Technological Innovation in Industry has produced a written analysis and in the Netherlands the subject was treated as part of a report of the Science Advisory Council entitled the Relation between Government and Industrial R & D. The findings in all these studies give a good description of the situation today and coincide with the observations collected by the author in the course of daily R & D management within the framework of a large multinational enterprise.
The influence exerted by government procurement on industrial innovation (and perhaps one should add explicitly: on the speed of innovation) is a special case which illustrated the influence which market conditions can have on industrial innovation. Accordingly, it seems proper to start with a few remarks on industrial innovation and market influence before going from the general case to the particular one.
The notion of innovation can have an absolute meaning, but also a relative one. In a captive market (a monopolistic situation or an autarchic national market) an innovation may be introduced which elsewhere would not be classified as such but would be regarded as falling under the diffusion of an earlier innovation.
One can ask what motivates a private industrial enterprise to embark on the often long and risky path towards an innovation. In line with the analysis in the Report to the Six Countries Programme * the aim is to achieve both a better product (functionally better of functionally the same at a lower cost price) and an improvement in the relative competitive position. This search for an improvement in the competitive position has to be bought at a price which contains the elements of cost and risk. While the cost involved can be estimated with reasonable accuracy in many cases, it is the risk which weighs heavily on the decision-maker. The risk has two components: the technological aspect (will it work as expected?) and the marketing aspect (will the customer buy it?).
In the jargon of industrial innovation, the notions of technology push and market pull are well established. The former mainly applies in the area of components, semi-fabricated products and manufacturing technology. Market pull involves the interaction between customers and suppliers and applies primarily to finished products and systems. Obviously, then, government purchasing can exert market pull.
Before continuing, we can deal with one specific case of indirect market pull resulting from government purchasing, namely its effect on manufacturing technology. Generally speaking, the government purchasing department specifies the product and not the way it is made. However, the sheer size of an order can enable the supplier to go over the financial hump and install a new, superior, and more economical manufacturing process which is only warranted for large-scale manufacture. In certain cases this, in turn, will enable innovation to come about in the enterprise supplying the capital goods for the manufacturing process.
The risk of a new product failing in the market can be considerably reduced if, during the conceptual phase (and to a lesser degree during the design phase), the supplier can cooperate closely with one large customer whose wishes can be regarded as representative of the future market. This cooperation, which should be between experts from both parties and may last for several years, should result in proof of feasibility and finalization of specifications.

* Ref. 3, page 17.

Provided it leads to agreement on the specifications, cooperation of the type just described will, with virtual certainty, lead to sales by the supplier to the customer concerned, thus diminishing the risk to the supplier and hence increasing his willingness to try and undertake the work aimed at innovation. The mechanism is attractive in markets with a limited number of potential customers (oligopsonistic) and almost a natural in monopsonistic markets such as those presented by utilities and defence where in most countries the government is the only customer. Similarly, the effect on product innovation in the case of standard catalogue items, for which the government is usually only one among many customers, is generally small, though more stringent or additional requirements imposed on the quality of a product by a government purchasing department may have the effect of raising the overall quality.
For a number of government requirements the cost involved in product innovation is so high that it cannot reasonably be borne by the potential supplier alone (e.g. military aircraft, nuclear reactors). In that case the enterprise is assisted by R & D funding. Usually the purchasing agency (held to low-risk decisions) will not be the source of this money. It is, however, essential for the ultimate user to be constantly involved in the project in order to avoid any divergence of views which might ultimately lead to the loss of the purchasing orders.
Another situation in which explicit R & D funding is justified is when great uncertainty exists in the market about what it wants with regard to detailed specifications. Then a prototype project for proof of feasibility is called for. This also applies to fragmented public markets such as hospitals where the necessary competence is not available in most units and the central government can lead the way with a demonstration of feasibility.

In the exposition above I have tried to describe how a private enterprise looks upon government purchasing as a potential incentive for industrial innovation. Allow me some room in the rest of this paper for a few remarks on the specific aspects of Europe in this connection.
Let us first look at the absolute volume of government purchasing, for this is an important parameter for assessing the measure in which government purchasing can give a successful innovation impetus to industry. To a large extent, economies of scale determine the relative competitive position in many branches of industry. These scale effects are important for the recovery of the initial cost of development of a product from the total number manufactured and sold as well as for the choice of manufacturing technique and the related investment cost. This implies that the size of a national economy - assuming the volume of government purchasing is more or less proportional to GNP - largely determines the importance of government purchasing as a motor for industrial innovation. In large countries it has already had, and will also produce, important results. In small countries its effect, if any, will be limited to a few product lines.
This observation leads immediately to the conclusion that innovative government purchasing policy should be aligned with sectoral industrial policy. In the case of smaller countries with a free market economy, the home market is too small for many products to be manufactured economically and competitively. If foreign markets are inaccessible, it does not in itself strengthen the economy of a small country to insist on national design and local manufacture, especially if the branch of industry called upon is not widely represented. This also includes the warning that specifications for products needed by the government of a small or even medium-sized country should not diverge too much from trends elsewhere. That kills any possibility for exportation. The purchasing policy of the British Post Office is a case in point.
If we look at industry across the world we all know that, insofar as technology plays a important role, the scene is dominated by North America, Japan and Europe. Business has become very international and for that matter competition in an increasing section of industry as a whole has become intercontinental. Europe is faced with strong competition from the United States and Japan, two countries with large homogeneous home markets which favour innovation. Europe is meeting this competitive onslaught in a hybrid fashion. Within the Common Market the customs union functions well; the Com-

mon Market as such almost really is a common market, apart from certain non-tariff trade barriers. By and large, however, government purchasing is national, if not nationalistic. This weakens Europe's position as an industrial power vis-à-vis the other two continents. Phrasing it in a fashion which is not yet generally accepted, one can describe this weakness as being due to the fact that Europeans attach the (emotional) meaning of the notion of national not to Europe but to each individual member state. In the other two continents government purchasing is overwhelmingly national; in the U. S. A. this is even formalized in the "Buy American" Act. A question which calls for serious consideration by the EEC Council of Ministers is whether the time has not come for the introduction of a "Buy European" Act. This could significantly strengthen European industry and put a stop to the destructive self-discrimination of always comparing purchases in a sister member state with purchases in the United States. It would put an end to a systematically non-reciprocal situation.
A policy which has been practised in Europe in certain fields is an ad-hoc cooperation between agencies in two or more countries for joint purchasing. This obviously promotes standardization and brings down through larger series the price of the product and often also the cost of maintenance.
The main focus has so far been on direct government purchasing. For industry this implies a market which, as already mentioned, sometimes leads to innovation. A central government also has other powerful means for the creation of new markets with innovational pull. It is appropriate to distinguish here between public sector markets and private sector markets. With regard to the former a central government can, through legislation, set advanced technical or functional standards to which lower level governmental purchasing has to adhere. Examples can be drawn from the fields of pollution control, hospitals and road traffic regulation, etc. This is closely linked with the role of a central government, which should cooperate with private enterprise in making feasibility studies and in sponsoring prototypes for the benefit of lower government levels, as already described above.
Private sector purchasing too can be partly influenced so that it has the same kind of impact on industrial innovation as that just described for the lower level public sector (e.g. standards for motorcars). This can also be done by offering new services such as television broadcasts in colour or the start of a Viewdata service.

At the end of this overview of experience with government purchasing from the supplier's end I should like to make a few remarks on patents. When we are working on innovation, patents are likely to be created. In negotiations with government departments on innovational work of a non-military nature the clause in a contract relating to patent property rights frequently gives rise to prolonged bickering. It is my considered opinion that it is best for governments to leave the ownership of patents created under development or supply contracts with the private enterprise involved. A free licence to the government to have the products covered by the patent made for its own use is an evident must. The further exploitation should be left to private industry! Additional income obtained under a patent will be additional gross profit, half of which goes to the government in most countries anyway. And a private enterprise will generally be easily more than twice as proficient in reaping further benefits from a patent than a government department.

1. Interview with Prof. C. Freeman, N.R.C.-Handelsblad 28th November 1977.

2. Government Procurement Policies and Industrial Innovation; report prepared for the Six Countries Programme on Government Policies towards Technological Innovation in Industry by W. Overmeer and F. Prakke, November 1978.

3. Publication of the Raad van Advies voor het Wetenschapsbeleid: "Relatie Overheid - Industriële R & D", July 1978.

Recommendations and statements

1. On the assumption that a national government has formulated an industrial policy it should ensure that government departments with important procurement needs adhere to it.

2. Lower levels of government (provinces, municipalities) play with their requirements a modest role in furthering industrial innovation because their jealously guarded autonomy leads to a fragmented market.

3. The procurement of services (contrary to hardware) by government from private industry might become more important in the future than it has been in the recent past and might well be promotional to industrial innovation.

4. European governments do not comply in general with the Treaty of Rome in their procurement policies. This leaves industry in Europe in a fragmented situation vis-à-vis strong intercontinental competition.

5. Apart from procurement policies Governments have other powerful means to further industrial innovation.

Panel discussion

Panel
Prof. Dr. G. J. M. van der Kerk, chairman
Ir. J. van der Meer
Dr. Ir. A. E. Pannenborg
A. W. Plattenteich
Dr. F. Prakke
Dr. R. Rothwell
Dr. P. A. J. Tindemans

(Chairman) Ladies and gentlemen, I reopen the afternoon session to proceed with the panel discussion. But let me first introduce a member of the panel who did not present a paper today: Dr. Tindemans, who will represent Minister Peijnenburg. Dr. Tindemans is a staff member of the Department of Science Policy and deals in particular with problems of innovation.
We have, as the French say, an 'embarras du choix' of questions and I have tried to arrange them in a way that, as I hope, will lead to a lively discussion.
Now I would like to start with a few questions for Dr. Rothwell, which are, of course, inspired by the paper of Dr. Pavitt that was presented by Dr. Rothwell.
The first is: You have indicated first, second and third division countries in Europe. Can you also rank the European countries according to innovation climate? The second question remarks that Dr. Rothwell highlights a widely-held belief that a healthy Medium Sized and Smaller Firm Sector equates with a good record of invention and innovation. The question is in two parts: Has any attempt been made to quantify this relationship as between North America and Europe? and: How do the Atlantic records compare with those of the Japanese - do the same factors apply?

(Rothwell) Well the second question really covers the topic I should be talking about tomorrow and it would be better if I did not answer it. I am not trying to dodge the issue, but ut seems wasteful to go over the same ground twice.
As regards to the first question about the ranking of innovation in Europe, that is a very difficult one. There is some evidence that the nature of innovation is different in Europe and North America and that in Europe much of the innovation is of the rationalisation type in traditional industry sectors, and this is certainly so in Western Germany. And in Western Germany this has paid very handsome dividends. If we take the machinery industry as an example, we see that the West Germans have not introduced radically new innovations, they produce machinery that has been improved, is better, more reliable and which has a greater design excellence. In Western Europe one tends to find a predominance of this type of innovation, and in the capital goods industry this sort of innovation is enormously important.
If one compares Western Europe with North America there seems to be a difference, because if one looks at the nature of American experts a greater percentage comes from science intensive industries, of innovation rich industries if you like. What fragments of evidence we have tends to suggest that the Americans have gone in more for new product development, and in some ways may have fallen behind in product improvement in traditional sectors. The Americans really have not done very well in mechanical engineering. They have done extremely well in producing semi-conductor devices and products based on semi-conductors.
Within Europe, I think one can say that certain countries have been more consistently innovative in improving traditional products and introducing new generations of products in traditional areas. I think one can say that the Japanese and the Americans have been rather more successful in new product development in new areas. I cannot give you a ranking of one to ten within Europe on which countries have the better innovation climate or the better record for innovation.

(Van der Kerk) Thank you, Then I have two questions for Dr. Pannenborg and Dr.

Prakke. The first refers to the third recommendation of Dr. Pannenborg where he makes a contrast between the procurement of services and of hardware by government. Would he please give examples of these services. Does he also think of denationalisation of public services, such as railways, or gas and water distribution?
The second question is addressed more to Dr. Prakke, I think, and runs: Widespread government procurement may well stimulate innovation in industry, but it also gives the government a powerful lever on private industry and it can be used to force them into a certain behaviour, for instance with respect to employment policy. What do you think about the risk involved?

(Pannenborg) The question refers to the third recommendation which was given in the introductory reports. When I wrote down these recommendations, I realized that this one was the most unclear and the most difficult to defend. But I wrote it down because in our type of society, and in many West European countries, it is assumed as completely logical that, when the community needs to have done something collectively, it should be done by the government. I think this is not a logical approach. The logical approach would be that the burden to the taxpayer is minimized. We all know that most government services are extremely honest, but at the same time extremely inefficient and therefore expensive. That is my point of departure. When we try to look into the future, I think you will agree that there will be a kind of shift from hardware to software. The needs of the future will be relatively more of an immaterial nature than of a material nature. And when I see that coming, I want to join that observation to my first statement and say: do not fall in the trap that of course government has to do it itself. They might well purchase the services. I can indicate with an example why this might be important. The government is a tremendous machine for the redistribution of income and this is done in huge silos full of civil servants. One of the drawbacks of that is that these organisations have not the slightest possibility nor the title to export their cumulated experience. In this world with emerging countries a very good and hard case can be made that the West should help these countries in teaching them these modern ways of government. We cannot do it because it is locked up in government. But if certain of these services were just rented from private sources, the private sources could exploit part of that accumulated experience in the international area.

(Van der Kerk) Thank you very much. Does Dr. Prakke want to add something?

(Prakke) Yes. We are both trying to point to ways the government can use to expand its procurement from industry. I have put emphasis on more and different types of hardware being bought from industry by the government for the public good, rather than being bought by private buyers. Dr. Pannenborg has put emphasis on the fact that many things which government produces itself, could also be provided by the private sector. A not too far-fetched example of this can be found in government research. Canada has really shifted its R & D policy from subsidizing government laboratories to simply contracting out to anyone who can undertake the R & D the government needs. Now, on the second question about government power, I think that we should always be concerned about government power, especially here where we are talking about the ways government could use its procurement power and be active in more areas. But I do not think that the situation is critical in Holland, as there are so few markets that are monopolized by government as a buyer. Of course, people from industry can be of another opinion. So I think that the question refers to the American situation, where the government uses its power of procurement to force firms into certain changes of behaviour in the area of employment, especially of minorities or women. And we could have an endless discussion about the question whether this is right or wrong. A typical area where the government uses its power, is the contract research field. The government has succeeded in forcing many of the nation's top universities to employ many more women especially, but also more blacks, because a university has to have a certain quota of these employees before they can do business with the government. As all of you know, most research institutes in the US are totally dependent on the government for their funding. Personally I think that you should be very careful and have a clear

idea of all consequences before even starting such a policy, but I also think that really this should not be discussed here, as it is a subject for a meeting devoted to the problem of government power.

(Van der Kerk) Thank you. Is there a comment from any other member of the panel?

(Tindemans) Yes, I have, on the first question answered by Dr. Pannenborg, and it is really two comments. First I think that the contrast between software and hardware in services, as described by him, is far too strong. One of the characteristics of our time is, I think, the increasing interwovenness of services and products from industry. This has also to do with the second point I want to make, namely that present trends in technology lead to a certain individualisation of collective needs. Industry certainly stimulates that also, but it is also a trend inhaerent in the technologies. It is not clear at present how this will work out, but I am quite sure that in due time this will induce our societies to ask themselves what should be the nature and the size of government involvement. I think there are already some examples of it, for instance in the field of transportation, in the field of health and even in the field of education.

(Van der Kerk) I now have two questions for Mr. Van der Meer. The first consists of two statements and runs: Do you agree with the following statements? First, one of the most important reasons for the fact that the USA has a leading role in the world, is that they are the most advanced in the application of the complete marketing concept. Second, the first condition for successful innovation is that Dutch companies apply the industrial marketing concept and abandon traditional product and/or sales oriented approach. And the second question is: If you want to stimulate innovation, how do you see to it that companies define their own problems and approach the right agencies?

(Van der Meer) Yes, I do agree with the two statements. When we are working with American firms, nearly always we are a bit envious of the way they are doing things, how they present their products and statements in such a way that the potential customer not only understands what it is about, but also gets interested. As I have said this morning, that may be a consequence of their educational system. As to the second statement, it is obvious to me that you should look whether there is a market before starting to innovate. My view may be influenced, however, by the fact that we are active in the capital goods market. Perhaps you can do it the other way round with consumer goods, by first developing a new product and seeking to establish a market for it later on. But this is extremely difficult in the capital goods market, to say the least. I do not have a good answer to the second question, I can only say that I don't know. The government can create all kinds of agencies and regulations to stimulate innovation, but there must be an active willingness in companies to use these. After all, you may lead a horse to water, but you cannot make him drink.

(Remark) When I visited a large German chemical firm a few days ago, I saw that they state in print that some of their most important products were developed without a market in mind. They add that in chemistry this may be always the case. This is true, for nobody knew anything about the market potential of plastics before they were there, and I think the same applies to transistors. In discussing innovation we should make a clear distinction between basic inventions and incremental innovations. What Mr. Van der Meer just has said is true of course, but it is not the whole truth.

(Van der Kerk) Thank you. It will surprise nobody, I think, that there are many questions on the papers of Minister Peijnenburg and Mr. Plattenteich. I will dose them carefully, just to hold your attention. The first question is: Can you give a suggestion for a model how to support unconventional research projects. Those who have to decide about the support very often cannot evaluate the risks and the chance of success. The second question runs: Could you explain what you mean with innovation potential of small and medium sized companies? Do you think that measures for the stimulation of innovation which are mostly directed at technological problems, are sufficient to help

small or medium sized companies in reaching a necessary level of innovation potential?

(Plattenteich) I do ask myself what can be meant by unconventional research projects. At the Ministry we are not afraid of unconventional research projects, we even welcome them, provided they are scientifically interesting and worthwhile. It is exactly our task to promote research projects that are not routine. We do not pretend to know all about every scientific subject, so we have a number of experts who are consulted before final decisions are taken. They give a recommendation and the Ministry decides on the basis of the recommendation. Lastly, I would like to point out that, as far as risk and chance are concerned, the Ministry is in exactly the same position as any commercial enterprise. We too have to decide under uncertainties, and would there not be any risk in a research proposal, I don't see why we should support it. It is a property of every good research project that there are risks in it, and a chance of failure.

(Tindemans) The only remark I have to add is that finding a model for something unconventional sounds a bit contradictory; for the rest I agree completely with Mr. Plattenteich.

(Van der Kerk) Thank you. There also was a second question.

(Plattenteich) As to the innovation potential of small and medium sized industries, the most important difficulty is to identify their real problems. We learned that from experience, and the first thing one has to do is to find out what kind of problems they have: is it organisational, financial or technological. Here one should be always on the alert, as financial and organisational problems often pose as so-called technological problems. So my answer is that technological assistance certainly is not all that is needed.

(Van der Kerk) Has Dr. Tindemans a comment?

(Tindemans) Just a small one. I agree with Mr. Plattenteich that behind so-called technological problems often lie financial, organisational or managerial problems. Therefore I think that it is essential for small and medium-sized industries that the assistance based on transfer of technology or transfer of knowledge is integrated in a complete advisory service. If one tries to transfer knowledge from a research institution, be it TNO, a Polytechnical University or whatever else, to a firm, a good insight into the real problems of the firm is essential. This is also borne out by the results of a project, carried out jointly by TNO and the Ministry of Economic Affairs, the Project for Industrial Innovation in Holland.
Further, I would like to point out that there are large differences between various firms, as there are firms in traditional industries and in very advanced industries. Technological advice will have to be completely different for these two categories, firms in the electronic sector should be dealt with in a quite different way than firms in the, say, food sector.

(Van der Kerk) This fits in nicely with the next question to Mr. Plattenteich and Dr. Tindemans: Transfer of knowledge is essential for the growth of innovative developments. However, transfer of knowledge is hampered by diverging interests in industry, institutions and government institutions. How could this situation be bettered: by professional organizations, by government stimulation or by other measures? We know that even within companies one has to deal with the NIH-factor, the Not-Invented-Here attitude. The transfer of an innovative idea from one department to another often is made difficult by a kind of mental resistance and the department that invented it originally hates to give it out of its hands to, for example, the development department. So there are not only barriers between industry, government and government institutions, but also within industry, where one would expect that all employees are working for a common goal.

(Plattenteich) I would say that it is not primarily the task of the government to organize the transfer of knowledge. This is the task of industry itself. What government can do is to promote the transfer of knowledge by various measures. We have advised Government funded research centres to organize bureaus for the transfer of knowledge, where they offer their research results to industry, to go to the Hanover Fair and show what they have to offer and to establish contacts in that way. But under the existing economic system government does not want to take over the tasks of industry.

(Tindemans) I have another small comment. It is not quite clear to me what is hinted at in the question. Is it the psychological resistance against working for industry, that exists in universities, is it the difference in outlook between people working in industry and in government? If that is what the question hints at, I would like to remark that the situation seems to be changing compared with five or ten years ago. The present discussion in this country, and others too, about innovation and the promotion of innovation is a witness to this new trend. We try to make the same point in our Memorandum on Innovation Policy, which will be presented around summer, and which will argue that in this field the various groups in society should not be kept separate, as it is to some extent a common effort.

(Van der Kerk) Thank you. I gather that Dr. Prakke has a comment?

(Prakke) Yes, I would like to make a comment on transfer of technology, as it is an area where there has been a considerable amount of research, at least in the US. One of the most striking conclusions is that technology is not transferred by the printed word. It travels by people who get into personal contact with each other. In the studies innovators in firms were asked where they had obtained the ideas that led to successes, and they could choose between books, data-banks, libraries, information systems, supplyers, vendors, colleagues, professors and so on. The results show clearly that it is almost never the printed word, it is almost always people who come face to face. This is true to a very high degree in engineering, and even to a surprising degree in science. These findings have led to the phrase that 'technology travels on the hoof'. Now I think that governments which wants to promote technology transfer, should bear in mind these facts very well. They should not think in terms of data, but in terms of people. They should promote by whatever means that technologists will meet face to face and they should promote mobility in such a way that a person who wants to go to another firm, does not loose the rights he has gained in his present job.

(Van der Kerk) Thank you. There is a comment from Dr. Pannenborg, I think.

(Pannenborg) I think it is very useful to bring up the aspect of transfer of knowledge, it is a very old point of course. The chairman reminded us of the 'NIH factor', and I have often said myself that generation of new knowledge is useless unless you pay almost as much time and effort to the transfer of that new knowledge to the next address as you have exerted in creating it. Knowledge can be transferred and experience can not, and in a cryptic way that is quite illustrative. This is something that is forgotten quite often too.
Once the vice-president of an American corporation wrote an article about the difficulties of transfer of know-how and one of his essential statements was: If you want to have effective transfer of know-how, don't combine a geographical separation with an organisational one. Under the roof of one organisation you can follow that rule. You have a laboratory organisation and you know that your customer, the product division or what not, is at another location. If you want to transfer a systematic stream, you might consider to post one or a few of your own experts on the premises of your in-house user in order to promote transfer of knowledge. Vice versa, you might invite some people from the next stage in the chain to work with you for some time. We must realize that transfer of knowledge is indeed very difficult if you have to transfer it from one organisation in a certain location to another organisation in a different location. Why is that so? It is because you use know-how always in a context. Everybody in an organisation

lives and works under a set of constraining boundary conditions. These often are not made explicit, but they are always there, and the sets of boundary conditions differ from one location to another. Usually people don't realize that boundary conditions are different for the next station. Now, if you talk about industrial innovation, one set of boundary conditions always has to do with economic evaluation and when you go through the chain these economic boundary conditions become more strict all the time. The research guy cannot understand why the development guy has not got the fantasy to see the big invention, and the development guy does not know how restricted the factory manager has to be to get the costprice down etcetera. It is not so much the know-how in itself as the assessment of its value under different sets of boundary conditions which is important. Anyone who manages a department should keep that in mind always.

(Van der Kerk) Thank you very much. The next question is for Dr. Rothwell and it says: In the paper Dr. Rothwell read, statistics on patents were mentioned for measuring innovation activities or detecting new trends in technology. Do you think that our existing Patent Offices could play a new or better role in this field? I would like to add that this is an interesting question, as the present tasks of Patent Offices are being questioned more and more. People say that almost everything has been invented already, especially in chemistry, and I know that it is becoming more difficult every year to invent brand-new things that can be patented. So if there is a new task for these very able organisations, it would be a good thing.

(Rothwell) There are some American studies on patents, which we at the Science Policy Research Unit in Sussex have found very useful as they tell something about the direction of innovation. For example, a comparison of patents granted on the same product in two countries gave some very interesting results. We found that in one country patents tended to be associated mainly with the production process, they were geared towards making the product cheaper and towards maximization of profits. Although this was not neglected in the second country, the main thrust of their patents was towards performance maximization, to make the product better and more efficient in use. When we looked up the trade figures, we found that the market share of the first country was declining and that of the second country was increasing, which told us something about the importance of performance maximization as a competitive dynamic. The problem is, however, that it is extremely difficult to get hold of this kind of facts about patents, as they are simply deposited in a central office and you have to go there and sort them out. That is rather time consuming. I do believe that patent offices could play a more positive role by either making access easier or by publishing patent statistics - patents produced in different sectors, the nature of the patents, whether you can classify them by major technological advance or minor technological advance, by product improvement or process improvement and so on. The availability of this sort of data would make the task of people like myself anyway much easier, but I also think that it is valuable and very useful information.

(Van der Kerk) Thank you. The next question is for Dr. Tindemans. It says: Mr. Plattenteich mentioned a number of facilities available in the Federal Republic of Germany. Has the Dutch government the same facilities available for Dutch companies that have developed an innovation and need assistance in putting it on the market?

(Tindemans) This question should be answered by a civil servant from the Ministry of Economic Affairs, and not by someone from the Ministry of Science Policy. I cannot recite all the measures and facilities, but I believe that the Dutch government is quite prepared to stimulate the later stages of the innovation chain. The Ministry of Economic Affairs can provide a whole package of advisory services, which has to do with finance, loans, guarantees and so on. Perhaps I may add that one of our reasons for preparing the Memorandum on Innovation jointly with the Ministry of Economic Affairs is that we want to improve on the present situation whenever possible.

(Van der Kerk) Thank you. The next question is for Mr. Plattenteich and it comes

from a colleague of his at the German Federal Ministry for Labour and Social Affairs. It says: Our two Ministries are co-operating in the R & D programme 'Humanization of Working Conditions'. One of the main problems in this field is the transfer of R & D results to the enterprises. This is an important question of innovation research too. But you cannot use the instruments for innovation promotion in the field of better working conditions, because there you have to deal with other than economic factors only. But the main social problems of the future seem to lie in the field of working conditions. Do you see a possibility for combining innovation research with research for better working conditions?

(Plattenteich) I can answer with an unqualified 'yes'. The programme the two Ministries are engaged upon, aims at improving the working conditions of the employees, of the labourers. To ensure that this will be achieved, we have introduced a procedure which is quite new and is not used in all other programmes executed by the Ministry. The project starts and the money is granted only after the representatives of the employees of the firm have agreed to the project that will be executed. There is close co-operation right from the start between the sponsors, the employers, the trade unions and the employees. I think this is very important, because we are becoming aware more and more of the social consequences of technological progress. Its results should be also socially acceptable. When buying new equipment firms very often can have the most modern machines that are friendly to working conditions at the same time. In this field the co-operation of the trade unions is very important, and they are represented in the various committees. Really there is nothing very new in this, as it is well known in many branches of industry that an investment in good working conditions may have a very short pay-back period, but it is still not known universally. The aim of the joint programme of our two Ministries is to diffuse modern insights on ergonomics, work satisfaction and so on as widely as possible, and I think it is a worthwhile aim.

(Van der Kerk) Thank you very much. The next question is for Dr. Prakke. It runs: Does the author mean by government procurement the purchase of goods, services, systems etcetera by government bodies on all levels? If so, this could be better described by 'direct procurement'. Laws, local regulations, general measures and so on also stimulate innovative activities and could be characterized as 'indirect procurement'. The third recommendation given by Dr. Prakke is a typical example of indirect procurement, but in my opinion direct procurement should have the first priority.
There is another question, quite short I think. In his third recommendation Dr. Prakke said that technological innovation in the public sector is neglected. Could the author be more specific and state in which sectors these neglects can be found, and could he give some examples?

(Prakke) Well, that is quite a bit. The first question is about terminology, and that is a subject which can lead to endless discussions. Generally you can distinguish between government measures that promote innovation by subsidizing R & D and other measures. In the last category, you can distinguish between regulations, which forbid certain things or prescribe that other things should be done in a certain way, and procurement, which uses the market power of the government to buy goods of a certain quality. What is meant in the question by 'direct procurement', I would call simply procurement, and the 'indirect procurement' I would call regulation.
Procurement and regulation are tied together, as they are both expressions of government demand or social demand, and in practice they cannot be distinguished as clearly as I have done here. Government might use procurement to fight air pollution or to promote energy conservation, which seem to be typical areas for regulation. Governments can use procurement for the development of demonstration projects or prototypes, and afterwards can use these demonstration projects or prototypes as a basis for their regulations. As soon as a government has demonstrated that a car can be built that causes only a low amount of air pollution, it can say to the car industry: We have shown that it can be done, now it is up to you to do it too, and from now on all cars will have to meet these specifications. So governments can combine procurement

and regulations very effectively.

(Pannenborg) If I may, I would like to add something. In between direct purchasing and regulations, mentioned by Dr. Prakke, there is a third type if you look at the procurement behaviour of the various levels of government. As I said in one of my statements, the lower levels usually are fragmented in their purchasing policy and this means that the scale is often small. A concrete example is hospitals; you can modernize hospitals, but who will take the initiative? Here the government steps in with an innovative prototype, and once that has been done the idea is that the lower levels of public authorities will follow that visible example in their purchasing policies. Then you have an interaction between centralized and decentralized procurement.

(Prakke) Thank you. I still have to answer the second question which asks me to be more explicit on what I mean by saying that the public sector is behind in technological change. I did not give examples in the abstact that was handed out, but I did gave them in my paper. There I mentioned public transportation showing fewer signs of rapid technological change than private transport, namely the car. I compared the telephone system with the development of computer terminals, and I pointed out that in the USA they are using the rapid technological change in the field of computer terminals to enhance competition in the telephone sector. Other examples in my paper are block-heating versus individual central heating units in homes, and preventive health systems, which typically are public, versus the development of medical drugs which are brought on the market by the pharmaceutical industry. You cannot really measure the rate of technical progress in both sectors with the same exactness, so it is a bit speculative, but it is my impression that the public sector is behind in technological progress.

(Van der Kerk) Thank you. In the next question Dr. Rothwell is asked to comment on three statements. The first is: A first and often forgotten condition for innovation is that the company applies the marketing concept instead of a product, a production or a sales oriented concept. Second: With respect to innovation there is far too much emphasis on the technical product or production process. Possibilities for innovation in the other marketing-mix instruments are underestimated, for instance, one could follow a 'me too' policy for the product and innovate in the other marketing elements. Third: Small and medium-sized firms should make joint efforts, initially perhaps with government help, to obtain continuous and adeqaute information on markets and technical developments which might influence their business.

(Rothwell) Well, I agree that close attention to the market is an extremely important condition for innovative success. If one looks at the statistics for successful and unsuccessful innovations - and there have been quite a number of studies on this topic - one finds that 75% of successful innovations responded to a need of one sort or another. So attention to the market is extremely important. I agree again that too much attention to technical aspects can be dangerous. In fact, I recently heard an example of two firms, one in Europe and the other America, which both developed new switching devices, using similar technologies that are quite radical in the technological sense. The European firm spent a lot of time in explaining to potential customers how brilliant the new technology was and how it worked. By doing so it may have frightened the customers a little bit. The American firm also went to its potential customers and said: Look, we have a new device, it is faster and it uses less energy. And by the way, it incorporates a brand-new technology, but you don't have to worry about that because our interface is compatible with the existing technology.
Needless to say, the American device took off much more rapidly than its European counterpart, which in fact is yet to take off. So I agree that you can lay too much emphasis on technical aspects.
In terms of market strategy I think it depends to some extent on the nature of the technology whether one should be first or second to market. When we did Project Sappho - a comparative analysis of success and failure in innovation - we found that most successful chemical innovations were first on the market. If you have a process that

produces a new chemical, or produces a known chemical at lower cost, you know that there are immediate benefits to the potential buyer. If you can prove that the new process is 20% cheaper, no potential customer will hang back, saying that maybe in two years time there will be another process that will knock off 25% of costs. In that situation first to market is a sensible policy.
But in scientific instruments there was some evidence to suggest that it was firms second to market which tended to be more successful. The reason is that with scientific instruments you cannot specify all needs of the users precisely. There is a great deal of market segmentation, and a firm that is first on the market will not capture the whole market, but only segments of it. For some firms it seemed to be a reasonable strategy to hang back as soon as the prototype development stage had been reached and wait to see how the market reacted to a similar product of a competitor. The first firm then could find out which points the users did not like, modify their own product accordingly and put it on the market saying that it would do the job better than the pioneering instrument. In some cases that seemed to be a successful strategy. But you cannot generalize this;whether such a strategy will be successful depends on the firm, on its R & D resources, on the structure of the market and on the nature of the technology.
As regards joint efforts for small and medium-sized firms, that again is something I will be talking about tomorrow. I think this is an area where governments can give a great amount of assistance, and in fact it is an area where the Japanese are particularly strong. For many years the Japanese government has supported collaborative efforts in R & D, in purchasing, in manufacture, in distribution and in collaborative exports. And that has been extremely successful.

(Van der Kerk) Thank you, Dr. Rothwell. Then I have a question and a comment for Dr. Tindemans. The question is: Could you describe in which way you expect to realize an investigation on the selection of the professional areas on which fundamental and applied research should preferably be concentraed in the Netherlands?
The remark is directed to Minister Peijnenburg and says: It is a pity that you did not mention this morning what the government is doing already in the field of innovation, for example direct development credits, indirect support to industrial projects on innovation, the activities of the Northern Development Company and so on.

(Tindemans) Let me start with the remark. I think everybody will realize that half an hour is not very long if one wants to sketch - and Minister Peijnenburg wanted to do that - the lines along which the future innovation policy of the Dutch government will develop. There was no time to go deeper into details. The first question about the selection of professional areas is quite important. The only thing I can say now is that, after many talks with representatives from industry, the universities, the reasearch system, other research institutions and so on, we have the impression that a larger orientation is necessary. The question then is how one can achieve that. We expect much from a working party which started its work recently and should sketch, as the first part of its task, a model for the selection of areas. In an exercise such as choosing professional areas there are a number of important problems; which professional organisations, which industries and which service sectors should be involved, what should be the balance between large and smaller industries, etcetera. We don't expect that the working party will have finished before the joint Memorandum of Innovation Policy will be published, as it has a rather difficult task. In fact it has to prepare a survey of the whole Dutch research system in consultation with all parties involved, and to give a reasoned opinion on the fields where our research effort is not big enough or, maybe, too large for a small country like ours. We are very interested in the subject mentioned in the question, but at the moment I hardly can say anymore about it than I have just done.

(Van der Kerk) Thank you. A glance at my watch has shown me that we have another ten minutes and I intend to spend these on a fundamental question that easily could keep us busy for the rest of the afternoon and the evening. The question says: It seems to

me that government policy on technological change and innovation is rather short to medium term, and more of a following than of a leading nature. One could imagine a more long-range strategy leading to a policy that promotes an innovative path to long-term aims and objectives for a future society. To what extent long-term objectives for a future society are considered, and if they are, can you specify these ?
It seems to me that this is a tough question.

(Plattenteich) Nevertheless, Mr. Chairman, let me try to tackle it. I think it is a very problematical question. Governments are unable to foresee the future from here to eternity and, at least in my country, nobody pretends to be able to do so. On the other hand, we should support those fields that promise to give results that may become important in the future, and we are trying to do just that by discussing trends with industry very thoroughly. It is not that civil servants are sitting in their offices and design programmes on their own; many think so but it simply is not true. Our programmes are being developed in close consultations with industry and the scientific community, and we hope that this combination of effort will enable us to chose the right tracks and avoid the dead ends, not always, of course, but in a majority of cases. But one of the problems is that science policy and research policy is long-term. Quick results are rare. A long breath is needed by everyone who has responsibility for R & D.

(Van der Kerk) Thank you. Is there any other member of the panel who wants to comment ?

(Pannenborg) Yes I do, because actually I think that the assumption behind the question is untrue. Quite a lot of money is spent on very long-term projects in Europe. In the Federal Republic of Germany a programme for a levitating train has been supported for many years. In several European countries there are huge programmes on breeder reactors, and on fusion research which is not only of a fundamental nature but has an applied consideration behind it. Now if we limit ourselves to these two fields of research, the most optimistic time-horizon for large-scale application is at least forty years distant, well into the next century. So I think that the statement that attention is focussed on short-term objectives only, is plainly not true.

(Plattenteich) Thank you Dr. Pannenborg for giving the examples I was not quick enough to present.

(Tindemans) I think it is true that from the political side there is a certain amount of pressure for projects that will show results in short or medium term. I agree with Mr. Plattenteich that this pressure should be resisted if the long-term significance of the research effort is promising. Dr. Pannenborg gave some examples where this might be true, but I would like to add that they are in very specific areas. Short-term thinking is still dominant in many fields, but I would like to suggest that the trends are changing. At our Ministry we understand the signs of the times, and that is the reason why Mr. Peijnenburg wanted to place the Dutch policy on innovation firmly against the background of the longer-term technological, social and economic trends in society in his paper this morning. One should really try to see things in perspective, to assess what is going on elsewhere in the world and to draw the consequences from that. I agree with Mr. Plattenteich that this should be done in close consultation with industry and the scientific research establishment, but I would not like to leave the labour unions out of that as they have an important say in it. Science policy and innovation policy are long-term affairs and one should not expect results any minute.

(Van der Kerk) I have to thank the members of the panel for answering this tough question in the way they did. I think it has been quite illuminating.
This, ladies and gentlemen, brings the panel discussion to a close.
However, I would like to make a short comment, not as chairman of the Conference,

but as a university teacher. When looking through the questions before the panel discussion strated, I was a bit surprised of finding no question about the possibility of educating for innovation, of breeding the ingenious type of mind that has new conceptions to offer. In this respect the polytechnical and other universities have much to offer. This is very important as we all seem to agree that we will become dependent more and more on a high general level of knowledge to maintain the present level of welfare. With that comment I really close the first day of the TNO Conference.

Research for Industrial Innovation *

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1. Introduction

Innovation in industry can be either of a major variety, such as the introduction of a new product or the adoption of a novel process for making an existing product, or it can be of a lesser variety, such as marginal improvement of existing operations. The latter sort is going on all the time and is perhaps not immediately obvious to the customer unless he looks over a period of years at the change in the product or in the price he pays for it. Indeed many improvements do not alter the product at all, but do in fact make its production easier or its properties more reliable. Nowadays much process improvement may be towards the environmental effects and therefore to the benefit of the community at large.

All of this innovative effort is based on research of some sort. I want to distinguish between the sort of research carried out in industry for defined objectives, and the research that is done in non-industrial establishments, such as universities, government laboratories and to some extent, in sponsored research establishments. The application of the first sort of research to industrial innovation should be fairly straightforward, in so far as the sponsor for the work knows what product or process improvements he wishes to make and he should know as much as anyone about the economics and the market factors. On the other hand, research in non-industrial establishments is frequently carried out as a general study of some area of scientific interest, or at least is set up against some general scientific objectives, such as a general study of metal winning processes or of the biochemical properties of a range of compounds.

It has to be admitted that the distinction I am making is not a hard and fast one. There has always been a certain amount of relatively unaligned research in industry, although of recent years this has diminished as industry has sought to obtain a better return on its research investment. At the same time research supported by government departments and even that in universities has increasingly had to define the likely benefits to be expected. I am, of course, speaking from experience of the activity in the UK but I believe it has been happening in most countries.

However, in spite of the greater tendency of recent years for researchers in the non-industrial sector to have to define the likely benefits of their proposed work to those who finance them, there remains the problem of how results of this work can be translated to the industrial environment. In the UK, it has for the past 30 years been the responsibility of the National Research Development Corporation to assist in this translation, although it does not by any means claim to be the only channel through which results of work in universities or government establishments can be developed in industry.

2. National Research Development Corporation

At this stage, it will be helpful if I give a brief outline of the activities of NRDC. I will then give some examples of situations within my own field, that of Industrial Chemistry, of how work in non-industrial establishments has been or is being developed for and by industry.

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* The views expressed in this paper are those of the author, and not necessarily those of NRDC.

NRDC was established 30 years ago under the Development of Inventions Act, 1948. This Act required the new Corporation to be responsible for the development or exploitation of inventions in the public interest. The Corporation was embodied in a Board of Directors, mostly non-executive, and appointed by the appropriate Government Minister from industry, commerce and academic life. The Corporation had the facility to borrow up to a certain limit from Government to get the activities started, but it was always intended that ultimately it should be selfsupporting.
There have been a number of amending Acts of Parliament, but the terms of reference of NRDC are still essentially the same. One effect of these amending Acts has been to raise the Corporation's borrowing limit from the original £5m. to £50m. in 1965. Also in 1965, NRDC was given wider powers to support research work that was likely to lead to useful inventions.

The activities of NRDC have always been seen as divided between a licensing function and a funding function. The first derives from the fact that many of the inventions made by university workers in the UK and by inventors in government establishments are assigned to NRDC. The Corporation then becomes responsible for obtaining appropriate patent protection (or other protection if appropriate), for licensing such inventions to industry, for policing the patents etc. The second function - the funding function - involves mainly provision of high-risk finance for development of inventions, either by sharing the cost of development with an industrial company or by funding further studies of an invention that is considered to be immature but potentially interesting. Where the funding is with an industrial organisation it may be related to the Company's own invention, to an invention it has licensed independently from a third party or to an invention licensed by NRDC.

Perhaps it will help to demonstrate these activities by reference to a few tables and figures showing the performance of NRDC. Firstly, some idea of the licensing activities can be seen in Table 1 which shows generalised statistics about numbers of patents held and of licences in existence. In technical terms these cover all of technology as can be seen from the breakdown related to the executive Groups in NRDC (Table 2). The most important in terms of revenue earning potential are listed in Table 3.

The extent of the funding activities of NRDC is shown in Figures 1 and 2, which represent in histogram form the numbers of projects and the sums invested in two sorts of projects. The first is for "Industry Projects" where NRDC shares costs with an industrial company for development of an invention in which the Company owns rights. The second relates to "Licensing Projects", where NRDC is supporting development of its own invention, either by further funding in the inventing establishment or by sharing investment with an industrial license. As can be seen, in the second category are included some subsidiary companies since on occasion, it has proved desirable to form new companies to exploit some novel technology.

Finally to round off this brief outline of the operations of NRDC it may be useful to consider the Corporation's Income and Expenditure data for the past eight years (Figure 3). This summarises the totality of NRDC activities. As some indication of important NRDC achievements, some examples in the Chemical and Biochemical fields are shown in Tables 4 and 5.

3. Research-based Innovation

I want now to concentrate on the development of novel ideas arising from non-industrial sources. Of course the first problem is to identify promising ideas and this has to be the result of a combination of alertness by inventors, liaison activity by NRDC staff and the functioning of certain formal functions in various establishments which require them to inform NRDC of inventions. By one means or another, at some stage NRDC executive staff are able to identify ideas that seem especially promising but which are judged to be too immature to offer to industry. Such cases will then be subjected to

more detailed study to establish their novelty, their potential utility and the likely size of the market. This stage frequently involves expenditure of small sums of money on patent searching and possibly larger sums to enable the inventor, or someone else to do work to identify the breadth of the invention. As a result of this work, it is possible to decide that a particular case may deserve more extensive funding and this may be in industry, in the inventing establishment, in some other independent establishment, or possibly some combination of these. The best way to understand this procedure will be to give a few examples and I have chosen some case histories from within my own field, that covered by the Industrial Chemistry Group of NRDC. These are as follows:-

1. Alkali-resistant glass fibre
2. High modulus polyethylene fibre
3. Flotation column
4. Monocrystalline semi-conductors
5. Silicon nitride

Only three of these examples have yet reach a fully commercial stage and for the other two it is too soon to say how successful the work has been. Of course, some inventions can be licensed directly to industry and there are many examples in the NRDC portfolio of this license activity without any associated funding.

1. Alkali-resistant glass fibre

The original invention from which this work derives was made in 1966 by Dr. Majumdar at the Building Research Station of the UK Department of the Environment. Dr. Majumdar had been interested in the possibility of using glass fibre to reinforce cement. However, it is common knowledge that:

(a) ordinary glass is attacked by alkali, and
(b) ordinary cement is alkaline.

Prior to Majumdar's work, the main attack on this problem had been by way of modifying the cement and there had been a lot of work on combining ordinary "E glass" fibre with non-alkaline cements. Dr. Majumdar set about finding a glass composition that was firstly resistant to the alkali content of cement and secondly capable of being fibrized. By 1966, he was sufficiently confident for NRDC to be able to file a patent application and publicise his results to industry.

Not surprisingly, the building industry was on the one hand excited about the possibility of manufacturing relatively light-weight cement components, without the weight and corrosion problems of using steel reinforcement, and on the other hand worried about using components in buildings that were expected to last for many decades, at a time that life testing had been possible for only about a year. At this stage NRDC had provided a small sum of money to enable Majumdar's team to have a substantial quantity of glass fibrized by a commercial company.

Early attempts to license the invention were difficult because of the uncertainty about market acceptability. Eventually, Pilkington Ltd, one of the major UK glass companies, acquired a licence and embarked on a detailed study of the technical problems and of the market prospects. In this early work, close collaboration was established between the inventor's establishment, where there was considerable expertise in the problems of the building industry, and Pilkington's who were, of course, very experienced in glass technology. NRDC took an active role in securing this collaboration as this sort of contact between inventor and developer is essential for good technology transfer. Within about two years it was apparent to Pilkington's that the potential market for this new material was very large indeed, but full development would involve a substantial programme aimed not only at the commercial production of glass fibre but also at developing applications and methods of production of cement composites. The Company felt that the technology was too risky for it to commit funds at the level that appeared to be needed and at this stage, NRDC agreed to fund 50% of the costs of the first £1.5m. programme. Close collaboration with Dr. Majumdar and his colleagues continued.

Now, some seven years after this substantial programme was started, the product is being marketed world-wide as CemFil. The NRDC investment is now being repaid by means of a levy on sales of glass fibre. Glass reinforcement cement (GRC) is truly a new material for the construction industry that gives many interesting possibilities for designers and architects.

2. High-modulus polyethylene fibre

My second example has not yet reached a commercial stage, and may never do so. It concerns research in progress at the University of Leeds, in the Physics Department on the drawing of fibres from high-density polyethylene (HDPE). Professor Ward has shown that by careful definition of raw material properties especially the molecular weight and of fibre drawing conditions, it is possible to attain a high degree of polymer alignment and thereby produce fibres of high modulus. Furthermore, the methods used should be relatively easy to translate into commercial practice, because no special equipment is likely to be required.

The original fundamental work was funded by the Science Research Council, which is continuing to fund these studies. NRDC decided that the products could be of considerable importance, since moduli of the order of 70G Pa at 0.1% strain could be made. These values are close to those for glass on a weight basis. It was therefore arranged for NRDC to fund an agreed programme at the University. The aims of the NRDC-funded work at Leeds University are firstly to scale up the fibre production to 300m/hr, secondly to consider applications to other polymers and thirdly to consider how the process might be converted to a production process. It also appeared desirable to consider the production of the material in forms other than fibre, such as tape, and film. To do this it was decided to involve industrial companies; licence options were negotiated with a number of companies who wished to study applications of the University ideas in their own fields. These fields did not essentially overlap and during this option period the organisations co-operated to some extent in the development.

As a result of the work in the University and in industry, the system is now much better understood than formerly. So far, two novel products that may find some limited commercial use have been identified but no commercially viable products that have any substantial market potential have emerged. This is for a number of reasons that were not obvious at the outset. Work is continuing at the University and in the laboratories of at least two of the optionees and some promising leads are being followed up.

I do not want to say more about the technology but would like to point out that this scheme for exploitation, involving parallel development programmes in a university and the laboratories of one or more companies, does lead to a situation in which any techno-commercial breakthrough can be followed up quickly. Selection of suitable companies, having the right attitudes and abilities, and establishment of mutually acceptable option and licence terms are clearly very important.

3. Flotation column

My third example is quite different and takes us away from materials science to process plant development.

In the mineral processing industry, one important method of separating different species of material in a fine ground raw material is by producing a froth and, by selection of appropriate additives, arranging that one class of material is wetted by the liquid, while the other is carried up in the froth. Traditionally, this proces is operated in flotation cells in which froth is created at the base by air injection and the hydrophobic material carried up in the froth is removed at the top. The hydrophilic material collects at the bottom but there is little counter-current washing effect. Mr. Dell at Leeds University showed that it was possible to create a counter-current washing ef-

fect by using a much taller column of fluid than usual and by arranging a series of baffles, or separators, so that the froth flowed up in a series of stages.

In 1974, NRDC provided finance for the University to build a laboratory cell and when this operated satisfactorily, a small five-cell unit was constructed and demonstrated for cleaning coal-washing tailings at a colliery. The demonstration was successful but it was still not possible to interest any UK company to license the technology on acceptable terms.

There are special problems with process plant developments, at any rate in the UK. Firstly, it is not always clear that the plant manufacturer gets the benefit of the development of a new piece of equipment. Secondly, the mineral processing industry is not always willing to commit itself to buy some novel plant until it has been developed to the stage at which the seller has reliable and reproducible equipment available. Thirdly, many of the companies involved are small. Added to all this, apart from coal, there are few mineral extraction industries in the UK and there is clearly an advantage in having the first use close to the development base.

The solution for this particular example has been to work with a small but important supplier to the UK coal industry and for NRDC to provide a substantial proportion of the cost of producing a commercial prototype that will be operated on stream at a National Coal Board site. The Company chosen will have a licence but NRDC will seek at least one other licensee, capable of operating internationally in the broad mineral processing field. During all this, close liaison is being maintained with the inventor and his colleagues in the Mineral Sciences Department at the University of Leeds, where there is much knowledge of the mineral industry, world-wide.

4. Semi-conductors

My fourth example concerns a company's own development programme, but involves close liaison with research at Government establishments.

Metals Research Ltd. is a company that originated as a supplier of very pure metals in monocrystalline form, mainly to academic customers. It has grown to a substantial and successful company, now a part of Cambridge Instruments Ltd. It produces a range of special crystals, equipment for growing and handling crystals, and for studying crystals and other materials. Amongst its products is the Quantimet image analysing system.

Some years ago, the Company entered the field of electronic materials and acquired a licence from the UK Ministry of Defence to build the particular design of Czochralski crystal puller that had been developed at the Royal Radar Establshment (now RSRE) at Gt. Malvern.

In 1970 further development at Gt. Malvern showed that in addition to being able to pull the range of oxide crystals then available a special modification could be made to pull gallium arsenide and gallium phosphide, important new semi-conductors, of special interest for making light emitting diodes and other devices.

It was soon clear that there were two important fields for commercial development. The first concerned the size of crystals that could be grown. In 1971 crystals weighing about 50g. about 3 cm in diameter and up to about 10 cm long, were being produced. Since much of the ingenuity of the process was in controlling the initial stages of the growth of a single crystal, there was clear advantage in making the crystal as large as possible, as well as the usual advantages of scale. The second development required related to crystal shape. The early crystals had quite unpredictable profiles and there was much potential advantage in being able to maintain a constant diameter.

It was therefore agreed for NRDC to support the development of a much larger puller (the "Melbourne" puller) capable of growing semi-conductor crystals, especially gallium arsenide and phosphide, of up to 8.5 cm diameter and up to 50 cm long. Techniques for diameter control were studied as well as various ancillary topics like production of cheap polycrystalline raw material. At the same time, work was in progress at RSRE (both at Gt. Malvern and at Baldock) to improve the diameter control by continuous weighing.

Most of these aspects of the development have been successful. The Company is now selling pullers and crystals world-wide.

5. Silicon nitride

My last example is another novel material, and its commercialisation has involved another scheme available to NRDC - the setting up of a development company. Silicon nitride is a hard, refractory material that can be produced in a form suitable as an engineering material. It is made either by hot-pressing of silicon nitride powder or by reaction-bonding, in which blocks or shapes of silicon powder are nitrided. An interesting variant of the reaction bonding process involves production of billets of partially-nitrided silicon powder that have sufficient strength to be handled. Suitable shapes are then made by machining or grinding and when these are further nitrided at high temperature and pressure, the products are formed with excellent dimensional stability.

Much of the early work was done at the Admiralty Research Laboratory at Poole, but there was no UK company suitable equipped or willing, to undertake commercial development. In 1970, NRDC was instrumental in forming a new company, Advanced Materials Engineering Ltd (AME) to undertake the development. It included, as equity holders, British Leyland, who were developing a silicon nitride rotary heat exchanger for a gas turbine vehicle, Royal Doulton Co., a major UK ceramics company, Clarke Chapman Ltd, a boiler and heat exchanger company, and Ransom Hoffman & Pollard Ltd. Much of the sophisticated early development work was done by the Atomic Energy Research Establishment at Harwell which was also represented on the Board of AME.

The major development work in the first year or two of the existence of AME was for the production of a rotary heat exchanger, comprising a honeycomb structure. It was made of reaction bonded silicon nitride because of the need for high temperature operation, with adequate resistance to thermal shock, combined with mechanical strength. In the event, the targets set for this product were not met and its development has to be described as a failure. However, during the work on the heat exchanger, a number of other products were considered and the company has, under a somewhat different ownership, continued to develop the production of a range of engineering products. The Company now has Allied Insulation Ltd as its major equity holder and is establishing itself in the production and sale of products like welding nozzles, hardware for handling of molten metals and items for production of semi-conductors.

6. General conclusions

I have summarised five case histories that have involved the development in industry of inventions from non-industry sources. It may help to consider Table 6, which presents an outline of how each case was handled.

The reasons for the different approaches relate largely to the structure of the industry in each field. Thus, for alkali-resistant glass fibre, there were UK companies who were dominant in production of glass fibre and one was chosen as the most suitable partner. The work on high modulus polymer fibres pointed to a range of possible products and collaboration with several partners in development appeared more appropriate than some totally exclusive arrangement. Process plant development has its own special problems, which resulted in an arrangement not dissimilar to that used for

TABLE

Summary of the Five Case Studies

Project	NRDC involvement: Patent	Funding in inventing establishment	Funding in industry	Equity holding	Company contribution
Alkali-resistant glass fibre	*	*	*		Funding
HDPE	*	*			Funding
Flotation column	*	*	*		Funding
Semi-conductors			*	*	Funding
Silicon nitride	*			*	Equity

alkali-resistant glass fibre, but without an exclusive licensee. The semi-conductor development has been a normal industrial joint venture for NRDC but special attention has been paid to secure the help of relevant UK Government laboratories. Finally, for the silicon nitride development, it was necessary to form a company specifically to do the work.

Of course, the simplest arrangement of all is to grant one or more licences to appropriate companies and leave them to undertake all development work.

One factor that is common to all of these examples is that there are risks involved in doing the development work. Some of these risks are:-

1. A promising research idea may work well on the bench but cannot be scaled-up for commercial use

2. Economic factors that can be determined only after development are unfavourable

3. The market may be too small or too late

The scale of these risks, especially the technical risk combined with market uncertainty, probably dictates the level of funding that is needed from outside sources, like NRDC.

In addition, a real problem in all cases involves what is called "technology transfer". Much of what is written about technology transfer applies to the problems of selling advanced products to underdeveloped countries. In the sort of technology transfer that I am talking about, the problem is relatively simple; all that is usually needed is adequate contact between the two groups of people so that the ones who have done the earlier work can work beside those who are taking it on. In almost every case, difficulties (large or small) arise that are not dispelled until this sort of contact has been established.

Generally, there will always be some inventions from university and government sources that can form the basis of industrial innovation. The best ones will find suit-

able industrial collaboration, whatever happens. However, the involvement of an independent organisation, like NRDC in Britain, with facilities for assessment and for funding, enables promising situations to be encouraged and hopefully for a speeding up of the processes firstly or recognition and later of adequate development.

Emerson is said to be responsible for the quotation about the better mousetrap. It is said that if one is invented, then users will beat a path to the door of the inventor. Unfortunately, it seems a common experience that, even if they do, they will firstly say that it will not work, secondly that it is not new anyway, and finally that they thought of it first. Because of these attitudes it is frequently necessary to spend public money to take the concept of the better mousetrap and show that it is at least capable of catching a mouse on what appears to be an economic basis.

U.K. PATENTS
& APPLICATIONS

* Biosciences	149
* Industrial Chemistry	275
* Scientific Equipment	378
* Computers & Automation	100
* Electrical & Electronics	221
* Production Machinery	89
* Mechanical & Civil Engineering	173
* Hovercraft & Tracked Hovercraft	160
	1545

Table 1A

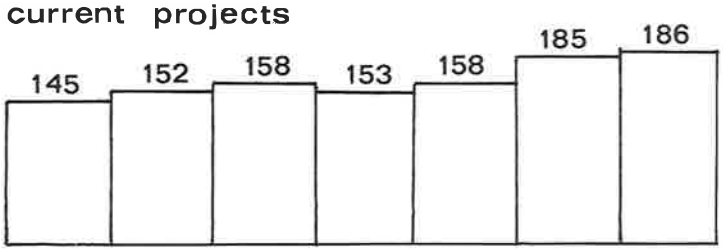
MAJOR SOURCES
OF LICENCE INCOME

* Alkali-resistant glass fibre
* Carbon fibres
* Cephalosporin
* Cholesterol assay
* Dental cement
* Foot and mouth vaccine
* Hovercraft
* PAM electric motors
* Pyrethroid insecticides

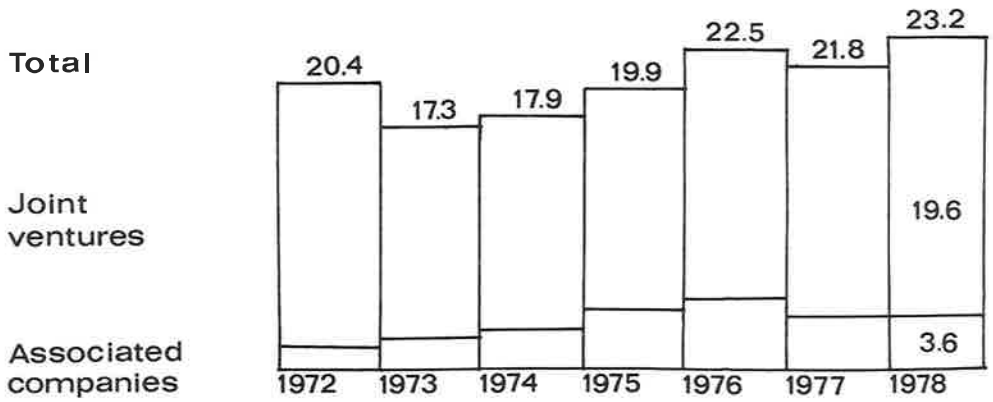
Table 1B

INDUSTRY PROJECTS

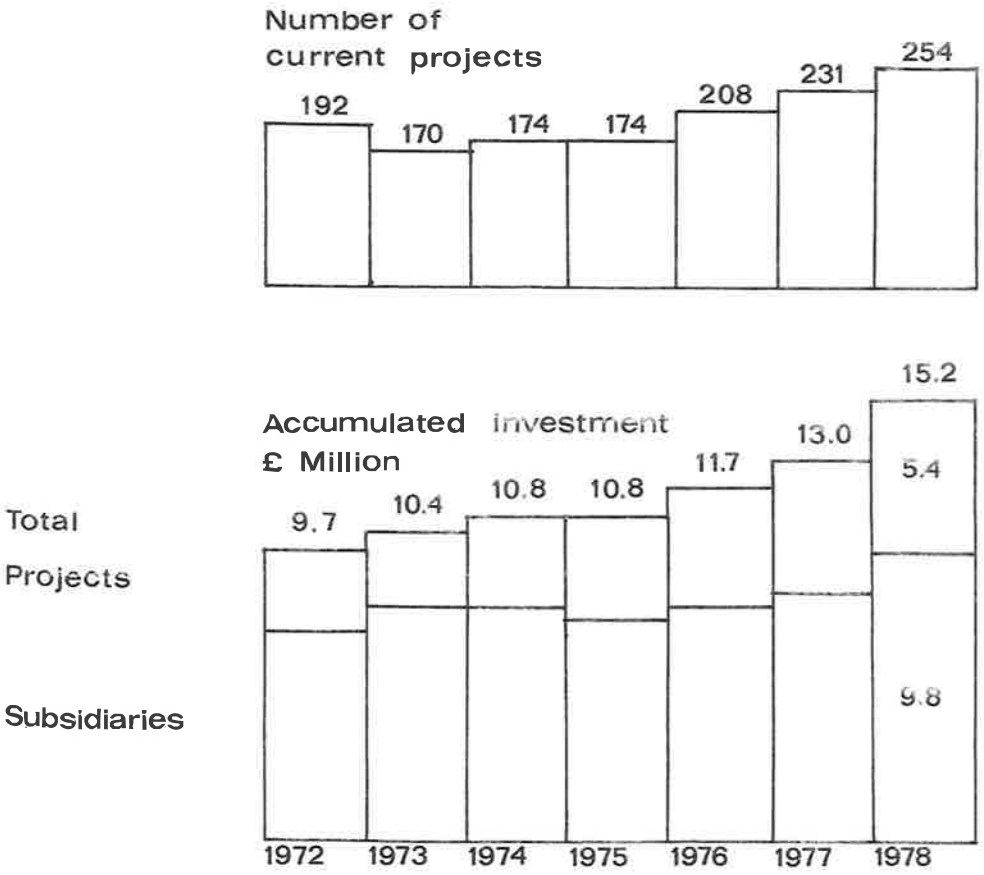
Number of current projects



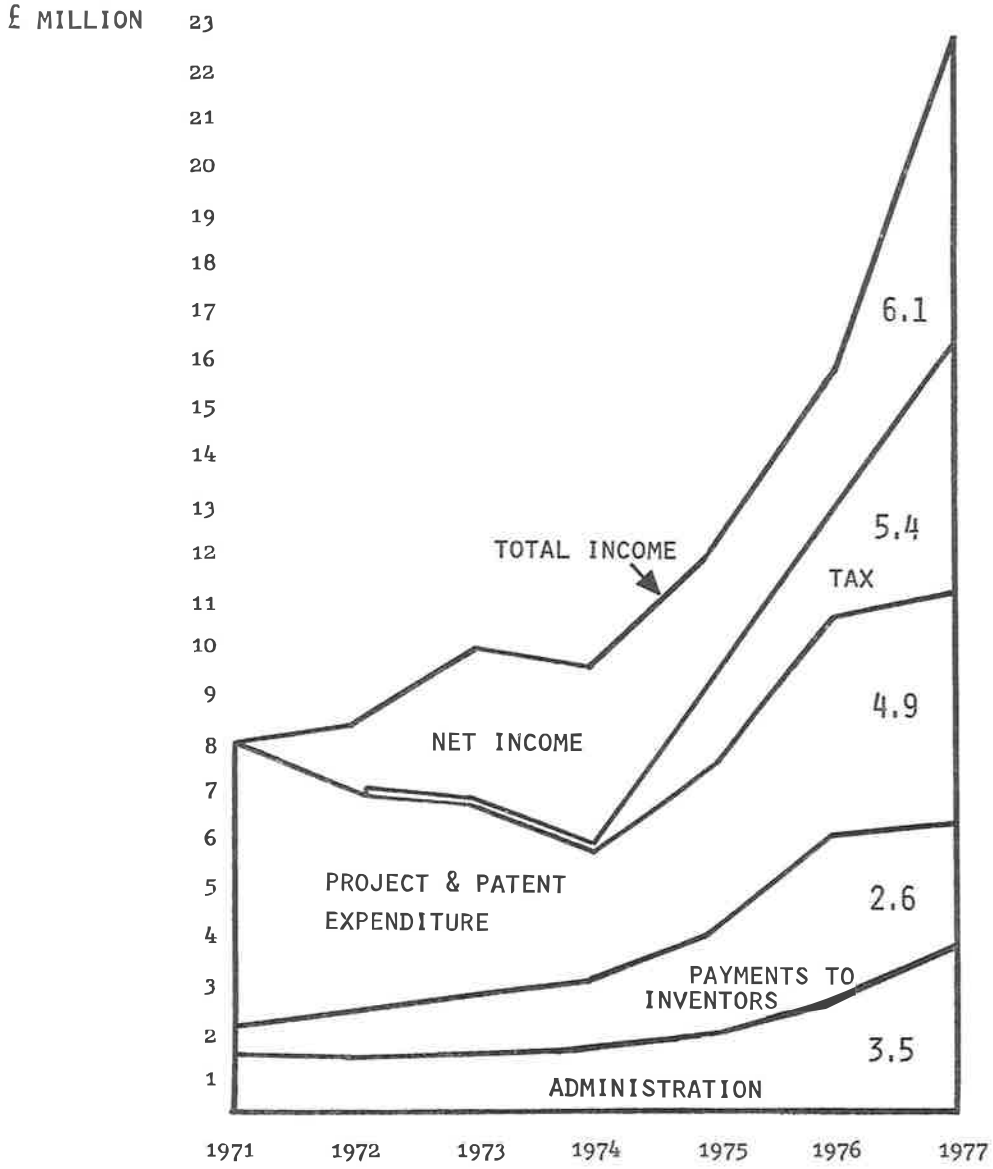
Accumulated investment £ Million



LICENSING PROJECTS



INCOME AND EXPENDITURE 1971 - 77



ACHIEVEMENTS

CHEMISTRY

* Carbon fibres
* Fuel cells
* Pilkingtons glass reinforced cement
* Dental cement
* Gallium phosphide and Crystal growth
* Silicon nitride

Table 4A

ACHIEVEMENTS

BIOCHEMISTRY

* Cephalosporin
* Pyrethroid insecticides
* Selective weed killers
* Foot and mouth vaccine
* Anti cancer drugs
* Cholesterol assay

Table 4B

NRDC LICENSING 1978

UK patents held	1,545
Overseas patents held	4,212
	5,757
UK licences in force	417
Overseas licences in force	114
	531
Revenue earning inventions	329

Innovation in the Chemical Industry

Dr. H. Dörfel
Head of the Plastics Laboratory of the Badische Anilin und Sodafabrik Aktiengesellschaft (BASF)
Ludwigshafen
Federal Republic of Germany

Ladies and Gentlemen:

The chemical industry, after a very modest start 100 years ago, has become a pillar of industrial production and helped to satisfy man's elementary needs. Its annual turnover of more than DM 90 thousand million in the Federal Republic of Germany accounts for instance for more than 10 % of total industrial production.

The chemical industry has developed by continuously renewing and improving its products and processes, in other words, it has constantly provided innovations. Innovation is indissolubly linked with the rise of the chemical industry to the importance it has today. Particularly qualitative, but also quantitative, growth is a direct consequence of numerous processes.

Unlike most of our other industries, the chemical industry did not primarily arise out of crafts and trades, but is the result of consistent translation of scientific research data into commercial-scale practice.

New developments in the chemical industry were characterized by a scientific, systematic approach and were much less the result, as was the case in many other industries, of mere empirical experimentation. Once the scientific theoretical principles underlying the laws of chemistry had been worked out, new developments were made more quickly and often represented a big leap forward.

E. G. after the increase in our basic knowledge of the nature and structure of organic compounds made by Berzelius, Wöhler and Kekulé in the first half of the 19th century, organic chemistry developed extremely rapidly and successfully.

Stages and innovation passes through in chemistry

What stages do innovations, i.e., the sum of all the scientific, technical and commercial steps by means of which new products are introduced into the market or novel processes or plants are operated on an industrial scale, pass through in the chemical industry? (Figure 1)

In chemistry too, the starting-point is the birth of an idea: in corporate research work, in cooperation with universities and scientific institutes or in the literature new chemical and technological possibilities are recognized which promise a considerable improvement in existing products or processes, or the creation of completely new products or processes, in other words, which open up new prospects. At the same time, new market needs or long-standing market needs unable to be satisfied by previous expertise are investigated with a view to determining whether they can be met by the new possibilities.

Combination of these factors gives a number of project ideas from which the most promising for the company are selected and pursued as projects. In applied research, a concept for these projects is first drawn up, and solutions are then systematically played through, if possible on a laboratory scale.

If the new product can be manufactured, or the new process carried out, it is usually

Stages of an innovation in the chemical industry [1]

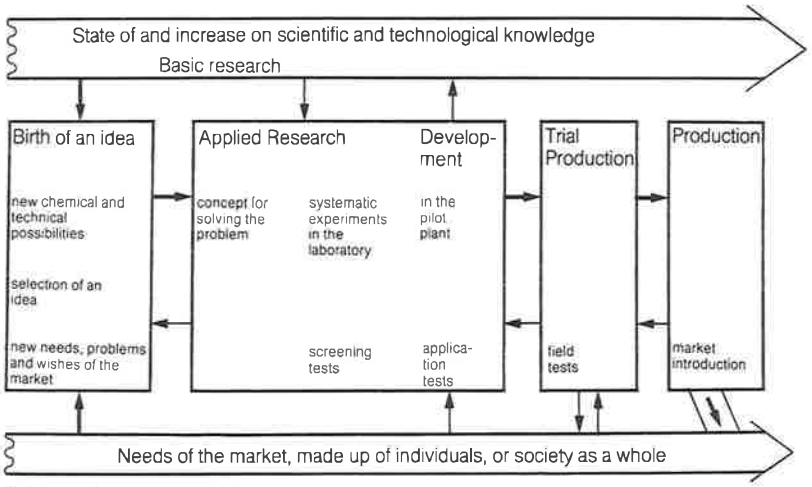


Figure 1

Typical conditions affecting the chemical industry

- raw materials, auxiliaries (availability, costs)
- energy (availability, costs)
- chemical products (requirements)
- customers, consumers, consumer habits
- transport routes and costs
- work force, wage costs, labour legislation
- state of scientific and technological research
- competitive situation, customs dues
- regulations of government

Figure 2

translated to commercial scale via a pilot plant stage, always assuming the market need still exists. Activities in the synthesis of new products are complemented by application and field tests for products, or by an accurate evaluation of the economics of a new process.

If all the results are positive, a production plant is constructed and the product introduced to the market.

Social changes - part of the general conditions influencing chemistry

In what way do changes in society influence these innovation processes in the chemical industry? As is the case with every branch of industry and indeed every activity the chemical industry was from the outset dependent on fundamental environmental factors, on general conditions. It was only able to develop within the limits of these general conditions. (Figure 2).

For the chemical industry, these conditions have changed to a greater or lesser extent in different countries at different times. Changes in these conditions have doubtless always been also influenced by changes in society in the country of the chemical industry in question, or in countries supplying raw materials, countries taking chemical products, and the countries where the most important competitors operate. Thus, wherever changes in society occur, they are part of the ever-changing conditions influencing the chemical industry and, with it, chemical innovation.

As changes in society throughout the world are extremely difficult to assess, but have an effect in one way or another on the chemical industry and thus on chemical innovation in a country or economic area, I would for the purposes of this paper like to employ the following method to elucidate the connections between changes in society and chemical innovation: innovation in the chemical industry of a country or economic area will be considered in its dependence on the change there in important general conditions for the chemical industry, particular attention being paid to changes in society as part of these general conditions.

Chemistry innovations have themselves, however, considerable changed fundamental conditions in various areas of life and have thus definitely cuased changes in society.

For example, the effective control of infectious diseases with drugs revolutionized medicine, and the use of artificial fertilizers and crop protection agents enabled agricultural production to be spectacularly increased and rationalized, followed by radical changes in the structure of many countries.

Difficult problems solved by chemical innovation in the past

Chemical innovation, which has always stood at the centre of raw material, energy, environmental and social problems, has in the past proved to be an excellent tool for mastering difficult problems which were detrimental to, and even seriously threatened, the life of man. When chemical innovation is considered at close range, it will be seen that it has itself adapted surprisingly quickly to changes in the conditions affecting the chemical industry, in other words, has been able to provide successful solutions to the problems at hand by changing its own starting position. This valuable adaptability instils us with the hope that chemical innovation will in future too be able to make an important contribution to the solution of difficult problems facing mankind. (Figure 3).

May I first, however, recall a few important examples from the past.

Justus von Liebig's well-known investigations into the constituents of plants and their occurrence in the soil led to the realization that the increased cultivation of field crops - necessary as a result of the increasingly rapid population growth - without

Difficult problems solved by chemical innovations in the past

Problem	Solution provided by chemical innovation
• rapidly growing world population; poorer yields from deficient soils	– use of fertilizers (phosphates, potassium salts) – binding of atmospheric nitrogen (NH_3) – crop protection agents – oral contraceptives
• infectious diseases	– chemotherapeutics, antibiotics etc.
• scarcity of rubber	– synthetic rubber
• scarcity of spinn. fibres	– cellulosic and synthetic fibres
• scarcity of oil	– coal hydrogenation

Figure 3

Mineral fertilizer consumption and yields in German agriculture since 1880 [2]

Year	Mineral fertilizer consumption (kg/ha)			Yields (t/ha)		
	N	P_2O_5	K_2O	wheat	barley	Potatoes
1880–1885	0.7	1.6	0.8	1.28	1.29	7.92
1910–1914	5.1	16.1	12.8	2.02	1.94	12.90
1925/26	10	15	24	2.02	1.71	12.87
1939–1943	21	14	46.2	2.19	2.07	17.52
1949–1951 *)	24	21.3	42.8	2.71	2.49	21.55
1959–1961	42.5	47.2	71.4	3.27	2.90	22.39
1969–1971	77.1	63	82.1	4.14	3.59	27.25
1975/76	92	59	83	4.47	3.97	26.63

*) only Federal republic from 1949 onwards

Figure 4

High-pressure syntheses

atmospheric nitrogen + hydrogen → ammonia

carbon monoxide + hydrogen → methanol

coal (tar) + hydrogen → petrol

ethylene → polyethylene

Figure 5

sufficiently long intervals leads to exhaustion of the soil of important elements such as phosphorus, potassium and nitrogen, which are essential for plant growth. These elements are removed to an increasing extent with the harvested crop. As urbanization grew, flush toilets were introduced and municipal sewage was discharged into rivers, the natural recycling of these elements to the soil functioning in the country via the field crop-food-natural fertilizer-soil chain became increasingly disrupted.

By fertilization with phosphoric acid and potassium salts it was possible to increase continually the yield in deficient soils. The big drop in fertilizer production in Germany in 1917 and 1918 - phosphate production was only a tenth of the 1913 volume - was one of the main reasons for the 1918 famine which claimed many victims in Germany. (Figure 4).

Finally, however, fertilization with naturally occurring phosphates and potassium salts was no longer adeqaute for feeding the growing population. In his famous Essay, Malthus prophesied that mankind was doomed to die of starvation. The soil was lacking in fixed nitrogen, an essential component of proteins and nucleic acids, those classes of substances to which processes incidental to organic life are in particular linked.

Since 1913, ammonia has been produced on a large scale by the catalytic reaction of atmospheric nitrogen with hydrogen under high pressure in accordance with the Haber-Bosch process. The ammonia produced in this way has been used especially for manufacturing fertilizers. Ammonia production started in Ludwigshafen in 1913 with 9,000 tonnes; at the end of the twenties, as much as 400,000 tonnes of fixed nitrogen was being used per year in fertilizers in Germany.

Completely new high-pressure technology had to be developed for the ammonia synthesis. The big high-pressure reactors, 20 metres long and having an internal diameter of 2 metres, weigh 300 tonnes and have to be manufactures by a special strip-winding process from special steel strip.

This important technological innovation started a chain of further chemical innovations. In 1920, Matthias Pier reacted, in the Ludwigshafen pilot plant for the ammonia synthesis carbon monoxide with hydrogen at 200 atmospheres with zinc chromate as catalyst, and obtained methanol in good yields; at elevated temperature, methanol and higher alcohols were obtained. Methanol is discussed in our days as fuel for automatives.(Figure 5).

As early as the twenties, a shortage of oil was feared in the U. S. A. ; in 1927, U. S. oil reserves were estimated to last for only another 7 years. Considerable interest was therefore aroused by a new process being developed at that time in Germany for the manufacture of hydrocarbons from coal. In the same pilot plant, in which the ammonia and methanol synthesis had been worked out, Pier hydrogenated coal-tar obtained from low temperature processes and then coal itself. On the basis of this and other work, up to 6 million tonnes a year of synthetic fuel was manufactured from coal during the Second World War in Germany.

The further development of this high-pressure technology for pressures up to 3,000 atmospheres and above later made the high-pressure polymerization of ethylene to polyethylene possible.

Chemical and medical research has had a particularly beneficial effect in the improvement in man's state of health. An important contribution to checking previously widespread infectious diseases was made with the development and introduction of a number of extremely effective new drugs such as chemotherapeuticals, antibiotics, etc. In 1927 in Germany, infectious deseases accounted for 20 % of all deaths; in 1976, for only 1 %. (Figure 6). During the same period, man's average life expectancy rose from 57 to 71. In the tropical countries, the extremely poor state of health of the population was im-

Decrease in mortality due to infections diseases as a consequence of significant progress in pharmaceutical and medical research [2]

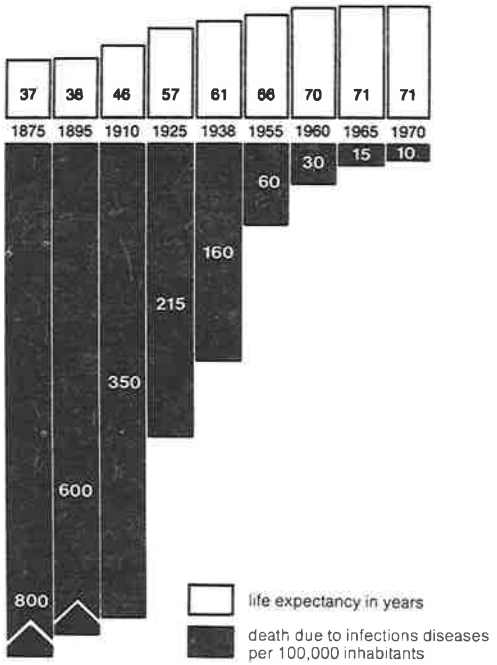


Figure 6

Change in important conditions affecting chemistry	Adaptation by innovation
cheaper oil after 1950	feedstock switched from coal to oil: cheap organic chemicals and polymers
rapid growth of industrial production	
• increasing need for chemical products • scarcity of labour • rise in wage costs • rise in capital costs	– new efficient processes – automated processes and – measuring methods – big single-line production plants

Figure 7

proved by the development of numerous specific drugs for tropical diseases.

Adaption by innovations to changes in the general conditions influencing chemistry

Even in the relatively stable phase of industrial growth in the fifties and sixties, the chemical industry, as a result of its innovative capabilities, quickly adapted to the changing conditions for its own activities.

With cheap oil in sufficient supply, processes for the production of organic chemicals and polymers soon switched to oil and natural gas feedstocks. The heavy demand for chemical products created by vigorous economic growth was able to be met by the introduction of efficient new processes. Scarcity of labour and the rapid rise in wage bills were countered by the development of substantially automated plants and measuring methods. (Figure 7).

Innovations in polymeric organic materials

The immense increase in plastics production made possible by numerous innovations in the field of macromolecular chemistry was encouraged as oil products from the growing petrochemical industry became cheaper and cheaper. (Figure 8).

In this growth period, plastics, illustrated here by the polyolefines, dropped tremendously in price. Because of their cheapness and their superior processing and performance properties, they in many cases replaced traditional materials such as paper, cardboard, wood and, finally, metals. The variety of plastics manufactured made completely new uses and technologies possible. The production of organic polymers - presently running at more than 40 million tons per year - corresponds in volume to about 300 million tons of steel. (Figure 9).

The use of organic polymers revolutionized the packaging, storage and distribution of goods, the textile-industry, and brought advantages for the building and furniture industries, the motor industry, electrical and mechanical engineering, the surface coatings sector, paper finishing, the adhesive industry, etc. (Figure 10).

There is today practically no area of human activity which does not use synthetic organic polymers created by chemical research in the last 4 decades. Without them, the standard of living which we and critics of plastics have become accustomed to would be unthinkable. This will be particularly apparent if we try to imagine what the consequences and changes for our civilization would be if all synthetic polymers, not to mention all chemical products, were suddenly to disappear.

Innovations saving raw materials and energy as a reaction to the increase in oil prices

When, in 1973, in addition to other negatively changing conditions for the chemical industry, oil and energy prices suddenly rose as a result of political and social changes in the oil-producing countries, numerous innovations were made to counter their effects:
- new processes with higher yields and less waste products
- new processes using no auxiliaries
- new and more efficient products to save raw materials
- new processes requiring less energy
- energy link-up and utilization of energy from waste incineration in chemical plants.

For economic reasons, it has always been an important research goal to develop processes with high yields, low energy requirements and as low an auxiliaries consumption as possible. For instance, the energy consumption in the manufacture of ammonia has been reduced in the last 60 years from 90 times to twice the theoretical value. (Figure 11).

Plastics consumption in the western world

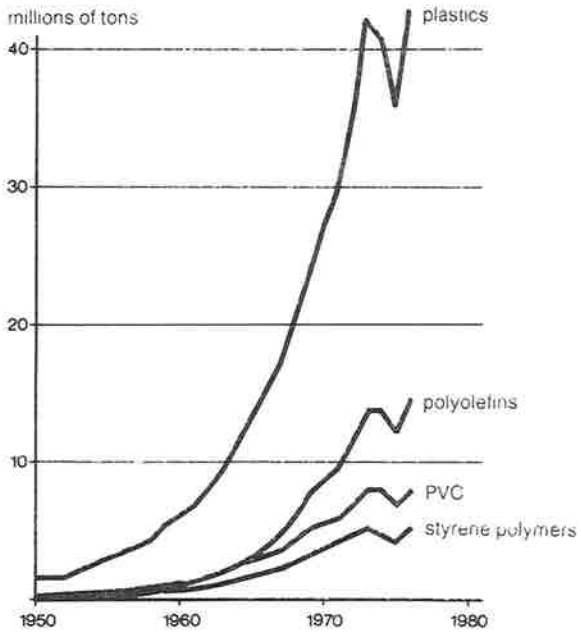


Figure 8

Polyolefine prices

(Federal Republic of Germany indexed prices)

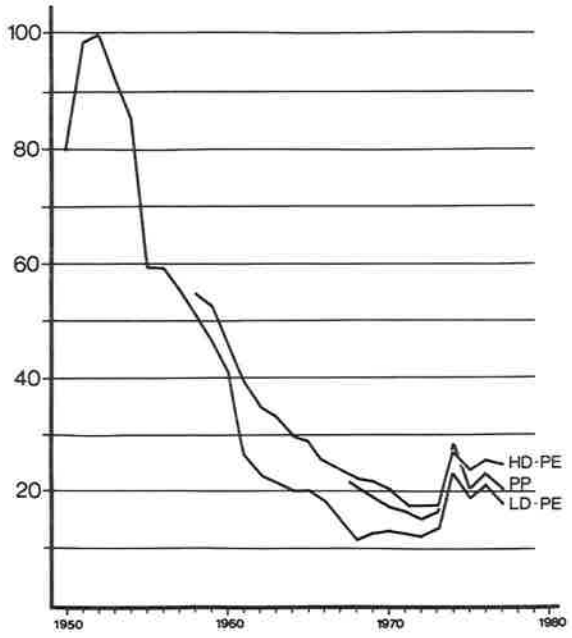


Figure 9

There is practically no area of human activity which does not employ synthetic polymeric materials [2]

The most important areas are:

transport
biulding
furnishing
household effects
sport and leisure pursuits
clothing
packaging
advertising
medicine and surgery
communications
astronautics
surface coating
adhesion
industrial equipment
electrical engineering

Figure 10

Chemical innovations saving raw materials and energy

- new processes with higher yields, without auxiliaries
- new energy-saving processes, extensive energy link-up
- recycling of chemical products
- new, improved more economical products
- further substitution of conventional materials by organic polymers
- heat insulation for buildings by polymeric foams

Figure 11

In one of the works of the big chemical companies, the proportion of energy obtained from waste heat and combustion of wastes rose from 12 % of the total energy consumed in 1965 to 27 % in 1976; in absolute figures, the amount of energy recovered from waste heat almost quadrupled.

As is readily apparent from a comparison of the energy requirements of traditional mass products and those of synthetic polymers, the latter have, by replacing traditional materials, helped us to save an extraordinary amount of energy in the past and will continue to do so in future. As energy gets scarcer and more expensive, this indisputable advantage will even more heavily favour synthetic organic materials in future, and open up further possibilities for replacing traditional energy-intensive materials, especially metals. (Figure 12).

The organic polystyrene and polyurethane foams which have been developed in the last 3 decades possess excellent thermal insulation properties and are being increasingly used for the insulation of buildings.

There are considerable opportunities for saving the energy used in heating and cooling here, because as much as 21 % of all our petroleum products is used for heating and airconditioning buildings.

Finally, the protection of metals against corrosion by new and improved synthetic surface coatings should not be forgotten. The protection of many millions of car bodies and other steel products against corrosion helps to save a large amount of steel, and thus energy, each year.

To summarize, it may be said that numerous chemical innovations are today directed to the conservation of raw materials and energy. Fortunately, higher yields and lower energy requirements are also advantages for our environment.

Negative changes in the conditions affecting chemistry

The special situation of the chemical industry and thus of chemical innovation in our time is (attributable to the fact) that the favourable conditions for the chemical industry existing in the fifties and sixties took a negative turn from the beginning of the seventies. The accumulation of several negative influences has had a particularly unfavourable effect.

Environmental problems

Although the emission of harmful substances by natural phenomena is much greater than that from human activity, reinforced efforts - investments and innovations - were doubtless necessary in conurbations (due in part to the rapid rise in the production of chemicals) in order to control better the factors influencing the environment. (Figure 13).

Downriver of Ludwigshafen there is a mammoth treatment unit which cost DM 450 million to build, where BASF effluents and those from the towns of Ludwigshafen and Frankenthat are purified. The plant costs about DM 70 million a year to run. (Figure 14).

These defensive investments were in part caused by the rapid rise in the number of laws and regulations relating to the environment which have come into force in our country. (Figure 15).

These defensive investments were in part caused by the rapid rise in the number of laws and regulations which have come into force in our country relating to the environment.

The development of new effluent treatment processes, new waste gas purification pro-

Energy and raw material requirements for production of some mass-products, made from organic polymers or conventional materials in tons of oil equivalents [2]

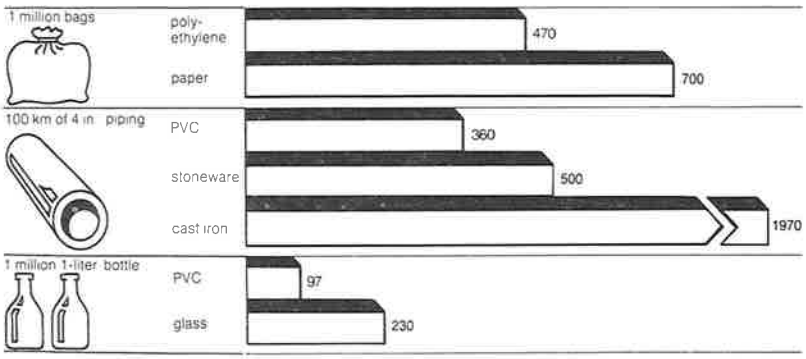


Figure 12

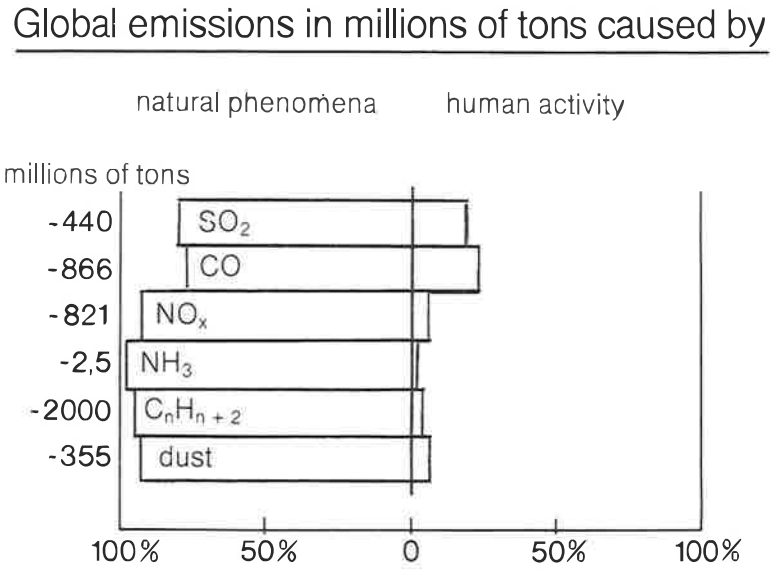


Figure 13

BASF Aktiengesellschaft,Ludwigshafen works
Wastes discharged into the Rhine

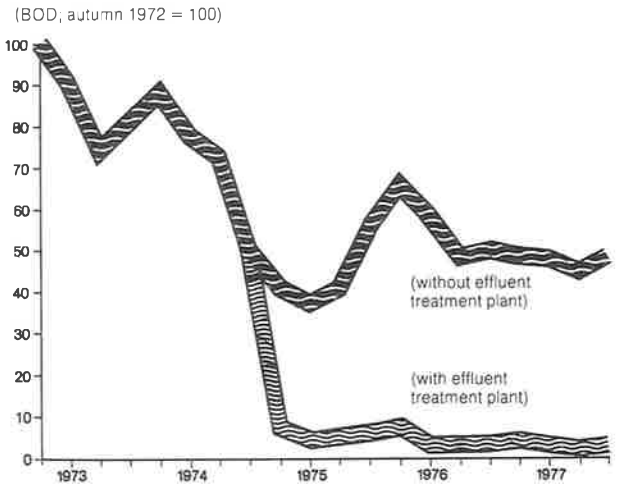


Figure 14

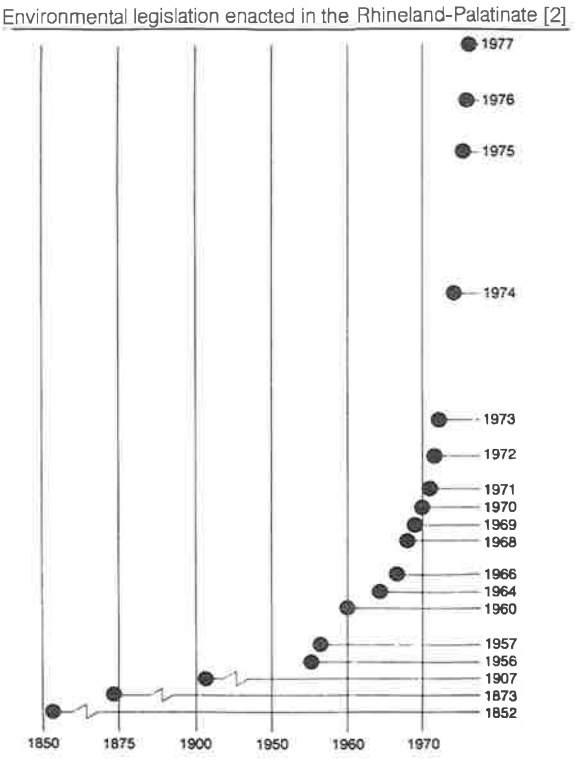


Figure 15

cesses and improved analysis and test methods for toxic substances is definitely useful and necessary, but they have a defensive effect on technical progress. They claim a considerable portion of the chemical industry's research capacity, which as a whole is stagnating.

The purchasing prices for chemical raw materials, which have risen rapidly since 1973, and the ever-increasing price of oil - a trend which is definitely in part attributable to changes in the political and social climates of the countries producing the raw materials - exert a negative influence on the chemical industry and its scope for innovation. By contrast, the drop in raw material prices in the fifities and sixties had a stimulating effect. This situation is aggravated by the comparatively depressed prices realized for chemical products: Mass products, especially the mass plastics, are in a particularly tight price squeeze. The main reasons for this are overcapacities, price undercutting by companies in which governments have a holding, and undercutting as a result of barter transactions with Eastern bloc countries. (Figure 16).

In many countries, and particularly in Germany, a factor further restricting the scope of chemical innovation is the rapid increase in wages. Compared with them, the profits of chemical companies have dropped because of the predominantly negative effects of the last 5 years. An increase in wages and thus in research costs and a drop in profits result in a decrease in the funds available for innovations. Domestic social changes put a brake on chemical innovation here. (Figure 17).

Figure 18 shows the rise in research costs by 7 leading German drug manufacturers over a 10-year period: in 1976, research costs were 370 % up on those for 1966.

The longer test periods particularly in the pharmaceutical and agrochemical fields lead to longer development times for new products, with the result that sometimes patent protection has already expired before the new products have been introduced.

Progress in chemistry is at the present time made not so much in a few large projects as on a wide front with many new and improved products and processes. The direct promotion of research projects which is at the present time favoured in Germany and which particularly the more spectacular projects in nuclear chemistry and the aircraft industry profit from, is a disadvantage for research activities in the chemical industry, were more indiract R & D promotion would be useful. (Figure 19).

All these tendencies are exacerbated by biased, exaggerated and not infrequently ideologically prejudiced presentations of the actual or potential dangers connected with chemistry. Objective comparisons with risks from other areas of life, e.g. traffic, or weighing the usefulness of chemistry against its risks, are carefully avoided. I am not in favour of keeping quiet about the drawbacks to innovations; I would rather plead for benefits to be balanced against damage, for a presentation of the whole range of effects chemistry has on our living conditions.

It is important in this connection to know that chemistry, other sciences and engineering also provide the tolls for recognizing the damaging side-effects of innovations, such as sensitive analysis methods for detecting toxic substances, specific methods for measuring their toxicity, and a range of instruments for overcoming or at least reducing these damaging side-effects.

Future tasks facing chemistry

One of the biggest tasks facing us in future is the satisfaction of the basic needs of people in the developing countries: ensuring an adequate supply of food and clothing, providing housing, and safeguarding health. The prosperity of the rich nations depends not least on the assistance they give to the poor nations, because prosperous countries in Asia, Africa and Latin America are better trading partners for the industrialized

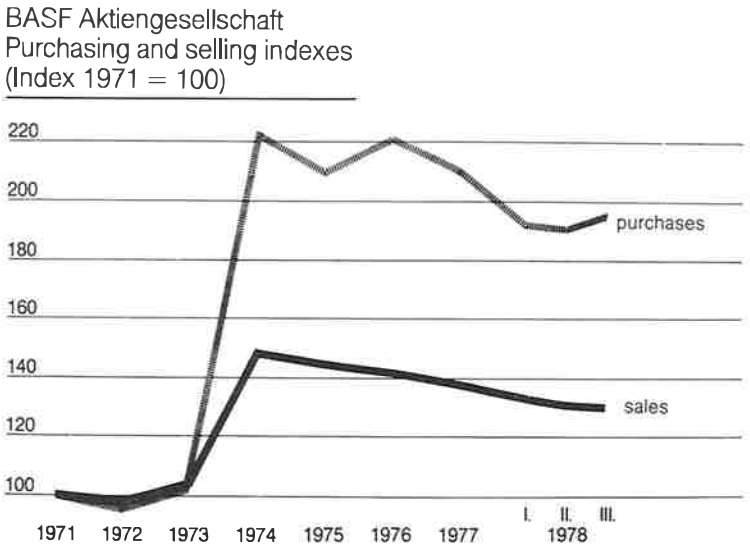


Figure 16

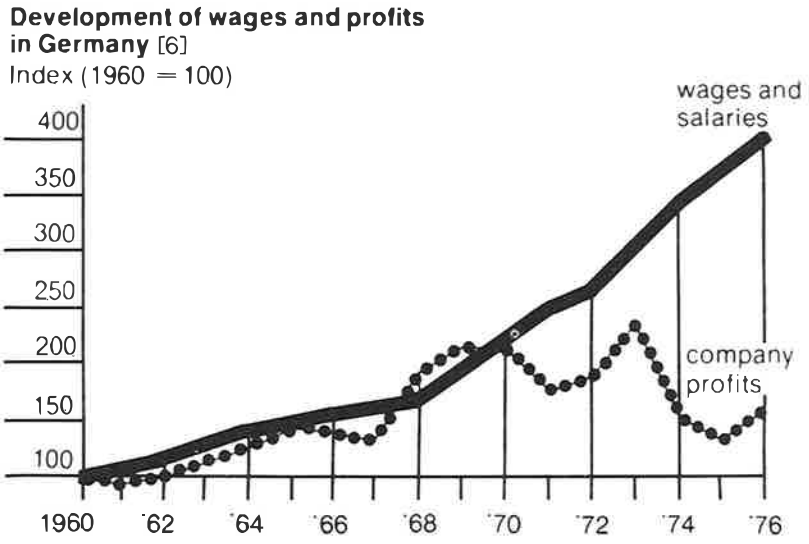
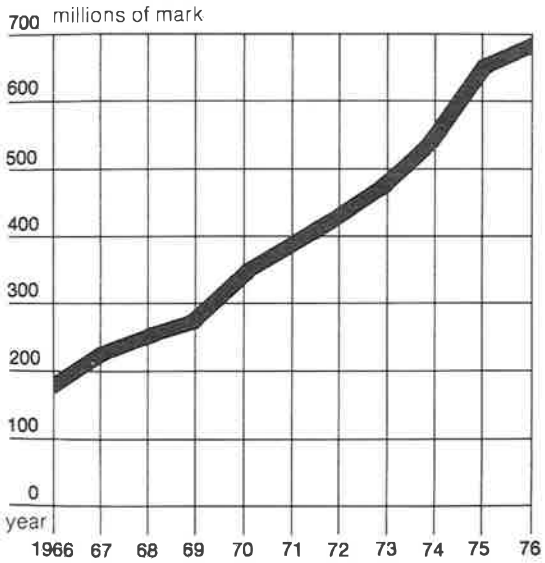


Figure 17

Rise in drug R & D expenditure by
7 leading German drug manufacturers[+)]
in the period 1966 to 1976 [2]



[+)] Bayer AG; C. H. Boehringer Sohn, Ingelheim; Boehringer Mannheim GmbH; Hoechst AG; Knoll AG; E. Merck; Schering AG.

Figure 18

Ratio of direct to indirect R & D promotion [6]

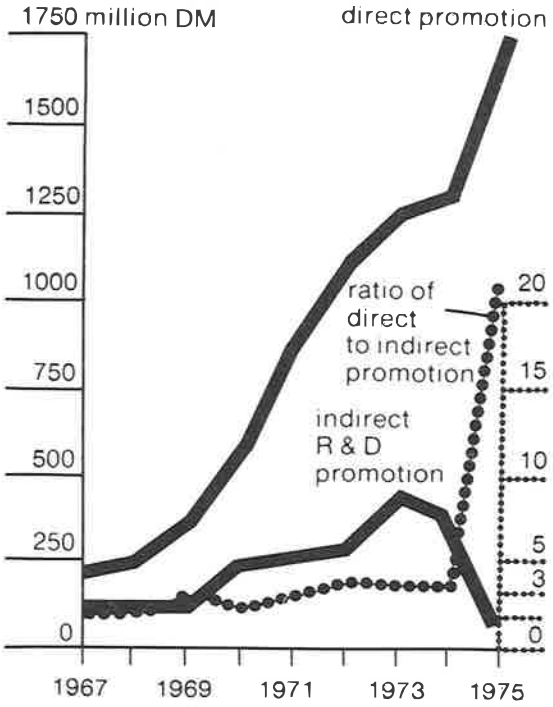


Figure 19

countries than poor ones.

Most chemical companies have recognized this and are already active in many developing countries, contributing towards improving the local economy and living conditions. These efforts are sometimes hampered by factors such as the wish of developing countries for prestige-technologies which do not fit in with the economy of the country: native engineers and scientists who have been wrongly trained, namely for solving problems in industrialized countries; a poorly trained labor force; lack of foreign currency; bureaucratic hindrances to the import of badly needed machines, auxiliaries and precursors; non-existent infrastructure; no interlocking industries, etc.

Chemistry could make a valuable contribution to improving the situation of the developing countries for instance in the following fields.

Agricultural yields in many of the world's poor countries are insufficient. Modern gricultural methods, combined with biological and chemical techniques, could radically improve yields and thus the food situation for the people of these countries. (Figure 20).

Contributions made by chemistry:

- more and improved fertilizers, specific crop protection agents and pesticides;
- increased use of plastics and foams for better packaging agents, and the safer storage and transport of perishables;
- plastics for economical irrigation units, new polymeric binders, still to be developed, for binding sand, and new soil conditioners with increased water retention for improving poor harvests in the world's arid zones.

It will be evident from a detailed presentation of yields and losses in rice cultivation that quite good yields are obtained in countries such as India, but that a large proportion of the harvest perishes. (Figure 21). A high rise in food production may be expected from application of the methods used in industrialized countries.

An important food source of the future may well be the production of proteins and other nutrients with the aid of microorganisms. Although projects for the microbial recovery of proteins have as yet met with little success, this should not discourage us from exploring this possibility in future too.

The inhabitants of tropical countries are afflicted by many dangerous tropical diseases and plagues which are not yet satisfactorily controlled. This will be a big field of activity for pharmaceutical and medical research.

The already considerable activities of the chemical industry in the finishing of local raw materials in the developing countries, e.g. skins, furs, fruit, and textile fibres, ought to be extended and continued.

It will also be important to manufacture binders for the more economical construction of houses and roads from the raw materials of the developing countries. Cheap, lightweight houses could be built there with the aid of organic thermal insulating materials, and their value considerably improved.

Another area is the greater use to which chemical auxiliaries and materials could be put for the more economic production of a developing country's own raw materials, which are often important currency earners.

A method of supplying hot countries having a tight foreign exchange position with raw materials and energy may be provided by the development of vegetable raw materials which continuously regrow. According to a study which has been published, it should be

Agricultural production: world wheat and maize area and yields obtained [2]

	Area cropped (millions of ha)			Yield (tons/ha)		
	1961–1965	1974	1976	1961–1965	1974	1976
Wheat worldwide	210	223	235	1.21	1.62	1.77
– developed countries	60	64	69	1.74	2.16	2.24
– developing countries	50	61	67	0.98	1.19	1.41
– planned economy countries	100	98	99	1.01	1.53	1.70
Maize worldwide	99	112	118	2.17	2.62	2.83
– developed countries	33	38	41	3.51	4.19	4.69
– developing countries	45	53	55	1.13	1.39	1.33
– planned economy countries	21	21	22	2.28	2.92	3.13

Figure 20

Yields and losses (1973) in rice in various countries [2]

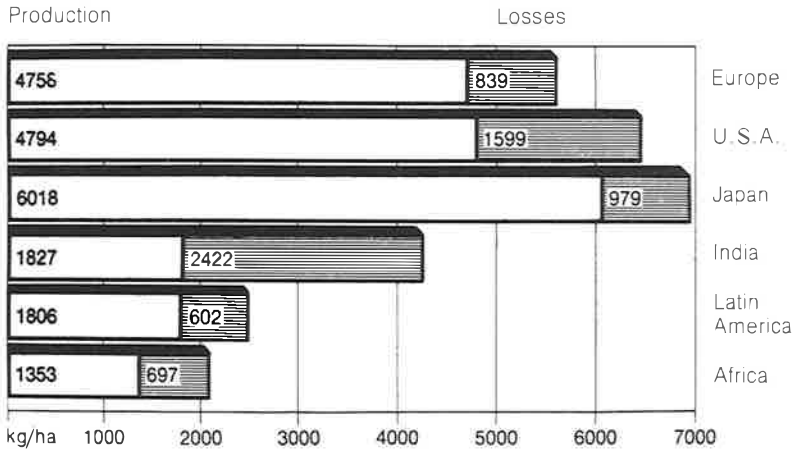


Figure 21

possible in Brazil to cultivate, on 2 % of the total area of the country, sugarcane enough, when fermented to ethanol, to make all the country's oil imports for fuel unnecessary.

A big step forward for industrialized and developing countries alike would be the as yet unsolved fermentation of cellulose to sugar.

A very big task facing pharmaceutical chemistry and medicine is the development of effective drugs for diseases which we cannot control to day sufficiently, if at all; examples are heart and circulatory diseases, rheumatic diseases, virus diseases, certain fungus infections, psychic illness, diabetes, and especially cancer. (Figure 22).

Another important task for the future will be the development of quicker, cheaper and more specific methods for determining the toxicity of compounds and for testing active ingredients.

A further goal will be to develop products and technologies to replace particularly toxic materials.

It will in future be just as important for the industrialzed countries to develop products and processes which help to conserve our reserves of raw materials and energy: new biotechnical syntheses, further replacement of metallic materials which are energy-intensive or which will soon no longer be available by organic materials which consume much less energy, e.g., electrically conductive polymers.
It would be a major advance if we could control photosynthesis and thus use diffuse sunlight too for producing energy and obtaining raw materials for organic chemistry.

Of all the oil products consumed the West German chemical industry at the present time needs only about 6 % as feedstocks. If the other big customers for oil products, namely power stations taking 41 % and households taking 21 %, could be converted to other energy sources such as coal or nuclear power, then oil reserves would last for a very long time as valuable chemical feedstocks. However, oil could become scarce for political reasons, as made conspicuous by the recent turmoils in Iran.

The chemical industry might, primarily for political reasons, be compelled to switch from oil to coal even earlier. For this reason, preparatory work for such a switch is being carried out particularly in the U.S.A., but also in Germany. (Figure 23).

The synthesis gas obtained from coal is substantially equivalent to that obtained from oil or natural gas; when process technology has been suitable adapted, syngas provides access to the large-scale chemical products ammonia and methanol, and many other feed materials. (Figure 24).

Let me sum up by saying that innovations in chemistry have for more than 100 years made essential contributions to the improvement in our living conditions. However, the great task still facing us is how to satisfy elementary needs of many people, particularly in the developing countries. Here, too, chemistry can and will make important contributions because, in a material world, manmade material conversions are an important instrument for changing our living conditions.

The multifarious activities of the chemical industry have in the last 100 years pervaded all areas of our life and are now of such importance that, without chemistry, our civilization would take a radical step back and collapse. Chemistry has thus itself an important general condition for our life in the civilized countries. For all these reasons, we should assess the advantages and disadvantages of this industry realistically and objectively, and attempt to put it to the greater use of mankind.

Diseases which can still only be controlled insufficiently; examples of fields concentrated on by drug research [2]

- heart diseases and circulatory disorders
- rheumatic diseases
- immune response diseases
- infections diseases: chronic bacterial diseases, virus diseases, systemic fungus diseases
- psychoneurotic disorders
- metabolic diseases: diabetes, gout
- malignant tumors

Figure 22

Drawbacks to coal as a feedstock

- very expensive to mine
- difficult as a solid to transport and process
- low hydrocarbon content
- processing involves environmental hazards

Figure 23

Coal as a chemical feedstock

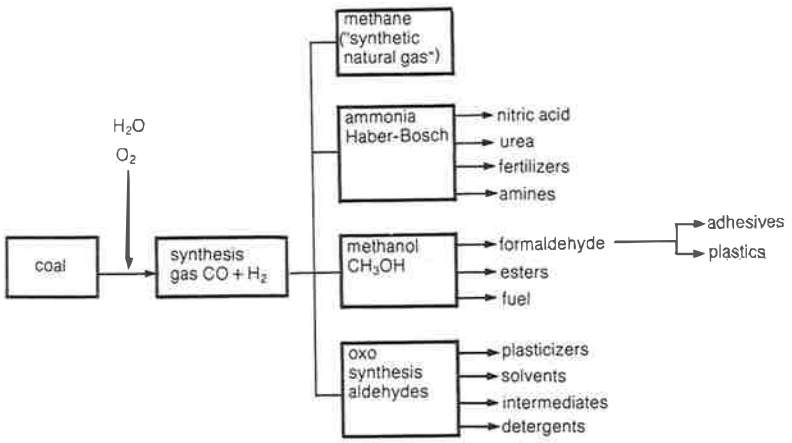


Figure 24

Society should strive to make conditions favourable again for the productive power of chemistry and its innovations, so that this important instrument for improving man's living conditions remains effective and useful in future too.

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Possibilities for Innovation in Small and Medium Sized Manufacturing Firms (SMF s)

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1. Introduction

There now exists a great deal of empirical evidence which suggests that, during the post Second World War era, small and medium sized manufacturing firms have played a significant role as producers of technological innovations. SMF s, particularly in the U. S. A., have also made an important contribution in the generation of radical new technologies, notably semiconductor technology. However, with increasing concentration of industry in the western economies, accompanied by a growing importance of economies of scale in production and distribution; with increasing governmental involvement in industry, and with a plethora of government regulations covering all aspects of industry, all of which place pressure on the limited resources of SMF s, it is now pertinent to pose the question: "What are the future possibilities for innovation in SMF s?" This paper attempts briefly to answer this question. The data presented in the paper are taken from a recent major report on the role and problems of SMF s in innovation, and on government measures to assist SMF s in Europe, the U. S. A., Canada, Japan and Israel. (1)

2. Why are we interested in SMF s?

There are a number of reasons why governments in the Western economies are taking an increasing interest in the welfare of SMF s:

(a) General Policy Reasons

- The distribution of economic power through a system of small firms leads to a more favourable distribution of power in society in general.
- A high degree of market concentration leads to economic inefficiency.
- Small firms are a necessary complement, rather than an alternative, to the economies of scale offered by large firms.
- Small firms are sometimes seen as a buffer to sharp fluctuations in employment, and as a source of future employment.
- Small firms offer the consumer a greater diversity of choice than large firms which are tending towards fewer standardised product lines.
- Small firms are generally thought of as being more pleasant places to work in than large firms.

(b) Technological Policy Reasons

- SMF s in traditional sectors must innovate in order to survive in the face of com-

petition from parallel industries in low labour cost developing countries.

- Evidence suggests that a significant number of basic innovations have originated in SMF s and that, especially in the USA, small firms often play an important role in industries characterised by a particularly high rate of growth and technological change.

- Evidence from the USA suggests that, in terms of innovation measured against dollar expenditure on R and D, small firms have a higher - though falling - productivity in certain sectors than their larger counterparts.

3. Advantages and disadvantages of SMF s in innovation

This is essentially a discussion of the benefits and disbenefits of scale. Large firms enjoy economies of scale in manufacturing and distribution beyond the reach of SMF s: SMF s often enjoy the organisational (flexibility, responsiveness) and human (quality of life, entrepreneural atmosphere) advantages of small scale.

(a) Advantages of SMF s

- Marketing:
  in some instances SMF s have a comparative advantage over larger firms by developing specific capabilities in certain areas of technology and serving a narrow but sophisticated market segment. They are also able to react quickly and efficiently to both market and technological changes.

- Dynamic, entrepreneural management:
  small, high technology firms in particular, are often controlled by dynamic entrepreneurs who react swiftly to take advantage of new opportunities.

- Internal communication:
  in SMF s, this is often fast, efficient and informal, offering the ability of a swift response in adapting to changes in the external environment.

(b) Disadvantages Viz a Viz Large Firms

- Qualified manpower:
  SMF s often experience considerable difficulty in attracting and financing on a permanent basis one or more qualified engineers and scientists. Such individuals are often crucial to innovation, especially radical innovation.

- External communication:
  a crucial area in which SMF s are disadvantaged viz a viz large firms is in the gathering of scientific and technical information. In this respect SMF s often suffer from a serious information gap. (2)

- Management techniques and practice:
  while small entrepreneural firms often enjoy the advantages of dynamic, openminded management, SMF s in traditional sectors often suffer through possessing a "Dickensian" management structure, i. e. are headed by an all powerful autocrat who fails to consult his subordinates and runs the firm according to his personal whims. SMF s often lack the management expertise to enable them to properly plan for the future.

- Finance:
  SMF s appear to experience greater difficulty than their larger counterparts in raising finance to enable them to undertake risky innovation endeavours SMF s are also less able to survive costly innovation failures than large firms.

- Economies of scale and the systems approach:
  in some industries economies of scale form a substantial entry barrier to SMF s. A second size barrier is the growing demand in some areas for companies to offer integrated 'systems' of interrelated products.

4. SMF s and radical new technology

- Experience in the case of semiconductors shows that they were developed and exploited initially by SMF s in the USA, which grew extremely rapidly and subsequently generated a great deal of employment and a large number of new small spin-off semiconductor firms. Semiconductors were exploited in Europe and Japan at a later date, and by large established electronics companies.

5. Impact of the microprocessor on SMF s

- In the light of the above, it seems reasonable to suppose that the latest radical semiconductor technology - the microprocessor - will lead to the growth in the USA of many SMF s producing 'smart' products. In Europe and Japan the microprocessor will be exploited, at a later date, by established electronics companies.

- Many SMF s in traditional sectors producing mechanical components and devices are threatened by the microprocessor unless they can adapt to its use (e.g. the watch making industry).

6. Contribution of SMF s to invention and innovation (3)

- Evidence from the USA suggests that SMF s produce a much higher number of patents per dollar of R and D expenditure than large firms, which is often claimed as evidence of superior small firm R and D productivity. (Table I).

- Evidence from the UK has shown that between 1945 and 1970, small firms (1-199 employees) contributed about 10 per cent of all industrial innovations with R and D expenditure of 5 per cent or less of the total. (4) (Table II).

- The contribution of SMF s to innovation varies greatly between sectors: they make their major contribution in areas where capital intensity and development costs are low, and where entry costs for new firms are low. (Table III).

- The relative contribution of SMF s to innovation appears to vary between countries.

- SMF s in the USA and the UK appear to produce a relatively higher percentage of radical innovations than do their counterparts in West Germany, Japan and France. (5)

7. New technology based small firms in the USA and Europe

Many observers believe that a significant percentage of major technological innovations in the future will derive from new, entrepreneural technology based small firms, and that this will be an important spawning ground for new employment opportunities. A recent detailed report on NTBF s in the USA, the UK and West Germany reached the following main conclusions: (6)

(a) While NTBF s have had a significant impact on the economy in the US, the number set up since 1950 and still in existence in the UK is only about 200, with total sales of about £200 million. In West Germany, the corresponding number of NTBF s is even less. The performance of NTBF s has been more impressive in the USA than in the UK and West Germany.

(b) Factors favouring the formation and growth of NTBF s in the US are:
- a very large domestic market conductive to rapid growth and development;
- the availability of private wealth as a source of seed capital for the start-up of new ventures;
- a fiscal framework which encourages the flow of private risk capital into new ventures;
- the existence of an active market for trading of shares in new ventures, i.e. the over-the-counter (OTC) market;
- a prevailing attitude in society at large which encourages entrepreneurship;
- high mobility of individuals between academic institutions and private industry;
- the behavioural and attitudinal character of American scientists, many of whom are willing to establish their own business in order to exploit their technical knowledge;
- a large and active government expenditure programme which provides significant opportunities for NTBF endeavour, particularly through Government procurement programmes.

(c) While the low level of investment and economic growth in the UK has had an adverse effect on the creation and growth of NTBF s, the much more favourable economic performance of West Germany has not led to the creation of large numbers of NTBF s. Therefore, while bad economic conditions can have negative impact on the number and performance of NTBF s, a favourable economic climate, by itself, is not sufficient to generate NTBF s.

(d) Three negative factors common to the UK and West Germany are:
- cultural and attitudinal factors among academics, government scientists and research institutions that have been unfavourable towards technological entrepreneurship;
- in the UK, government R and D expenditure which has consistently neglected NTBF s - until recently the same was true in West Germany;
- the fragmentation of the European market which has restricted the growth of NTBF s in both countries.

(e) In West Germany high rates of corporation tax act as a disincentive to the formation of NTBF s.
In the UK, high rates of personal taxation pose a dual disincentive to investment in NTBF s: they make it difficult to accumulate private savings and disfavour the investing of savings in high risk, high return ventures.

8. The role of government

In this section the past influence of governments on the innovative potential of SME s is outlined:

- In all the advanced economies there exist a wide range of government R and D specific measures to assist industry; in many instances measures have been formulated specifically to assist SMF s. (See reference I).

- There exists some evidence to suggest that many firms are unaware of the range of government R and D measures available to them; this lack of awareness is likely to be most marked in the case of SMF s. (7)

- There is some evidence from the UK to suggest that the scientific and technical infrastructure (universities, research institutes) interacts much more frequently with large firms than with small firms. (See reference 2).

- Most aid available from the infrastructure has, anyway, focussed on the R and D end of the innovation process, while the innovation literature suggests that most innova-

tions fail because of market and management problems, and not technical ones. (8)

- In Europe there exists a lack of venture capital to fund the establishment of NTBF s. There also exists a general lack of risk capital to fund innovation in existing SMF s. Statistics show, however, that the bulk of Government financial aid to industry in most European countries has gone towards funding large projects in a few high technology sectors (e.g. aerospace, nuclear), and small projects in large firms. SMF s have been very much neglected in the allocation of cash resources.

- As was seen earlier, high taxation was seen as a major dissincentive to the formation of NTBF s in the UK and West Germany. In fact, evidence to-date strongly suggests that general government measures (e.g. taxation policy, safety and environment legislation) have a greater impact on industrial innovation than R and D specific measures. (9) It seems that unless the general social and economic environment is favourable, specific R and D or innovation-related measures will have only a limited impact on entrepreneurship (founding new firms) and on stimulating existing small companies to innovate.

- There is some evidence to suggest that many firms feel because of bureaucratic application procedures and lengthy delays, and because of the need for accountability, the benefits gained from government aid are often out-weighed by the disbenefits incurred in applying and accounting for this aid. The message for government here is clear; that is application procedures should be considerably simplified and decision making speeded up. This is particularly true for SMF s, which have very little time or manpower resources to devote to these procedures.

- Finally, it can be misleading to generalise concerning SMF s, and it is certainly worthwhile making a distinction between SMF s in traditional industry sectors, and NTBFs, since their problems and needs are often different. NTBF s need ready availability to risk capital (often accompanied by some management counselling) and tax concessions which allow for the re-investment of the bulk of their early profits to enable them to grow. SMF s in traditional sectors often need encouragement to actually cause them to innovate, not only in their products, but also in their production processes: they very often need technical assistance and access to management and marketing skills. Perhaps it is with the latter class of small firms that the infrastructure has the major role to play.

9. Some recent trends in government policy

Having discussed the problems of innovation in SMF s and the factors affecting the formation of NTBF s, it is interesting to consider some recent trends in government policy aimed at assisting and stimulating innovative endeavours in these firms.

Innovation Vs R&D

- In the past, most government aid has gone towards assisting the R&D end of the innovation process. This is, however, by no means always the costliest aspect of innovation, nor always the most risky. There is some indication that governments are becoming increasingly aware of this, and are beginning to fund activities of "innovation" rather than "R&D".

- It might be that governments should intensify the trend towards the support of firms rather than just projects. This would enable them better to establish a portfolio of projects and hence to spread the innovation risks. This would also enable SMF s to formulate longer-term development and marketing strategies.

The Scientific and Technological Infrastructure

- In the past, Universities - at least in most countries of Western Europe - have played only a minor role as instigators of ideas for innovations developed in SMF s, despite the wealth of research done there. A number of schemes have been instigated in recent years, however, which should significantly increase industry's utilization of university facilities and expertise, especially SME s. Among the most significant of these are: Innovation Centres in the U.S., * the Teaching Company Scheme in the U.K., * University Industrial Parks and University Industrial Liason Officer schemes.

- Industrial research institutes and associations are the primary mechanism for technology transfer in most Western countries. They should be of particular utility to SMF s, which generally lack inhouse R&D resources (although there is only limited evidence to suggest that they are currently fulfilling this role). A notable and promising trend on the part of RIs and RAs is that, in a number of countries, they are beginning to offer management services to SMF s, i.e. they are beginning to become involved in the complete innovation process, and not just the R&D end of it.

- If RIs are to be really effective in assisting SMF s, then they must adopt a more active stance towards informing them of the range of services they have to offer: they must more effectively sell themselves and their services to industry. Several governments are tackling this problem from the other end by offering incentives to SMF s to contract out R&D to RIs. This also offers an incentive to SMF s to actually become involved in technical development activity.

Procurement policy

- "Need-pull" is a factor that is universally acknowledged to be crucial to innovative success: need-pull innovations more often meet with success than technology-push innovations. In view of this, and in the light of the fact that public markets account for between a quarter and a half of total demand, it is surprising how unaware have been those responsible for procurement in the public sector of their strategic potential for affecting both the rate and direction of innovation.

- There have, however, been a number of recent instances where procurement has been deliberately used to stimulate new innovations and the performance of existing products. (10) These have, by and large, benefited larger firms, although in the USA the Small Business Administration has a scheme to assist SMF s in the procurement of government contracts. Perhaps this scheme could be gainfully copied in Western Europe.

Regulation

- Regulation can have a mixed impact on innovation in SMF s. On the one hand it can compel firms to innovate (often unwillingly) in areas such as safety and the environment; on the other hand it can open up new opportunities for SMF s to produce, for example, pollution monitoring and control equipment. On balance, this type of regulation acts to the disbenefit of SMF s, and governments might be compelled to assist SMF s in complying with stringent new regulations.

- Certainly SMF s in the U.K. see the plethora of government regulations and especially employment protection regulations, as a time consuming burden. The marked trend towards the growing number and complexity of new regulations must act to the disadvantage of SMF s. It might even pose a serious disincentive to entrepreneurs to found their own new small firms.

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* For details, see reference 1.

Co-operative Incentives

- A number of governments now offer incentives to SMF s to establish common management, R&D, production and distribution facilities to enable them to gain economies of scale in their operations. They also offer encouragement to undertake collaborative exporting. This system is at its most prevalent in Japan, where a wide variety of co-operative efforts are a marked feature of the industrial scene.

Regionalization of Government measures

- There appears to be a trend in government policy towards SMF s to provide regionalized services. This implicitely recognizes that innovation in SMF s is often a local phenomenon. It should result in an increased awareness among SMF s of available government measures, and might reduce the lengthy and cumbersome bureaucratic procedures which currently often affect the application process for government aid. SMF s have neither the time nor the resources to devote to lengthy, involved applications and, because of this, will often refrain from seeking government assistance.

Development Credits

- There appears to be a growing awareness among governments of the need of SMF s for development credits to assist them with the risky business of innovating. A number of governments have also recently instigated schemes to increase the availability of risk capital to entrepreneurs to help them establish NTBF s. It seems likely, however, that the bulk of government development credits will continue to be allocated to large firms.

10. Comment

- This paper has shown that, since 1945, SMF s have made an important contribution to technological innovation. As regards to future possibilities, the following important pointers have emerged:

  (i) In Western Europe taxation policy is seen as a disincentive to innovation and to the formation of NTBF s.

  (ii) Increasing government regulation is having a detrimental effect on firms, especially SMF s.

  (iii) Many SMF s are unaware of the range of government measures available to assist them.

  (iv) Bureaucratic and lengthy application procedures pose a disincentive to SMF s to apply for government assistance.

  (v) Cultural attitudes in Western Europe do not favour the formation of NTBF s.

  (vi) The wide range of government measures currently available are designed primarily to assist existing SMF s, rather than the formation of NTBF s.

- Thus, despite the favourable trends in a number of government measures to assist industry described in Section 9, the climate in Western Europe does not seem to be generally favourable to the encouragement in SMF s of innovative endeavours. In particular, there is little encouragement for the formation of NTBF s. Because of the cultural as well as the technological contribution SMF s have made to society in Western Europe, and because of the employment generating potential of NTBF s, this adverse, often hostile environment, should be viewed by policy makers with a great deal of concern.

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Possibilities for innovation in medium sized and smaller industries

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The previous paper by Dr. R. Rothwell describes my own thoughts and opinions on the subject so well, that it is difficult to add anything of significance. So in the first part of my paper I will confine myself to some remarks and statements relative to the specific case I know best, namely the pharmaceutical industry, whereas in the second half I will follow a suggestion of the chairman and describe in broad lines the history of my own firm since its foundation in 1953.
The point I would like to make is that the possibilities for innovation in medium-sized and smaller pharmaceutical industries have been declining rapidly in the past two decades and are at present virtually nil. The number of important new drugs introduced in Europe, America and Japan was between 50 and 100 per annum twenty years ago and has declined since then to a mere 5 to 10 per annum now. The average R & D costs per new drug increased astronomically and have reached the incredible figure of at least $ 250,000,000. It is estimated that the total worldwide sales of the pharmaceutical industry are approximately 50 billion dollars. Approximately 5% of this amount, i.e. 2.5 billion dollars, is spent by the industry on R & D. In my view, the research part is declining and the development part is increasing logarithmically, which partly explains the huge amounts involved. With this tremendous amount the industry is able to introduce no more than five to ten significant new drugs per year. It is a question of simple arithmetic that the average R & D costs per new drug are between 250 million and half a billion dollars.
In the early 50's we were not talking about millions of dollars, we thought in terms of hundreds or thousands of dollars. In those days the average R & D costs per new drug were hundreds, and even thousands of times lower than they are today, and the time spent between discovery and marketing was several years shorter, often not longer than one or two years, and I remember that then it struck me as rather long.
Today we have to wait seven to ten years and sometimes even longer, and it has happened that the patent expired before the drug could be marketed. That does not strike me as normal, but it is not perceived as being abnormal by the population at large. Virtually all new drugs introduced in the last two decades are based on research carried out in the fifties and the sixties, or even earlier. Although today research on the possibilities for fighting diseases pharmaceutically is still going on, even the largest companies think twice before starting a programme for the development and introduction of a new drug, because the costs are so huge.
There are still a number of debilitating or life-threatening diseases around that are a scourge of mankind - malaria is a case in point - but even if we know that a drug against these diseases can be developed, it is not done, or it is not done at the speed the seriousness of the situation warrants. This is an unmitigated disaster.
Another point I would like to make, is that virtually all new drugs that were introduced in the last twenty years, were developed in Western Europe, the USA and Japan. The Comecon countries, China and other state-regulated economies did not contribute at all, and in my opinion this is a point that should be kept in mind firmly.

What about a young man in a small or medium-sized pharmaceutical firm today? What will happen in 1979 if he discovers an important new drug? First of all he would have to find an enormous amount of capital to patent his invention, to protect his patent against infringers - and for these two fields alone he would need a huge amount of money - to finance the costly and time-consuming toxicological, metabolic, pharmacological and clinical experiments that are required by the health authorities and the armies of bureaucrats all over the world simply for registration purposes in the various countries. He does not do this to satisfy his own curiosity, he has to do it to answer the thousands

of questions with which he is bombared, many of them quite silly. If all goes well, this process will cost millions of dollars and will take at least five years of hard work; in my experience five years is an absolute minimum. After five years our young man would need the capital for expanding the chemical and pharmaceutical production facilities of his small or medium-sized company, and that would involve millions of dollars or even tens of millions of dollars. He would have to expand his marketing organisation in the major markets: the USA, Japan, Western Germany, France, the Benelux, Italy and so on. No wonder that our theoretical young man, or his superior, would rather try to license his patent to one or the other large pharmaceutical company. If he is lucky, his invention will be marketed some seven to ten years later, and by then his patents are about to expire, his product is likely to be more or less obsolete and his profits will be taken away by taxes.
The conclusion is simple: under the present climate the formation of new entrepreneurial, innovative pharmaceutical firms is no more than a utopian dream. The youngest successful pharmaceutical company of this type was created more than 20 years ago.

In the second half of my paper I would like to elaborate somewhat on the reasons behind these statements and on the reason why I believe they are true. It is based on my own experience. A quarter of a century ago we did start a research company with a capital of exactly $ 1000,-, because that was the sum I borrowed from my father. Now in 1953 one thousand dollars was a huge amount of money; today we pay it each month to an employee. But then it was enough to carry out research - obviously on a small scale - for a period of about three years. Being unmarried and having no special needs, I used part of the money to buy some equipment, a few animals and a few intermediates to synthesize new chemicals, to screen them pharmacologically and to satisfy one's curiosity. In those days the goal was to get a patent and our strategy consisted in trying to do so and then to find a licensee who would develop the patented substance, put it on the market and pay us royalties. My hope was that we would be able to build a research company with these royalties.
In 1953 this was relatively simple; the first compound we patented is still sold widely all over the world, and with the license revenue we were able to hire first one assistent, then a few more and so on. Looking back, I think it was fortunate that in those days I understood almost nothing about economics, otherwise I would probably never have done such a foolish thing. But in those days economic considerations played only a very small role, whereas today they do, as Dr. Rothwell has indicated. In those days it was not considered disgraceful or undesirable to try to create something; it was considered very difficult but at least desirable. Taxes were much lower than they are today; the state did not seize more than ten to twenty per cent of our profits, so we could plough back the money into the business to enlarge it. We did that untill 1958 or 1959, when we had a company doing research and nothing but research, employing about one hundred people. Business was very good, in the sense that our patents were yielding increasing amounts of royalties.

We could start to think about stabilizing the company by making compounds ourselves and building up a marketing organisation. The reason for that was very simple. By then I had realized that a company doing research and nothing but research is a rather risky proposition, and does not give a sufficient guarantee for the future. The average age in the company was around 25 years then, and many of my collaborators thought about getting married and raising a family, and I saw that they would start to ask themselves questions about their own future and that of their families. This was quite a new phenomenon, because in the pioneering years nobody asked any questions about the future as it all was high adventure.

To ensure the stability and survival potential of our company we transferred ourselves into a research and production company, and this was done gradually. The average growth rate was around 28% per year, and I still remember that our annual turn-over passed the 1 million dollar mark in 1956. This year our total sales will be more than $ 650 million, and I do not mention this to brag about it, but only as an example of what

could be done as short as twenty-five years ago. Today it is absolutely impossible.

Suppose I had a son with the same ideas as I had twenty-five years ago, it would be completely useless to help him financially. Even with millions of dollars he would not have the slightest chance of success. He would have to spend all his money on wasteful activities, which I have tried to describe, and which have to do with bureaucracy, with unnecessary controls, with demotivation, which are sterilizing influences that do not originate in business, but come from society itself. On this subject I am in complete agreement with the views Dr. Rothwell has just unfolded in his paper.

In my view one of the most dangerous things mankind can create, is a society in which those in office - and I don't mean politicians only, but everyone from civil servants to industrialists - cannot be proven wrong because they have the total might of the State behind them. It is a type of society that is favoured by a vocal minority. These people do not want to convince their fellow men of the rightness of their views by reasoning and argument, by experimenting in scientific, social or other fields, but by naked power alone. They want to command, and they want everyone else to obey the opinions of Jacks-in-office, not because those opinions are right but because the jacks are in office. In our Western civilization we have seen some experiments with that type of society in the last sixty years, and anyone who is not totally blind will have to admit that the results have been disastrous. It has caused men not to state their own opinions and criticisms, but to bow to those in office, and that alone has caused an untold amount of human misery. As a dedicated pharmacologist I am against human suffering, whether in the medical or in the social field. As a scientist I believe in experimenting, and I do think that society should experiment. Experimenting means the acceptance of criticism, of being proved wrong. In business criticism resides - and here I agree with Dr. Rothwell again - in small firms that cock a snook at the big established ones and prove by their existence that large is not always beautiful. It are the small firms that by their success keep a whole branch of industry on the tip of its toes.

It is of the utmost importance for society to provide the circumstances in which vigorous small companies can be founded and thrive, and can become medium-sized or even big. If society does not create these circumstances, then the larger firms will become bigger and bigger, either by taking over the smaller ones, or because the smaller companies fold up of themselves for lack of survival potential. And we can be certain that after a time nobody will be stupid or foolhardy enough to found a new small firm.

If that is what the people want, then they have to go on with whatever they are doing, but they should realize what the results will be. It will lead to a society dominated either by a restricted number of large companies, or by the state, and there is not much to choose between those two options. If the people do want to do it differently, major sociological changes are needed to give the theoretical young man I am talking about, even a fair chance, not a big one, but a realistic one. At the moment his chance is zero.

No wonder that young graduates, fresh from the university, get disenchanted with present society. I don't believe that they see the reasons for their disenchantment clearly, and they are utterly confused. But I think that they experience present society as rather suffocating and that they feel hemmed in on all sides. Those with a spirit of adventure, who in former times would have founded their own firms and made a success of it, are frustrated in their desires by all kinds of silly regulations. Even if they succeed after a fashion, the slight amount of joy they might still have in being able to run their own show and shape their own fate, will be killed by the tax laws, which seem to be based on the absurd notion that a man who has the cheek and perseverance to found a firm that creates jobs, should be punished for his daring. Even those who prefer a less hectic life, run into many silly bureaucratic rules that interfere with their freedom of action and often give the impression that they were scribbled down just for the love of interfering. But those who are frustrated by present society often do not seem to see

the causes of their frustration clearly and tend to blame the wrong sections of society. They don't blame the bureaucratic mentality that seems to pervade present societies, the love for regulations, the love of interfering and the tendency to cut down outstanding talent to the level of the greatest common denominator. Instead many blame capitalism, free enterprise and industry, and it often seems that these terms have become the four-letter words of a modern ideological jargon.

What I am pleading for, is a renewal of the spirit of capitalism, and I know it is a subject that is not quite popular, to state it mildly. I think that such a renewal is necessary, because I believe strongly that without an acceptable form of capitalism, the only viable alternative will be a dictatorial system that will kill what I consider as democracy. This should not be taken to mean, as is often suggested by innuendo, that we wish back the terrible social circumstances of the industrial revolution and the last century. Also it should not be taken to mean that we are against all rules, regulations and laws. We are not, as we know that rules and laws are a necessary ingredient of any society. The anarchistic ideal is an unattainable idea.

But we have to put an end to a dictatorial bureaucracy that is creeping on and on, is seen and felt by everybody, which is responsible for most of the sterility and waste I have been trying to describe and for the fact that young people no longer get a chance. Laws and regulations should be used to oil the wheels of society and to prevent abuses from occurring, although it will never be possible to do so on a one-hundred percent basis. But they should not be used to prevent individuals attaining their own wishes and desires, as long as these are compatible with the general aims of society.

I realize that in the second half of my paper I have been discussing constraints more than challenges, and that most of the issues are of a political nature. I did so because I am convinced that the real challenges are in the political field. Everyone agrees on the theoretical goal we want to attain. Every individual wants the freedom, compatible with the general aims of society, to realize his personal wishes and desires. Nobody wants to be restricted unnecessary in his personal and public life. But we seem not to be able to reach a consensus on the means of reaching our common goal. In my opinion that is quite serious; for what we do need is a consensus followed by action.

Paneldiscussion II

Panel
Prof. Dr. G. J. M. van der Kerk, chairman
Dr. H. Dörfel
Dr. P. A. J. Janssen
Dr. R. Rothwell
Dr. J. G. Waller

(Van der Kerk) Ladies and gentlemen, I open the last session of this Conference, the panel discussion on the papers of this morning. We have received quite a number of questions and we will need all the time that has been reserved for it. I would like to start with a few questions for Dr. Dörfel. The first is: You said that the transfer of knowledge to Eastern European countries and to developing countries raises certain problems. What do you think of the work of the United Nations on an international code of conduct for technology transfer? The negotiating conference re-opens on Monday, February 26th. in Geneva.

(Dörfel) Yes, I know about it and actually a member of our Company will be in Geneva to help in preparing this code of conduct. I have heard that some countries will argue that all technology in this world should be the common property of all people and everyone should be free to use it. That will lead to no new technology being created that could be transferred in the future. In principle there is nothing against a code of conduct, but it is to be hoped that it will deal realistically with the real problems of technology transfer. We have some experience in this field, for example I participated in the construction of a big plant in Mexico which works very well now. Here the real problem was not technology transfer at all, it was transfer of payments. By far the biggest problem in that project was how to get a reasonable fee for the work we had done, the fiscal authorities in both countries having their own ideas about that. Conferences like the one in Geneva are useful of course, but it should also be realized that lawyers behind a green table often have not any idea about the real problems and real difficulties. In the ideal situation a code of conduct will lay down certain rules and regulations that have to be observed always both by the receiving country and by the firm doing technology transfer.

(Van der Kerk) The next question for Dr. Dörfel has some relation with the last one: Do chemical companies take the basic conditions of developing countries into account in their research and development?

(Dörfel) Yes, we do, and we have to! BASF produces in countries with highly different levels of technology. We have to adapt to local conditions and often to local raw materials, and this influences your R & D effort. In some countries we have very simple facilities, in others we can do things in a bigger way because the (potential) market is larger, but we always have to adapt to local conditions, as the most sure way to end up in disaster is trying to export Western technology just as it is.

(Van der Kerk) Thank you. The next question to Dr. Dörfel sounds a bit critical: You said that direct promotion of innovation by governments is a disadvantage to the chemical industry, but that indirect promotion could help. Can you explain that statement, as it sounds, to me at least, basically illogical. If governments can help at all - which is arguable - why is indirect help more relevant than direct help?

(Dörfel) I can understand that it sounds illogical, but it is a consequence of the nature of the chemical industry and similar industries. If a company has one large project, say a nuclear power plant, and asks the government for assistance, the paperwork, the bureaucratic outlay, is rather small in relation to the total amount of money involved. But we have some six thousand products and a few hundred research projects going on,

and each of them is far smaller than a nuclear power plant. If you want to have direct assistance from the government, the bureaucratic outlay can become unrealistic large, because you have to tell everything about the project before the government is prepared to finance even only a part of it. So we think that indirect promotion is far more effective in our type of industry. There is another good argument for indirect measures: they are aimed at a whole branch of industry or even many branches of industry, and that means that the smaller companies can profit too. But it should be realized that in the chemical industry bigness does not say very much, as large firms tend to produce far more products than smaller ones and that in terms of turn-over per product both types of firm often are in the same boat.

(Van der Kerk) Thank you. The next question is for the panel as a whole, but I'll ask Dr. Waller to answer it in the first instance, and then I have another question addressed to him.
The general question runs: How does one tackle the problem of estimating the demand for a non-existing product?
The question to Dr. Waller is: How does NRDC deal with the initial commercial and technical outlook of an innovation? What is the mechanism of recognition of a good idea for a good proposal?

(Waller) The general question is difficult to answer. How do you determine the market for a novel product? It depends on how novel it is. Nothing is completely novel; when we came into Hovercraft we knew that there were ships sailing across the Channel and it is possible to make some estimates from that of how much business a Hovercraft can pick up. With glass reinforced cement, which was a new material for the building industry, it was replacing other materials. It is not very often that you get something that is completely novel, even the transistor was replacing ordinary old-fashioned valves. There is always something you can key into, there is always some way in which to estimate what is the total possible market you are looking into. Then you have to take a deep breath and say: Well, we think we can make 10% or 15% penetration. But I think the other thing one ought to say is that market forecasts, so far as I can see, are always wrong, but that is no reason why you should not do them. You should do a market forecast when you start developing a project. You should update it all the time and usually you will find that the market is running away from you and is getting smaller. Never mind, your public is getting more precise all the time, and you need this information as a feed-back into the project to decide whether it is worth continuing.
Then there is the question of how NRDC does deal with this. Well, we sometimes engage specialists to advise us. If we are working with a company, we discuss it with them and through the company with their customers to build up the best picture we can of the market.
In a crude way, if somebody comes to us with a proposal and tells us what the market is, we usually divide that share of the market by two or three and set the development time at two or three years longer. We then think that we are getting somewhat nearer to the truth and then we find out that we were wrong too.

(Van der Kerk) Thank you very much. Is there any other member of the panel who wants to comment on the general aspects of these two questions? If not, I'll go on to the next question which is for Dr. Janssen and Dr. Rothwell. It runs: Government help for small firms must logically mean diverting resources from large firms one way or another. What justification can there possibly be for taking resources away from the large, successful and profit-making companies to encourage smaller, and therefore less successful companies to take more risks? Is that the best way to ensure employment?

(Rothwell) Well, I am not sure life is quite that simple. Why should government help small firms? There are good social reasons for that, because if one supports large firms only, industry becomes more concentrated and that will lead to a sort of cultural impoverishment in the range of products. A second problem is that much of the invest-

ments, which are bad for jobs. Small firms tend to be quite labour-intensive, and that is good for jobs. I think that small firms have shown by the record that they can be highly innovative, at least in some areas, and they show a high degree of entrepreneurial spirit. It is the sort of atmosphere where employees have a personal commitment to the firm and put in more than they are paid for. Also the potential for growth is greater in small firms than in large ones, and small firms that are growing tend to invest in people. So I think that there is a whole range of reasons for supporting small firms; you can call it competition policy, social policy, technological policy or whatever you want.

(Janssen) I agree with Dr. Rothwell, but I would like to make two comments. If governments really want to promote the health of small firms, one of the things they can do is to reduce taxes. That in itself would be a tremendous incentive to small firms. Another simple measure is cutting red tape and seeing to it that small firms don't have to waste so much time on the bureaucratic paperwork Dr. Dörfel mentioned.

(Waller) Well, I think that the question suggests an antithesis that is not there. I don't see that the support for small firms has to come out of the money that is available for large firms. After all, in the UK, support that is available for industrial development is not being fully used; certainly NRDC has more money to put in than it is being asked for. In the UK there is money available for development for both small firms and large firms.

(Van der Kerk) Thank you. It will surprise no one that there are quite a number of questions to Dr. Janssen, which could be expected in view of the rather strong statements he made this morning. The first is: Your complaint is basically that it is impossible to start a new pharmaceutical company because of the high initial costs. Now the same is true for car manufacturing, and this may have to do with the type of technology. However, in other fields there may be plenty of possibilities.

(Janssen) I can't say anything about other industries than the pharmaceutical industry, and in our field I don't agree with the statements put forward in the question. On paper or theoretically there may be plenty of opportunities, but in practice they are non-existent. And in our industry it has nothing to do with the type of technology. I can give an example that will be, I hope, rather convincing, and that is a vaccine against malaria. There are more than one thousand million people in the world suffering from malaria and a vaccine against this debilitating disease would be a tremendous step forward. To ask a panel of experts on malaria vaccines whether these are a distinct possibility is like asking a group of Cardinals whether God exists. They are here already, there are five to seven very effective vaccines against malaria in animals, but they are not developed further because the costs are horrendously high as a result of all kinds of bureaucratic constraints. In the opinion of the same experts, such a vaccine, although highly desirable for the millions of sufferers, is unlikely to be developed within the next ten years. This is a case from the pharmaceutical industry and I don't think that the car industry is working under such constraints. And it is one of the major reasons why new, small pharmaceutical industries will not be founded unless things change.

(Van der Kerk) There is another question related to the last one: Dr. Janssen complained about the high cost of testing pharmaceuticals before they may be sold. First, has this resulted in a safer range of drugs for human use than would otherwise have been the case? Second, if he complains about the high cost, what other system of approval and certification Dr. Janssen could suggest?

(Janssen) Well, to take the last question first, the other system of approval I can suggest, is the scientifically correct system based on inspection. All we know about drugs is derived from experiments, and in order to find out whether a statement about a drug is true or false, one has to be a witness of one or more experiments. If not, one has

the knowledge only from hearsay. Now the whole system of so-called control in all countries is based on the notion that one can control experiments by reading paper, something which I don't believe at all. As regulations are different from country to country - and there are 120 of them - we have to pay an army of scribblers who fill tons and tons of paper with words, trying to describe the experiments conducted in our laboratories. We then have to send shiploads full of paper to Washington, or Tokyo or whatever town you have, to be read by bureaucrats. There are two things here that strike me as idiotic. First I don't believe that the bureaucrats, however zealous, will really read these tons of paper, and it is known that they do not read all of it. Second, even if they read everything, it would not help them to judge whether the statements made about experiments are right or wrong. Therefore I believe that the only way out is to set up an experiment and be a witness of it if you really want to know whether a statement about a drug is true or false. That would simplify matters tremendously. I would welcome a system of control based on inspection. That would make severe control a real possibility - and I am not in favour of relaxing controls or taking risks with public health.

(Van der Kerk) There was the first question whether in general safety has been improved by these measures.

(Janssen) Well, I had not forgotten that one. I don't think that safety has been improved by these measures. Most, if not all of you will know that the old-fashioned drugs that have been around since the Middle Ages have never been investigated. A classical example is papaverine. This is one of the classical drugs mentioned in all textbooks. It is well known by experts that in comparison with modern drugs, it has no effect whatsoever, and in some exeptional cases it does some harm. So if it were a new drug, it would never pass the regulations, but for some, and to me mysterious reasons, these old-fashioned drugs have, as the Americans say, grandfather clothes, and they are simply not being investigated, which is strange to say the least.
Secondly, I am not aware of an example of a dangerous drug that this bureaucratic system has prevented from entering the market. However, I am certain that this bureaucratic system prevented very useful drugs from entering the market as soon as they were ready. A very good example of this is the polio vaccine. Everybody knows that this vaccine wiped out polio in those countries that started a programme of nationwide vaccination. But what most of us forget is that we wasted for no reason at all, or only for bureaucratic reasons, four to six years before the vaccine was approved. We could have introduced it much sooner. And that strikes me as strange because during the Second World War penicillin was developed and approved in just one year. The question that haunts me is: Who takes the responsibility for the hundreds of thousands of victims of polio who became ill in that period of delay and who are now maimed for life? Who will take the responsibility: the bureaucrats who read their tons of paper, or who else?

(Van der Kerk) I think you made a tremendous point just now. Safety of drugs is an essential requirement, but it should not be used to hold up their introduction because in exeptional circumstances they could have some unforeseen side-effects. If I may make a short comment, some drugs are used although it is known that they are very toxic, and I am referring to the cytostatic drugs used in cancer therapy.
I would like to go on with some more general questions, which seem to have some political implications. The first is: Innovation is a long-term activity which may take ten to twenty years. Politics is a short-term activity, going from one election to the next. Innovators cannot plan properly, because they don't know what kind of society and what kind of market situation the politicians will have cooked up at the time that an invention is through its development stage. Changes introduced by politicians are often counterproductive with respect to innovation. The second question runs: Government support of innovation may be necessary, but in doing so governments influence the economic position of certain industries or of certain branches of industry. Does not this interfere with the EC regulations or with free economic competition? Perhaps Dr. Waller wants to try an answer?

(Waller) The first one, if you like. I think that the statement in the question is quite true, but that most of the methods for handling support of innovation tend not to be party-political issues. They are not in Britain and they will survive changes of government between one complexion and another. So I don't think that the situation is as serious as the question seems to suggest.

(Rothwell) I would agree with that and I would be interested if anyone could present evidence to show, for example, that the Swedes, who have had a social democratic government for forty years, have been more innovative than the Americans, who changed governments regularly in the same period.

(Van der Kerk) Than I have a question for Dr. Dörfel and Dr. Janssen, and it is: The purpose of drug control legislation is partly to reduce the amount of spurious pharmaceutical product diversification - brand prolifiration, differences in packaging etcetera - and partly to reduce the dangers to public health from premature use of products which have still unknown side-effects. This seems perfectly reasonable, and can one expect political support for any other policy than this one?

(Dörfel) I have only a few short comments, as I am not an expert on toxicological testing, I only know something about patents. When I use my common sense, I can say that the whole purpose of toxicological testing is to prevent harmful pharmaceuticals reaching the public. If the bureaucratic system described by Dr. Janssen does not do that reasonably well, it should be scrapped and something else should be created in its place. I think every scientist will agree with that. If the system functions reasonably well, we still should try to minimize the costs to the producer, as it is always the public who pay in the end for bureaucratic extravagances.
As to the fact that the 120 countries of this world all want to have their own rules and regulations on toxicological testing, this is well known too in the patent field, and there it is a source of great annoyance. It is idiotic that something can, for example, be patented in Germany, but not in France, and vice versa. In both fields, patents and toxicological testing, the way out seems to lie in the direction of international standardization.

(Janssen) My main comment would be: The regulations of today seem to be based on the absurd notion that a disease is a disease, that there is no difference between a headache and sleeping sickness, or between the common cold and an extremely rare disease. As a consequence, less and less firms are trying to develop drugs against rare life-threatening diseases, and this is a disaster. We really should not tolerate that silly bureaucrats behind their desks scribble down absurd rules and regulations that have no relation whatsoever with the problem. I fail to see why regulations are needed at all when it concerns rare life-threatening diseases, for the obvious reason that nobody has to be protected against nobody. No industry on earth has a motivation, economical or otherwise, to put on the market a new drug against a rare and life-threatening disease, that will harm the patient. So I would be in favour of simply removing all regulations in the case of rare and life-threatening diseases. In the case of the malaria vaccine I fail to see why the regulations are not removed immediately, because it is the regulations that prevent the development of the vaccine. It should be realised that more than one thousand million people on this earth suffer from malaria, which is a delibitating disease and a scourge of mankind. According to the unanimous opinion of all experts, all governments would have to do is to remove all regulations, and then they will have their vaccine in a year or two.
On the other hand I am certainly not in favour of removing all regulations on all drugs. One has the drugs that are sold over the counter without a prescription - sleeping pills, tranquillizers, aspirin and so on - and here I am in favour of very strict control. That kind of drugs should be investigated very carefully for side-effects and harmfulness, as there we have the very real danger of self-medication by the uninformed public.
I am afraid that, when I am talking about drugs I am talking about something quite different from what the public associates with drugs. I am talking about drugs against

sleeping sickness, malaria and other life-threatening diseases, and the public thinks it is about sleeping pills, tranquillizers and asperin. That are two completely different things. We need strict regulations for drugs that are sold over the counter, but we don't need the same regulations for drugs against life-threatening diseases that can only be prescribed by a physician. I think that this should be realised quite clearly and that governments should start to act on the insight that a disease is not a disease, but that there are important differences between the gravity of diseases.

(Van der Kerk) Thank you very much. There seems to be a remark from the audience.

(Remark) Yes, I have a short supplementary on that, Mr. Chairman, as it was my question. I am very much in sympathy with what Dr. Dörfel and Dr. Janssen have just said, but we live in a world of political reality. Would they not agree, or would other members of the panel agree, that part of the pressure for national regulations, to the proliferation of which our speakers rightly object, comes from national trade-associations who wish to invoke those national regulations as non-tariff barriers to international trade?

(Van der Kerk) Thank you. This seems to be an important comment. Would any member of the panel like to go into that?

(Janssen) In my opinion this certainly is an important factor; national regulations can be used in that way. But an equally important factor is simply ignorance and indifference. I wonder how many people do really visualize what the malaria problem is in fact. If they did so, they would not stand politicians saying what they are saying. So we have to educate the public, and I am certain that, if the public knew what the problem of malaria, of sleeping sickness, is they would immediately start to clamour for action.

(Van der Kerk) Thank you. If I may give a short comment, I would like to say that you have impressed me again. It is a fact that we do not read in the newspapers about the malaria problem and its consequences for many millions of mankind, but we do read that there have been found slight traces of DDT in the body fat of penguins at the South Pole. Both things are facts, but I don't like that I can read about the one and not about the other.
Now I have a question for Dr. Waller, which is: In the UK the Advisory Council on Applied Redearch and Development has just recommended that the National Research Development Corporation should not licence British technology to foreign companies without prior approval of the British government. What is your opinion about it?

I think this question is also relevant to TNO.

(Waller) Well, my answer has to be a personal view because it is a very recent report from ACARD. To be quite honest, we are perplexed about it. NRDC has in its Act the requirement to operate in the public interest and we do this; we give priority to British companies in licensing. But you can't just do this totally in a vacuum, you can't deny the opportunity to license overseas. Last year we had just over four hundred licences to British companies and just over a hundred overseas, and a great deal of our income derives from overseas licences. Personally I think that if ACARD had solved the problem of making industry more innovative in the UK, it might not be necessary to license overseas so much but I don't see they have done that yet. Finally, I don't see that government has the machinery to help us to make these decisions anyway. In any case we are doing this already most of the time, we give preference to British companies so far as we can within the European Community and other rules around the world, and personally I think there is little more we can do in this area.

(Van der Kerk) Thank you. There is another question for Dr. Janssen. It says: Although I agree with your criticisms on red tape and the tremendous costs involved, I would like to point out that the pharmaceutical industry as a whole never opposed this

trend strongly. It is possible that the industry, and in particular the larger firms, could live with it. It kept newcomers out, and that might have been a very important thing. Today they see that their own size is stifling their research creativity and the deplore the absence of newcomers.
Dr. Janssen, is it clear what is meant?

(Janssen) Mr. Chairman, it is quite clear. The present system is acceptable to the large companies, because it makes life very difficult for the smaller ones. But it is not even advantageous to the big companies, certainly not. If the question implies that what I have been saying today is new, I can only counter that by stating that I have been saying that for the last 25 years.

(Van der Kerk) Thank you. Then I have two questions for Dr. Rothwell and the first is: You said that small firms produce more innovations per unit of R & D expenditure than large firms. But this comparison is useless, unless the innovations all are roughly of an equal weight, and we know that innovations are not. Why then do you advance an argument that clearly is spurious?

(Rothwell) Well, I agree that innovations are not all of the same weight, but I don't think that the argument is spurious. In some industries, for instance scientific instruments, the data show conclusively that small firms produce more innovations per unit of R & D expenditure than large ones. Secondly, there has been a recent study in the US which looked at 500 innovations and split them up by firm size. It classified the innovations in terms of radical break-through innovations, major technical shift innovations, improvement innovations and imitation. If you look at the percentages by firm size for radical break-through innovations, you find that small firms take 27% and large firms 24%. This is against all expectations. One would expect that the share of large firms, with their huge R & D budgets, would be far larger than that of small firms, especially in the field of radical break-through innovations. In fact it is the other way round, although the margin is rather small.

(Van der Kerk) Thank you. The second question to Dr. Rothwell goes: Is there any indication that family ownership, especially if the stock is held by several members of the family, prohibits real innovation because of the higher capital risks involved?

(Rothwell) My answer is simple: I really don't know. I have never seen any data that broke down innovations by firm size and by nature of ownership.

(Van der Kerk) Well, I would like to make a small comment, based on my own experience. When I was a young chemist I joined one of our medium-sized family firms, owned by many members of the family. I still remember those years with pleasure. The directors knew everybody in the firm, they motivated us in an exceptional way and as a result got a tremendous effort out of us. This experience has convinced me that the innovative spirit is not so much a question of finance, it is a matter of mentality.
I think Dr. Waller wants to make a comment?

(Waller) Well, no. I was just going to make a rather trivial point about family firms: I think it all depends on the family. Some families are keen to be innovative, others are not.

(Van der Kerk) It is the rare gift of the British to put things in a nutshell quite nicely. Thank you for that one.
Then I have a general question for the panel as a whole: Does the panel think that market research is as important as technical assessment of innovative ideas and if so, what do they consider as the best way of providing it for single inventors and smaller companies?

(Waller) Well, I think it is impossible to say that either market research or technical

assessment is more important than the other; they are both important and you need to do both. Maybe small companies could do with some help, but there are consultants around who will do market research for you.
If the implication is that government should supply it, I don't think that is the way it should go. Maybe government should be willing to provide finance for having market research done, but they should not try to do it themselves.

(Dörfel) I agree with Dr. Waller that both are necessary, but if the technical invention is quite big you may find an application for it quite easily. Then your effort in market research can be rather slight. But if the invention is rather small, you will have to do a lot of market research. So I think it depends on the nature of the invention how you have to divide your effort between technical assessment and market research.

(Rothwell) I think it is often in the market area that small firms have the major advantage, because they operate in small, narrow market segments which they know extremely well. Big firms tend to operate more across the board. So I don't think small firms are necessarily disadvantaged in a market research sense, they often have a competitive advantage.

(Janssen) I tend to agree with the previous answers, but I would like to point out again that in the pharmaceutical industry these matters may be slightly different. It is well known by insiders that a new drug usually goes through three phases. The first phase is one of scepticism, people will say: That is what he is saying but it is probably not true; he is trying to sell something. Generally speaking this goes for all innovations, or for things that ten years later are perceived as being innovations. In my experience market research people will follow this trend and will try to kill the innovation. The second phase occurs when the truth cannot be hid any longer, and then the usual reaction is: Of course, there is something to it, but it is not as important as was claimed at the beginning. Very often this is said under the influence of the same market research people. In the third phase, when the product is on the market and becomes a success, the general reaction is: Of course, this is true, but it really is a very old story. So you may understand that I am somewhat reluctant to put too much reliance on market research.

(Remark) Mr. Chairman, if you will allow me, I would like to make a comment from the floor. The same question came up at an international Conference in New Orleans last November. There the Americans presented an estimate of the cost of introducing a new product on the market. In their experience about 10% of all costs goes into the first phases, up to building a prototype, and about 90% of costs in incurred afterwards, in marketing the product. I think most governments, in their incentive programmes, tend to overlook this. Small and medium-sized firms can get help from the government in the R & D phase, but in the marketing phase a firm is on its own. Of course, a firm can rely on the marketing know-how it has already, but this is not true when a firm wants to do market diversification and goes into unknown markets. Then the costs of obtaining market know-how - market research if you want - are two to three times as high as when one intriduces a product in a well-known market. I think the civil servants involved in incentive systems for innovation should give some attention to this problem.

(Van der Kerk) Thank you for your remark. Does Dr. Rothwell want to comment upon it?

(Rothwell) No, I would agree with this remark.

(Van der Kerk) I have another two question for Dr. Janssen which I would like to take together. The first is: Why does the development of new drugs not go into the direction of drugs from nature, drugs "made by nature itself"? Does there lie a possibility for starting a small company? The second question also seems to deal with something similar: Taking into account the present and future climate, how do you see the possib-

ilities for innovation in small and medium-sized electronic biomedical industries? Do you think there will be a European governmental institution comparable to the FDA in the US?

(Janssen) To take the last question first, that is exactly what I expect. It is inhearent in bureaucracy that it will always seeks to extent its sphere of influence. As far as the first question is concerned, the drugs from nature, there are two reasons I think why this idea is not attractive for small or medium-sized companies. One is that a natural product cannot be patented, the maximum you can get is a process claim. For a small pharmaceutical company in a small country that depends on its ability to export, this is not an attractive position as it makes the firm extremely vulnerable to competition and imitation. A second reason is that the few natural drugs that are extracted and not synthesized use raw materials that come from the tropical and subtropical countries, which means, especially at the present time, that you cannot control your supply. That too makes a firm very vulnerable. Most of the natural drugs that were extracted in former times, are being synthesized today.

(Van der Kerk) Thank you. I have another question here that seems rather similar: What kind of future do you expect for small, innovating chemical companies when the coming Toxic Substances Control Act is enforced in the same way as the present pharmaceutical and pesticide laws, especially in the USA? Couldn't we better prepare for their bankcuptcy instead of talking about new opportunities?

(Janssen) Of course, when the regulations become still tougher than they are today, the process I have been trying to describe will be accelerated. Then we should really try to prepare for the bankruptcy of very many small companies, but how we should prepare ourselves for that I don't see, as it will mean a terrible loss of jobs and know-how.

(Remark) Mr. Chairman, this has not been my question, but I do have a supplementary on it. I am Smith from the OECD and I think it may not be sufficiently appreciated that the Toxic Substances Control Act in the USA was an Act introduced by Congress and was not initiated by the Administration. The Administration negotiated over many years with Congress and it was only at the end of that negotiations and immediately before a Presidential election that the Act was actually signed into law, without consultation with the international community.
The international community - and I was serving in Washington at the time and was in fact partly instrumental in this - the international community reacted very strongly indeed, and the result was that the Americans had to bring the Toxic Substances Control Act to the OECD, where they gave us a declaration that it would never be used as a non-tariff barrier to trade.

(Van der Kerk) Thank you for your comment. Is there anyone who wants to go deeper into it? Well, then we'll go on with the last question I have here. It is for Dr. Waller: NRDC has had positive financial results for many years. I find this difficult to believe. Could Dr. Waller specify cost budget and turnover?

(Waller) I have our annual report here, I thought I might need it. In the last financial year we had a total income of 20 million pounds, out of which we spent just over 6 million pounds on investment in projects and in funding patent costs. We paid 3.4 million pounds to inventors. We had our own intern administration costs of 2 million pounds, and we were left with a net income of 8 million on which we paid 4 million pounds of tax. If the questioner is interested, I can send him a copy of the annual report.

(Remark) Although I did not put it into a question, I was interested in the same thing. The graph Dr. Waller projected this morning showed clearly that a few years ago NRDC was not paying tax at all.

(Waller) That is correct. We started paying tax about 1974 when our income started to become really significant. I cannot explain why, I don't understand the operations of the tax laws.

(Van der Kerk) I have just received another question, which is rather long. It is for Dr. Janssen and it says: You stated that the formation of new, innovative pharmaceutical firms is an utopic dream and that the possibilities for innovation in all but the largest pharmaceutical firms are virtually nil. Now there is product innovation and process innovation, and I assume that the obstacles you mentioned refer to product innovation. Are there no possibilities in process innovation? One could think of the use of natural wastes as raw materials for pharmaceuticals instead of chemicals. If that could be realized it would be of particular interest for the developing countries, as they would not have to import the raw materials or the end products anymore. It might help employment and it could perhaps bring down prices, leading to a wider use, which would be interesting both in the social and the commercial sense.

(Janssen) My comment is that I don't understand the question very well. It is true that I have been talking about product innovation, what we try to invent are new products. We refer to process innovation as development, but that might be a question of semantics. Especially for small and medium-sized pharmaceutical firms the important point is patents, legal protection. Products can be patented, but processes can't usually. So process innovation is not a very attractive proposition. With regards to the use of natural waste as a raw material I find that hard to understand technically. Even if it were possible to use it, I would turn the waste into pure chemicals first and use those to synthesize the product.

(Dörfel) I think the question does not apply to the pharmaceutical sector at all. Pharmaceuticals are products with a high added value and even developing countries could afford to buy the raw materials to synthesize the products in their own countries. The problem is not raw materials, it is know-how and expertise; you must have the ability to put together on an industrial scale the molecule that has a pharmaceutical effect. As to the use of waste products, this is a coming technology for all countries - not only for developing countries - but we are not over the hill yet. It has been suggested that countries like Brasil could fermentate sugar cane into alcohols that could be used as fuel for the tractors they use in agriculture. In several European countries animal waste products are fermentated into methane which is used as a fuel, but this is done on a very small scale only, on the scale of the individual farm. As yet there are no processes that can provide the chemical and pharmaceutical industries with the huge amounts of chemicals they need as feed-stocks.

(Van der Kerk) Thank you. If you allow me I would like to make a small comment, after all I am a chemist too. The development of synthetics often has been a blow to the producers of natural substances, it takes away earning power from developing countries. That has been the case with synthetic rubber when it was first introduced, but let me add that at the moment the level of production of natural rubber is as high as it was before the synthetic variety was introduced. There are two sides to this problem that, in my opinion, do not get the attention they deserve. The first is that if natural products would be produced at the wage levels we are used to in the West, we would not use it at all, or only very sparingly. The second point is that a lowering of the demand for commercial natural products frees the soil for production of other products, food products for instance. I don't think that the development of synthetics needs to be detrimental to the real interests of the developing world, provided that these countries use their opportunities intelligently.
Having said all this, I would like to open the floor to a general discussion about the things said at this Conference. We still have some ten minutes left. Is there anyone in the audience who wants to make a comment? Yes, there is.

(Comment) Mr. Chairman, I have been here only this day and I may have missed quite

important information by not being able to come the first day. As a matter of fact I have some doubts about the strong statements I have heard on the role of small industries in innovation. It is one of those statements that everyone is going to believe if it is repeated often enough.
First of all - and it has been said in the panel discussion, I think - the weight of an innovation is difficult to take into account. I think that the weight of an innovation is very important. Secondly, Dr. Rothwell compared the USA, where they have a lot of small science intensive industries, and the Federal Republic of Germany, where they have hardly any at all. Now, if one looks at the record for economic growth in both countries, I could use the same material to say: Bringing innovations into the hands of international companies, who can exploit them all over the world, instead of exploiting them just in the national market, might be a more successful system than leaving them into the hands of small firms that have a lot of growing pains anyway and that are not adapted to exploit the innovation as it should be.

(Rothwell) Well, I agree that it is difficult to take into account the weight of an innovation. Most studies that relate to the relationship between firm-size and innovations simply count numbers. I think the best way to do it would be by sector of industry. I know that then one would find that in some sectors small firms play an extremely important role, and in others they don't. In some sectors there has been an enormous amount of technically radical innovation, and this has led to a very high degree of concentration because only the large firms have the R & D resources to exploit radical innovations. In other sectors, such as agricultural engineering, there have not been technically radical innovations, outside the milk and diary sector where nowadays sophisticated electronic techniques are used. There the real novel ideas - design changes and new ways of organising things - derived from small firms that dominate small segments of the market. I agree that it is difficult to generalize, one should do it sector by sector. And if someone has the cash, we will do it gladly. The second part of the remark was about the ability of international or multinational companies to exploit an innovation. Well, we should remember that in the USA some multinationals started as small firms, and here Polaroid, Texas Instruments and Xerox come to mind. The semiconductor was exploited mainly by small, technologically based firms which grew.
There is some concern in the USA about the slowing down in growth in certain sectors, for example scientific instruments which is a fairly innovative sector, and some studies tend to show that the slowing down is related to increasing concentration. New entrepreneurial firms are taken over by large firms increasingly, and many entrepreneurs simply give up because they cannot operate in an increasingly bureaucratic environment. I think that, on average, it leads to a healthier society if we have lots of small firms that continually cock a snook at the big boys; that is healthier than monopolies or oligopolies.

(Remark) That is more a philosophy than a scientific attitude.

(Rothwell) Okay, it is a philosophy, and it is a philosophy I happen to subscribe to.

(Waller) Mr. Chairman, I think that quite a number of the entrepreneurs that set up small firms have as their strategy to be bought out and to become part of a large firm. It depends on the individual. But in some way or other you can expect that. Small firms have problems in raising the capital they need if they want to exploit an important innovation, and sometimes the best way is to sell out to a large firm.

(Van der Kerk) Thank you. There is another comment coming, I think.

(Comment) Well, Mr. Chairman, I would like to act as an advocate for licensing again. For small and medium-sized companies licensing could be the best way of getting international acceptance for their innovations, as it takes away some of the burden of marketing on an international scale. In my company about 50% of the licensing turnover is between small and medium-sized companies on both sides of the Atlantic, and the flow

of money certainly is not going one way only. Lastly, I want to point out that it can be very refreshing to learn from your licenser or licensee.

(Van der Kerk) Thank you. Would Dr. Waller make a comment?

(Waller) No, in fact not. I would agree.

(Van der Kerk) Thank you. I see that Dr. Smith from the OECD wants the microphone.

(Smith) Since this is an international Conference, Mr. Chairman, may I try to introduce a really internationally note? There is no more fertile field of innovation than the innovation of slogans about innovations.
We have heard at this Conference how very actual and topical the subject of innovation is in the Netherlands. I would like to remind the Conference that similar national level enquiries are going on in at least seven other industrialised democracies, including the USA where the domestic policy review is on the presidential level, Finland where the enquiry is at prime minister level, Sweden, Norway, the UK and France. In Japan it is a continuing process and has been for twenty-five years.
As the slogans develop and become popularized at the international level, they provide argumentation for more and more government intervention in the private sector. This intervention has become and is becoming more direct and more detailed. There are very sound arguments on economic grounds why social intervention in the creation of knowledge and the acquisition of skill is desirable and beneficial, and should be promoted. Those arguments are that it is impossible for investors to capture all the benefits from the creation of new knowledge or the acquisition of new skills. But the same fact, that the benefits cannot be all appropriated by private investors, means that governments when they intervene, cannot predict very well what the ultimate effects of their interventions may be. Even when they intervene to promote technology for their own national, naked commercial comparative advantage, they do sometimes succeed in giving a comparative advantage to another country whose social structure may be more appropriate to the technology which is thus developed.
I think the audience might have some observations from their personal experience about what I am saying. My responsibility is to draw attention to this general international trend and to ask all members of the Conference whether they should not think twice before initiating new slogans. Thank you, Mr. Chairman.

(Van der Kerk) Thank you very much for this highly interesting comment. I think Dr. Dörfel would like to say something about it.

(Dörfel) Yes, Mr. Chairman. My comment will be quite short. I don't think that the slogan of 'innovation' is popular in our company. When I was preparing my paper I had to ask for a definition of it. I then discovered that, although we had been in innovation for nearly a century, we never felt any need of defining it, but perhaps in the English language it is otherwise. Also, we are not very eager to get assistance from the government, so we may be not as prone to slogan promotion as some seem to be.

(Van der Kerk) Thank you. Does Dr. Waller want to comment?

(Waller) Well, I can introduce another slogan, because one of my directors has said that Britain is certainly suffering from analysis paralysis.

(Van der Kerk) Ladies and gentlemen, this is a good slogan to end the Conference. I do hope you have not been paralysed by the analyses you heard on both days, but if you have been you should shake off your mental paralysis to go home invigorated.
Before closing the Conference, I would like to thank quite a number of people. I thank the speakers who presented their papers with such enthousiasm, I thank the members of the audience who listened so carefully that they could pose many difficult questions, and, in particular, I thank the members of the panels on both days who did their utmost

to answer all questions. On behalf of you all I would like to thank those who organised the Conference, who saw to it that it went as well as it did and who, as we all know, are seen but not heard. Thank you.

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