The Anatomy of Chemical Holland

Special Issue of Chemisch Magazine

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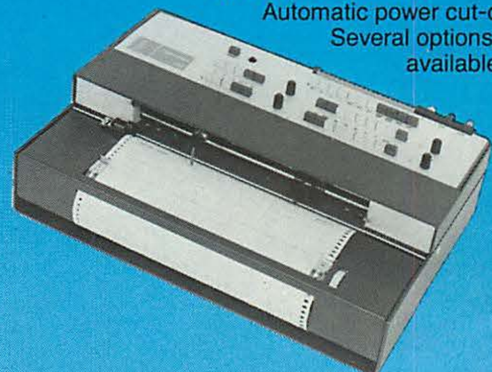

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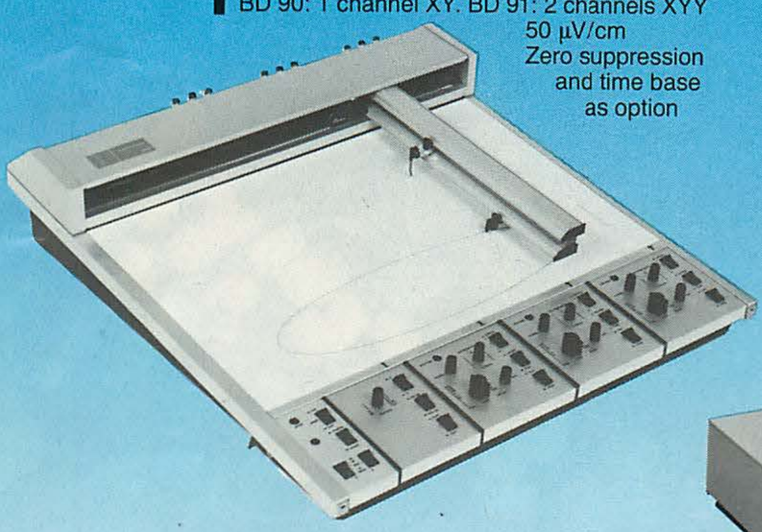

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The turnover of the Netherlands chemical industry per head of population is the highest after the USA. There is a heavy emphasis on bulk chemicals. Because of its sensitivity to market trends, there is a drive for more knowhow-intensive products with a higher added value.

Research activities abound in biotechnology. Five years ago the Dutch Governement announced an Innovation-Oriented Research Programme to stimulate biotechnology-related research to exploit its commercial potential.

The quality of research at Netherlands universities is, even by international standards, good. The low level of investment by the Ministery of Science and Education in equipment and personnel is threatening to undermine this situation. In this respect the Innovation-Oriented Research Programme is source of comfort.

Chemistry is taught not only to train people for employment in the chemical industry but also to provide ordinary citizens with a fair picture of this industry. At universities, a new Two-Phase structure is in operation, comprising two courses with a duration of four and two years.

The Ministry of Economic Affairs has succeeded in 110 foreign companies operating in the distribution field to establish a business within the last 8 years. In their new campaign they present the Netherlands as a high tech country, also emphasizing chemical know-how.

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The Anatomy of Chemical Holland

Special Issue of Chemisch Magazine


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Your guide to opportunities

Don't expect our tulips to grow in *mesitylene*-like patterns. Don't come to Holland to see what the cover suggests. In that respect the picture is misleading. On the other hand, the integration of the national trademark with a quite familiar chemical symbol underlines the importance of chemistry to The Netherlands.

To make that point clear and to explain why this is so, we decided to publish a survey on chemistry in our country, an 'Anatomy of Chemical Holland' – a special issue of our monthly Chemisch Magazine specially written for an international audience. For you, dear reader. For us this issue is almost unique. A comparable magazine was published more than a decade ago. It had the same aim: to present Dutch chemistry to the world.

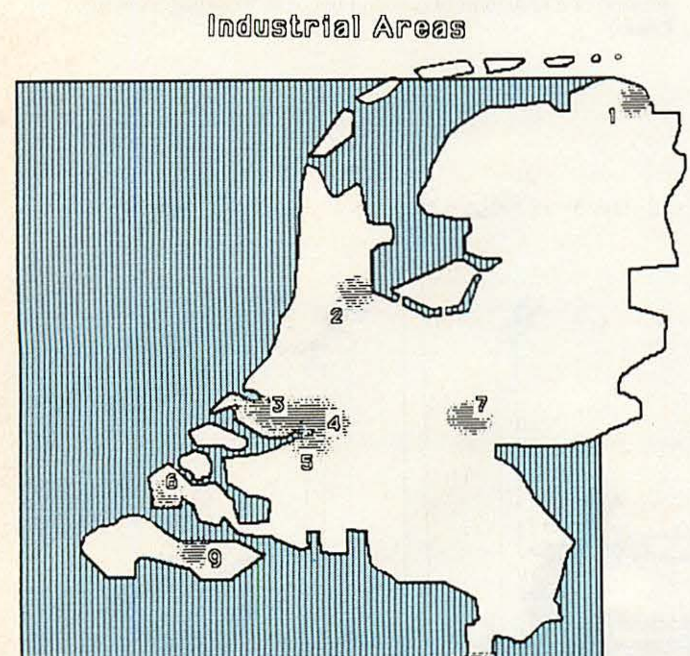
What we want to do is to show you round our chemical world (after you have walked past the bulbfields-with or without chemical symbols). We will show you what is going on at the universities, how good they are and how badly (in a way) they are faring – describe for you the trend in the industry, the swing from bulk to specialties – cast light on biotech enterprises emerging like mushrooms from the soil after a pleasant summer rain – analyse how the Dutch chemists are educated (which was until recently very thoroughly) – and see how hard it is to get the right ones. What hardware do they use? On what scale do they work with computers? How sophisticated are their instruments?
And last, but not least you will learn how to launch a business in this country.

Why are we doing all this? In the first place, of course, because we want you to share in our professional pride about what we have achieved and what's on its way. But, on the other hand, to give you an insight into the chemical side of our country which, we hope, will open up for you new opportunities, be it in business, industrial or scientific cooperation.
Edwin Kisman
(Editor)

THE DUTCH CHEMICAL INDUSTRY IN 1986; HIGH-TECH AND HIGH-CHEM

The total turnover of the Dutch chemical industry will, it is estimated, amount to almost 50,000 million guilders this year and a good 90% of the production which this represents will be exported. The industry has been making a good recovery since 1984 but its heavy emphasis on bulk chemicals production makes it extremely sensitive to market trends. Hence, the drive for know-how-intensive products with a higher added value.

Fridus Valkema



MAJOR INDUSTRIAL AREA'S. Except for DSM (8) all chemical industry locations are situated near the North Sea coast or on waterways leading to it. These area's are Delfzijl (1), Amsterdam (2), Rotterdam/Botlek (3), Dordrecht (4), Moerdijk (5), Vlissingen (6), Arnhem (7), Geleen (8) and Terneuzen (9). Most locations are fed feedstock by pipeline.

Evert Meinsma, the Chairman of the Dutch Association for the Chemical Industry and General Manager of Shell Nederland Chemie at the beginning of the eighties, is in grave danger of being proved wrong. He always shook his head whenever he was asked whether the Dutch chemical industry should not follow the Swiss pattern more closely and thus place less emphasis on bulk chemicals and more emphasis on fine and special chemicals. Meinsma refused to believe that the latter products could ever contribute substantially to the industry's turnover.

'Market discipline' should, according to him, be the guiding principle in the Dutch chemical industry, an industry which at that time was at a low ebb as a consequence of the second oil crisis and the economic recession, overcapacity and low prices for commodities like polyethylene, PVC and polystyrene entailing monthly losses of the order of 200 million guilders for Western Europe as a whole.

Thanks to the closure of unprofitable businesses, portfolio swaps, joint ventures and, last but by no means least, a market revival, the tide began to turn from 1983 onwards, 1984 being a top year. The gloomy start to the eighties was a matter of grave concern to industries throughout the world, including those in the Netherlands. Market discipline and rationalisation proved to be essential recipes for short-term survival, whilst the essential recipe for long-term survival is clearly seen to be the development of a less market-sensitive range of products. This is why companies like DSM, Dow Chemical, Shell Nederland Chemie and AKZO have set themselves the target of extracting a major part of their turnover from *high-added-value products* by the nineties.

This is clearly reflected in the steeply rising research and development budgets, the increasing number of employees engaged in research and the intensive activity of Dutch companies on the acquisition front, particularly in the USA.

To illustrate how heavy the emphasis on *bulk chemicals* and fertilisers was, the situation in 1976 can be quoted as an

HIGH-CHEM

Prof. Wolfgang Hilger, Hoechst's new top man, has added the new term *'high-chem'* to the already richly endowed language of chemicals. He uses this term to describe knowhow-intensive products with a high added value, so that products already bearing the designation *fine chemicals* and *'specialties'* can now also be referred to as 'high-chem' products.

In the old days it was all much simpler, when chemicals were either *'bulk products'* or *'non-bulk products'*, depending on the volume. Bulk products were sold in large volumes for a relatively low price, whereas non-bulk products were sold in relatively small volumes for a relatively higher price. The dividing line was crawn at about the 10,000-ton mark, if I remember rightly.

In the course of time the need arose for a more precise distinction, in terms not only of the volumes of sales but also of the basis of sales, whether this be product composition or formula (in other words, *specification*) or whether this be product properties (in other words, *performance*).

Hence, the following definitions were devised:

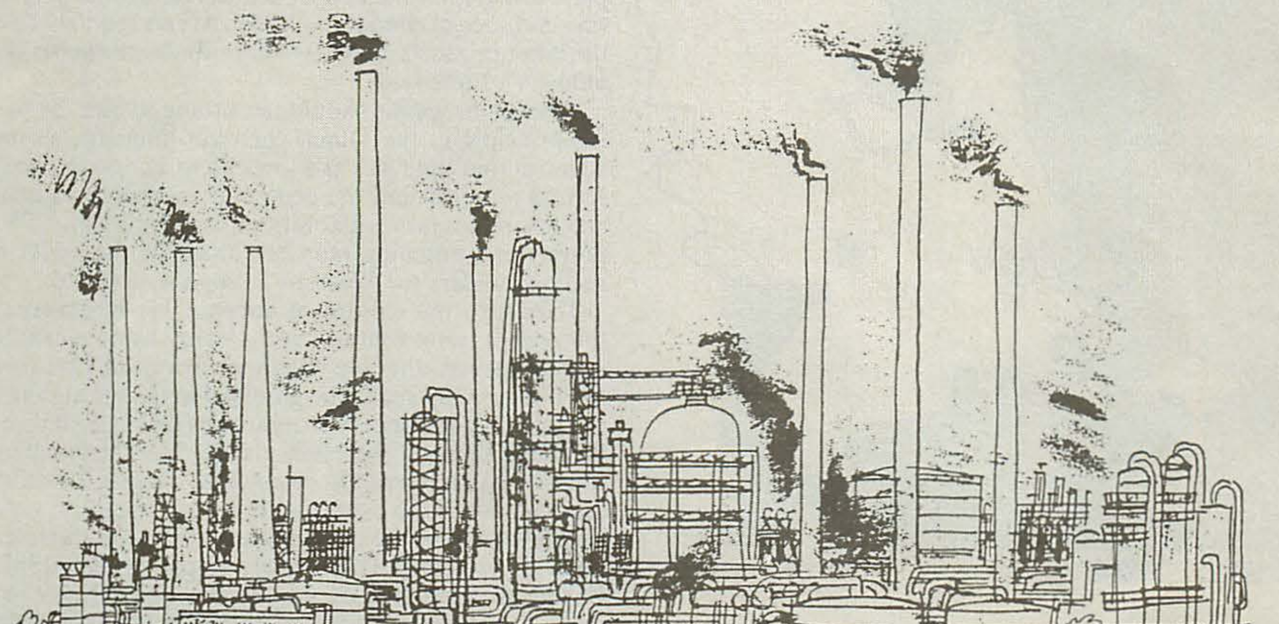
- Commodities: Bulk products sold according to specification.
- Fine chemicals: Non-bulk products sold according to specification.
- Pseudo-commodities: Bulk products sold according to performance.
- Specialties: Non-bulk products sold according to performance. (I have borrowed these definitions from R.E. Selman of DSM). A distinction was, therefore, made between specialties and fine chemicals despite the fact that they were both sold in only small quantities, specialties being sold for what they do and not for what they are.

There is now a worldwide drive throughout the chemical industry to shift the centre of gravity of product manufacture and product range as much as possible in the direction of fine chemicals and specialties, since the latter, as compared with bulk products, are less market-sensitive and have a more rapid growth potential. They are, moreover, knowhow-intensive, which makes them difficult products for newcomers to the market. The profit margins in these sectors can be as much as 50%, which means that even products with a turnover of only a few millions per year already constitute an interesting prospect.

For some industries this new differentiation between chemical products is not yet detailed enough. DSM introduced the term *'commodity plus'*, which is, as far as I can see, approximately equivalent to *'pseudo-commodity'*. John Harvey Jones, the British ICI's top man, then introduced the term *'effect chemicals'*, which, in my view, is the same as the *'specialties'* of the Selman definition.

And now Hilger has thrown the cat amongst the pigeons by creating the term *'high-chem'* to cover both fine chemicals and specialties, 'high' referring to the level of both the knowhow and the profit margin of the product.

The next stage in this trend in product terminology could well be the creation of a new form of greeting between industrial chemists – **'Hi Chem!'**



example. In that year this type of product accounted for 66% of the total turnover of the Dutch chemical industry, as compared with 33% in Western Germany and 41% in Great Britain.

The Dutch emphasis on bulk chemicals is mainly due to the country's favourable geographical location in relation to the rest of Western Europe, its sound infrastructure (in terms of transport, storage and transshipment facilities), its political stability, its high educational standards etc. Although as yet undiminished, these virtues are now being challenged, particularly by the Middle East, where bulk chemicals production based on low-priced raw materials is on the increase. Western European methanol manufacturers are keenly feeling the effect of this challenge.

DSM, widening scopes

DSM, the state chemical concern, is an excellent example of an enterprise which is trying to change its course. Its strategic objective is to earn about one-third of its turnover from the production of fine chemicals by 1990. In order to reach this objective, an active research programme with the focus on biotechnology, new materials (including ceramics) and reaction kinetics has been launched under the slogan: *'widening scopes in chemistry'*.

DSM has now been performing biotechnological research for ten years or so, for part of that time in collaboration with the Danish Novo concern. In the Spring of 1985 DSM entered into a joint venture with the Japanese company of Toyo-Soda for the manufacture of the sweetener *'Aspartam'*. Toyo-Soda has developed an economic route for manufacturing this product, while DSM is the supplier of one of the basic products, a typical example of a high-added-value product with a high growth potential.

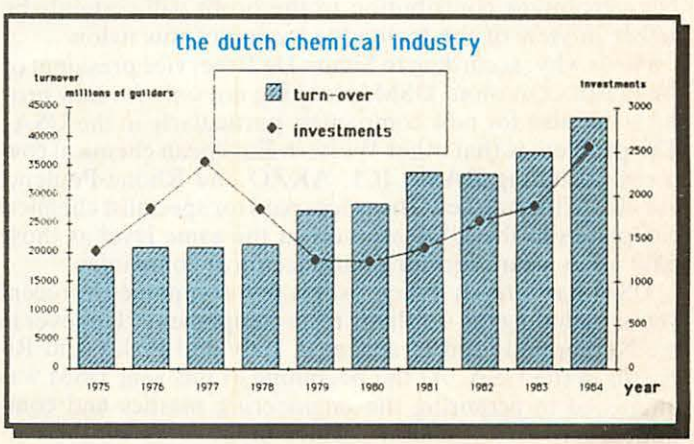
A project with an investment value of 100 million guilders is, needless to say, a fairly large project for the development of a fine chemical product. At DSM there is also an interest in products with an annual turnover of 5 million guilders, because for such products profit margins of 50% are no exception. In the biotechnological sphere, for instance, DSM is contemplating the enzymatic production of chiralspecialty amino acids.

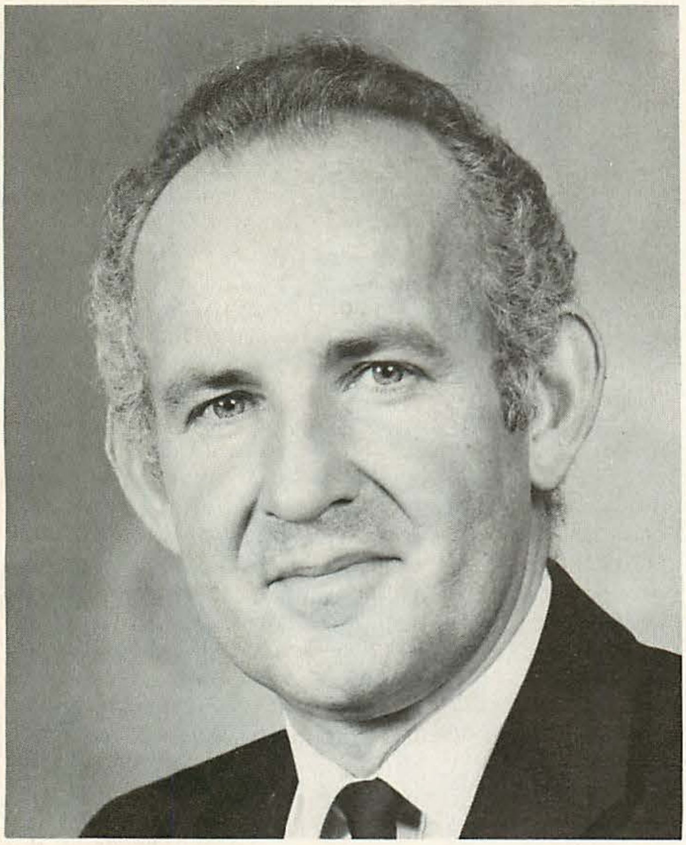
Another product apart from 'Aspartam' in which DSM has great expectations is Stanyl, nylon 4,6. At the end of 1986 the concern will decide whether to build a 20,000-ton capacity commercial plant. Meanwhile, since the beginning of 1986 a trial plant with a capacity of 150 tons per year has been operating in Geleen. DSM has acquired the exclusive rights to a polymerisation route developed at the Technological University of Twente. Nylon 4,6 is an interesting product because it has properties superior to those of existing engineering plastics, its higher temperature resistance being a particular advantage. DSM intends to use Stanyl to fill the gap between existing engineering plastics such as nylon 6 and 6,6 and high engineering plastics such as PEEK (polyetheretherketone). The product's price of DM 15/kg will accordingly be in line with those for the above-named products.

I have quoted this example to illustrate how long it takes for this sort of product to make a substantial contribution to the turnover of a bulk-chemicals-oriented enterprise. Stanyl

EVERT MEINSMA, an advocate of 'thinking European' because of the dependence of the Dutch chemical industry on exports, always refused to believe that fine chemicals could ever contribute to the industry's turnover.

TURNOVER AND INVESTMENT IN THE NETHERLANDS CHEMICAL INDUSTRY. The sensitivity to trade fluctuations is clearly seen in the situation at the beginning of the eighties. Hence the drive for knowhow-intensive products which are less sensitive to economic fluctuations.





S. DE BREE, Vice-President of the Plastics Division of DSM, is not only looking for new products like, for instance, their new nylon 4,6, Stanyl, but also for new companies. The problem is that other European companies are also on the market.

will not be on the market until 1989 at the earliest. Let us suppose that the total capacity of 20 000 tons is sold at a price of, say, 15 guilders per kilo. This means that the product will contribute 300 million guilders to the turnover. The total turnover of DSM's Plastics Division amounted to at least 4000 million guilders in 1985. Stanyl, representing an investment of about 150 million guilders, may, therefore, be expected to contribute 7.5% to the turnover of this division in 1989 if the turnover remains constant in all other respects. The percentage contribution to the profit will certainly be higher in view of the high added value of this nylon.

This is why, according to Simon De Bree, vice president of the Plastics Division, DSM is looking not only for new products but also for new companies, particularly in the USA. The problem is that other Western European chemical concerns, including BASF, ICI, AKZO and Rhône-Poulenc, are also in the market. The prices paid for specialist chemical companies in the USA are now at the same level as those paid a few years ago for pharmaceutical companies.

DSM has already taken over a few companies in recent years, including the synthetic resin companies of Unilever in the Netherlands and Urachem in Italy and Pixley and Richards in the USA. At the beginning of this year DSM was interested in acquiring the engineering plastics and composites activities of Union Carbide in the USA but these finally went to Amoco. The price paid of $ 210 million was much too high for DSM, according to De Bree. His colleague from the chemical products Division, Van Waes, told the European Chemical News that, unlike BASF and ICI, DSM certainly has no intention of paying a thousand million dollars for acquisitions in the USA.

The show piece of DSM's range of new products is its own internally developed extra-strong *Dyneema polyethylene fibre.* To manufacture this product, DSM has entered into a joint venture with Toyobo, the Japanese fibre manufacturer. Both companies are building a trial plant in Japan and, if this is successful, a commercial unit will be built in Geleen.

Needless to say, DSM has no intention of abandoning bulk chemicals production. On the contrary, the concern has very modern efficiently operating plant engaged in this type of production, since it relies on bulk chemicals to generate the cash flow required to finance fine chemicals projects; for, however lucrative the fine chemicals business may be, it is still a risky one and not every new project will have an equal chance of success.

In view of the successful involvement of a state chemical concern like DSM in the whole range of activities described above and the currently favourable market conditions, it occurred to Minister of Finance Ruding, in the Dutch Government's general privatisation drive, that DSM would be an excellent candidate for phased privatisation. DSM itself is in no hurry, but it is not inconceivable that such a move will take place before many years go by.

Innovations at AKZO

DSM's strong fibre came as an unpleasant surprise to the AKZO concern, which is still heavily engaged in developing its own extra-strong *Twaron,* an aramide fibre, production of which commenced this year. AKZO is already involved in a patents dispute with Dupont about this fibre and so is reluctant to be confronted with yet another antagonist in the shape of DSM. Although there is some overlap in the applications of Dyneema and Twaron, particularly in the low-temperature range, it seems likely that the two fibres will ultimately find their own specific fields of application.

The patents dispute between AKZO and Dupont serves to illustrate AKZO's greatly increased self-confidence. Until the beginning of the eighties the Enka Fibres Division was the lame duck of the AKZO group, but, after ten years of closing, re-organising and selling-off companies, Enka has since 1984 again become a going concern (the last loss-making element, American Enka, was sold to BASF at the end of 1985). Enka has now again built up an internal structure strong enough to sustain a high-risk-bearing project like Twaron. What is more, Enka is also co-operating with Toray, a Japanese company, in the manufacture of carbon fibres, production having already started in a plant in Überbruch in West Germany.

Just like DSM, AKZO ('the champion of chemical and technological innovation') has also decided to start a rapid expansion of its research and development activities between now and the end of the eighties, biotechnology, new materials and composites being the main targets of its research, it being particularly in these fields that AKZO is seeking to strength its position by way of acquisitions. In 1985 AKZO took over two American companies operating in the pharmaceutical sector, the Diagnostics Division of *Warner Lamberts* and *Litton Bionetics,* a research and development company specialising in monoclonal antibodies.

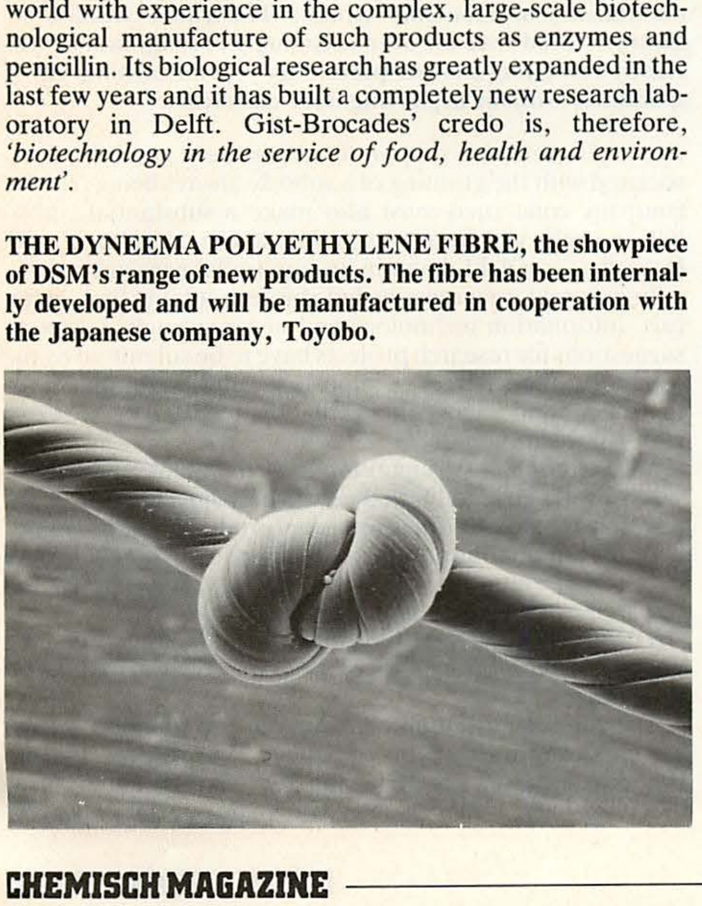
The concern also took over two paint companies, *Lundel* in Britain and *Levis* in Belgium, thus emphasizing the importance which it attaches to coatings.

1985 was again a record year for AKZO. The turnover increased to 18,000 million guilders and the profit rose from 752 million to 840 million guilders. The concern is also optimistic about 1986, although it is not yet clear what effect the lower dollar and oil prices will have on the results. The diversification policy is in any case beginning to be successful and has made AKZO less dependent on market fluctuations. Nevertheless, the fact remains that the concern still has considerable direct or indirect commitments in the heavy chemicals field covering the manufacture of chlorine, lye, VCM and methanol.

Biotechnology at Brocades

Gist-Brocades has always been the Dutch chemical company which by tradition has been oriented rather more towards fine than towards bulk chemicals. At the end of the seventies this company took the difficult decision no longer to continue with pharmaceutical research in view of the high costs involved. The only other alternative would have been to expand research in this field considerably, but this was considered to be too much of a risk. Instead, the company took the carefully considered step of opting for *biotechnology as the target area.* This is one of the few companies in the world with experience in the complex, large-scale biotechnological manufacture of such products as enzymes and penicillin. Its biological research has greatly expanded in the last few years and it has built a completely new research laboratory in Delft. Gist-Brocades' credo is, therefore, *'biotechnology in the service of food, health and environment'.*

THE DYNEEMA POLYETHYLENE FIBRE, the showpiece of DSM's range of new products. The fibre has been internally developed and will be manufactured in cooperation with the Japanese company, Toyobo.



Shell Chemie

Shell Chemie is the only one of all the large chemical companies in the Netherlands which has not publicised any new research projects or ambitious programmes for the development of higher-added-value products. Doubtless, such programmes exist, but it is not company policy to publicise them in the outside world. Shell is, therefore, the only one of the companies mentioned which has not applied to the Ministry of Economic Affairs for any subsidy or support for a special research programme.

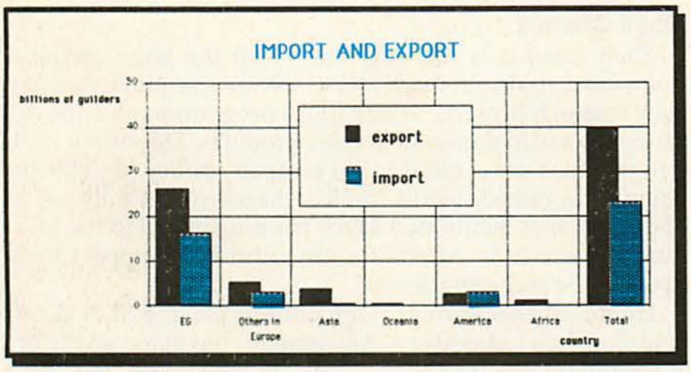
Hence, Shell's strategy is not entirely clear. KSLA (Koninklijke/Shell Laboratory, Amsterdam) has made severe organisational cuts in recent years. Furthermore, the Shell Group decided to build a new synthetic applications laboratory at Louvain la Neuve in Belgium at the end of 1985, a decision which was a hard blow for Amsterdam.

The ministry of Economic Affairs; High Chem

The Ministry of Economic Affairs is at the moment playing a remarkable role in supporting the research and development projects of the large chemical companies. Over a year ago it was revealed that Gist-Brocades were to receive 100 million guilders in government subsidies for the performance of a number of biotechnological projects. Following in Gist-Brocades' footsteps, AKZO, DSM, Dow Chemical and Océ, the fine chemicals manufacturer, have also received support, albeit considerably less than Gist-Brocades. Dow Chemical's subsidy application was, in fact, the subject of considerable discussion in various quarters, the central issue being whether the Dutch Government should subsidise the research and development activities of an American subsidiary, with the inherent risk that vital knowhow could be 'leaked' back to the USA. In the opinion of the Ministry of Economic Affairs, however, it makes no difference whether it is a Dutch or American subsidiary as long as the research and development work is carried out in the Netherlands and the results are also applied in the Netherlands.

Gist-Brocades has concluded an *'umbrella' agreement* with the Ministry of Economic Affairs. According to the Financieele Dagblad (the Dutch 'Financial Times'), this means that the Ministry has created a reserve fund of 100 million guilders to cover subsidies and advances to Gist-Brocades, composed of a development advance of 20 million guilders and subsidies of 80 million guilders. Gist-Brocades, in its turn, has undertaken to allocate 900 million guilders for research and investment purposes between now and 1988, 400 million guilders for research and 500 million guilders for investments (including the 100 million guilders of government subsidies). A sum of thirty million guilders out of these subsidies is earmarked for twenty or so research projects and two independent advisors are helping the Ministry of Economic Affairs to assess the projects.

In elucidation of the Ministry's policy, W.C. Koomans, Head of the Main Chemistry Division of the Ministry of Economic Affairs, stated that the Dutch chemical industry is faced with the overwhelmingly difficult task of constantly extracting a larger and larger percentage of their earnings



IMPORT AND EXPORT. The export trade is extremely important to the Netherlands chemical industry, especially exports to EEC countries.

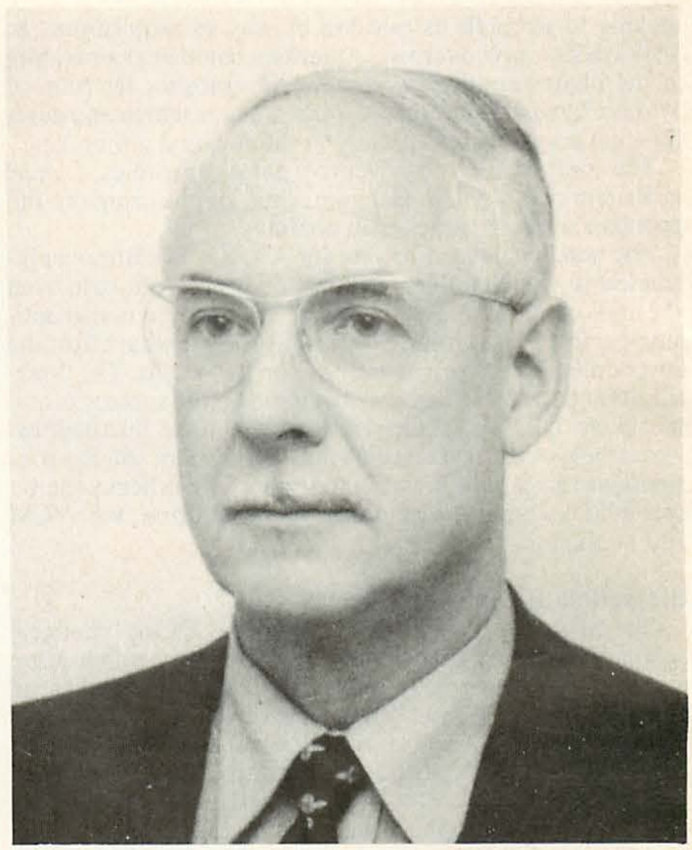
out of specialities without neglecting bulk chemicals. In developing new products, it is important to be ahead of the market. The purpose of the Ministry's target areas policy is to boost companies' research programmes. The chemical fine-processing industry is so knowhow-intensive that it is essential that all companies forming part of it have a high-quality, market-oriented research and development infrastructure. The creation of such an infrastructure is a slow process entailing a great deal of expenditure, substantial risks and a huge research and development effort.

Dr. M. C. G. Hartmann, Deputy Head of the Research and Development Division of the Ministry of Economic Affairs, explained that the above policy differs from that pursued in the seventies when government subsidies were mainly channelled towards companies with a more immediate need. 'It was essential to pursue such a policy at that time', she said, 'because job creation then had top priority'. After the issue of the 1979 Innovation Paper there was a change in policy, whose objective was to raise the standards of knowhow and to seek out promising product/market combinations.

This 'promotion policy' really consists of two separate policies, one generic and one specific.

The purpose of the generic policy is to limit the high costs and risks of research and development. To this end, the INSTIR (*Innovation Promotion Measure*) was introduced at the end of 1984. This applies not only to chemical companies but to all companies, both large and small. The INSTIR makes it possible to subsidise the wage costs expended on both internal and farmed-out research and development work. A total of 1100 million guilders has been allocated for this purpose to cover a period of five years.

In 1984, to complement this generic policy, *Target Area policy* was introduced, a specific policy which makes it possible to give selective support to certain areas, a condition associated with the granting of a subsidy always being that the company concerned must also make a substantial contribution itself, which, as was mentioned in the case of Gist-Brocades, was laid down in an 'umbrella' agreement.



W.C. KOOMANS, Head of the Main Chemistry Division of the Ministry of Economic Affairs: 'The Dutch chemical industry is faced with the overwhelmingly difficult task of constantly extracting a larger percentage of their earnings out of specialties without neglecting bulk chemicals.'

Important target areas include biotechnology, fine chemicals, information technology and new materials. Concrete suggestions for research projects have to be submitted by the companies themselves, an important criterion for the Ministry of Economic Affairs being that the research must be of a high-risk-bearing nature.

W.C. Koomans strongly emphasised that target area subsidies always cover a limited period of from 5 to 10 years. In addition to looking for promising product/market combinations, the intention is to create communication networks between research workers from industry, universities and research establishments such as the TNO.

The objective of the above-mentioned measure could be defined as *'the improvement of the technological/scientific infrastructure'*.

The Innovation-Oriented Research Programmes (IOPs) are important instruments of policy in this respect. For the chemical industry the following IOPs are of importance: biotechnology; polymer composites and special polymers;

M.C.G. HARTMANN, Deputy Head of the Research and Development Division of the Ministry of Economic Affairs: 'The stages preceding the commercial-scale production and marketing of new products are now receiving more attention in our technology policy.'

carbohydrates; membrane technology; technical ceramics; catalysis (on a trial basis); new materials (pre-study).

In the Ministry of Economic Affairs' technology policy, the preliminary stages of a project, the stages preceding the commercialscale production and marketing of new products, are, according to Mrs Hartmann, now receiving more attention.

The Ministry's policy can be summed up by stating that, regardless of the phase of the project, the Ministry can always give it a helping hand.

Although the policy is not focussed entirely on the activities of the large multinational companies, it has to be admitted that a large proportion of the research and development potential is, in fact, concentrated there, However, in the last year or so more small companies have also been coming up with good projects, for which they have been granted subsidies.

It can thus be seen that the Target Area policy is also aimed at the small and medium-sized category of companies. This category also makes ample use of the possibilities offered by a generic measure like the INSTIR.

The innovation policy pursued by the Ministry of Economic Affairs is not unique to the Netherlands. Most other European countries have created similar measures to promote promising developments. In most of these countries such measures are based on the assumption that new technologies have an important role to play in the drive for industrial innovation. The distinctly international character of technological development has given rise to many striking similarities between the innovation policies of the Western European nations.

The Dutch chemical industry is actively preparing itself for a *diversification* of its product range, to judge by the increasing amount of attention being paid to research and development work as the end of the eighties approaches. This is in marked contrast to the situation at the beginning of the eighties when research budgets and research staff virtually everywhere were cut back in order to achieve the maximum-possible cost savings. This cost-saving policy was prompted by the economic recession being experienced at that time, for which the second oil crisis was partly responsible, since the latter caused oil prices to rise steeply.

The burning question of the day now is: 'What if the oil prices, which have dropped steeply of late, remain at the present low level?' Simon De Bree of DSM told the Chemisch Weekblad in February of this year that the lower oil prices would as yet have little influence on DSM's business results. The lower dollar exchange rate, another factor having an important influence on the Dutch chemical industry, would also affect DSM only slightly, at least, as long as the rate remains above the f 2.50 level.

If we were to expect a lower oil price to have the opposite effect on the economy from that which the high oil price had at the end of the seventies, this would mean that a strong revival of the economy, and hence, of the chemical industry, was on its way. With its drive for knowhow-intensive products with a high added value, the Dutch chemical industry seems to have arrived at the threshold of a new period of prosperity.

As was said earlier, Meinsma looks as if he is going to be proved wrong as far as the diversification potential of the chemical industry is concerned. On the other hand, his plea for a policy of market discipline for bulk chemicals and commodities still retains, it would seem, an undiminished impact in the light of the large incidence of excess capacity for the manufacture of these products which still exists in Western Europe. Meinsma is a strong advocate for *'thinking European',* because the Dutch chemical industry is strongly dependent on its exports, particularly to Common Market countries.

Akzo:

Versatile Giant on the Move

From its head offices in the unassuming Dutch town of Arnhem, the international Akzo corporation is applying a unique combination of prudence and innovation to maintain and expand its world leadership in areas ranging from salt and chemical products through aircraft coatings to the state-of-the-art in biotechnology, fibers and new materials.

The Akzo group – with its dynamic and ambitious programme of international growth – numbers among the world's 20 largest chemical concerns, with an annual turnover in 1985 of $ 7.1 billion and 65,000 employees in 225 operations around the world.

Through these operations at home and abroad, Akzo is not only active in production, but also in the development of products and services to meet the world's present and future needs.

Akzo is, for instance, an international market leader in the industrial fibers sector, a sector in which this company has pioneered the way in spectacular new developments.

As the only company in the world producing all of the following three new types of fibers: aramid fiber (Twaron), carbon fiber (Tenax), and Silica fiber, this Dutch multinational has a special place in the hearts of the aviation and automotive industries.

Akzo's industrial fibers are earmarked for such major applications as rubber reinforcement for tyres and conveyor belts, asbestos replacement, sports equipment and ropes and cables. The use of these fibers, which is expected to hit its stride in the early years of the next decade, is currently the subject of discussion with such major builders as Fokker, Airbus Industries and Volkswagen.

The group's Enka division also numbers among the major European producers of chemical fibers for textile applications, particularly tailored for use in clothing, home textiles and carpets.

And the list of achievements doesn't stop there. Few people know, for instance, that Akzo is by far the world's largest supplier of salt; a major part of this salt is converted into chlorine and caustic soda lye, from which many other chemicals are made.

The group is also the world's leading supplier of membranes for medical purposes, and, in the field of specialty chemicals, Akzo is a major supplier of catalysts for cracking processes and organic peroxides for the plastics industry. Furthermore, the company is one of the biggest producers of coatings for the automotive industry and car repair, aircraft and steel construction.

Yet despite its position of international leadership, the company doesn't plan to rest on its laurels.
For as Akzo president Aarnout Loudon said in a recent interview, one of the Akzo's goals is to boost U.S. holdings to 20% of the group's total from the current 15%. Such high-profile names as Bostik Finch and Wyandotte Paints, Wilson-Fiberfil International, Litton Bionetics and the diagnostics activities of Warner Lambert have recently joined the Akzo fold.

In addition to new acquisitions, there is yet another direction in which the versatile Dutch giant is taking seven-league strides. Via R&D activities of some 5,500 research workers Akzo is actively improving and developing products for new and existing markets.

In 1982, the Akzo Pharma division's Intervet company became the first in the world to introduce a genetically engineered veterinary vaccine. The company's intensive work on the diagnostics front recently resulted in an antibody screening test for AIDS which is now sold throughout the world.

But what may be even more surprising than Akzo's success with high-tech and marketing intensive products is the recent and enormous surge seen in the group's results. During the last four years, the company's earnings have more then quadrupled to $ 332 million in 1985. Liquid assets, essential to the group's ambitions on the world market, increased during the same year to around $ 600 million.

Stringent economies, as some would say only the stringently economical Dutch can impose, have put Akzo firmly back in the black. After a thorough trimming and restructuring of its operations, the road is now clear for the opening of new markets for the future.

In the meantime, however, Akzo will continue reinforcing its position of focussed leadership – with both eyes open for attractive opportunities in the developing world as well. For it is precisely in those areas in which growth is dynamic – such as in Asia and South America – that this advancing giant sees clear horizons for the sales of its successful and vast range of products.

THE HISTORY OF THE DUTCH CHEMICAL INDUSTRY

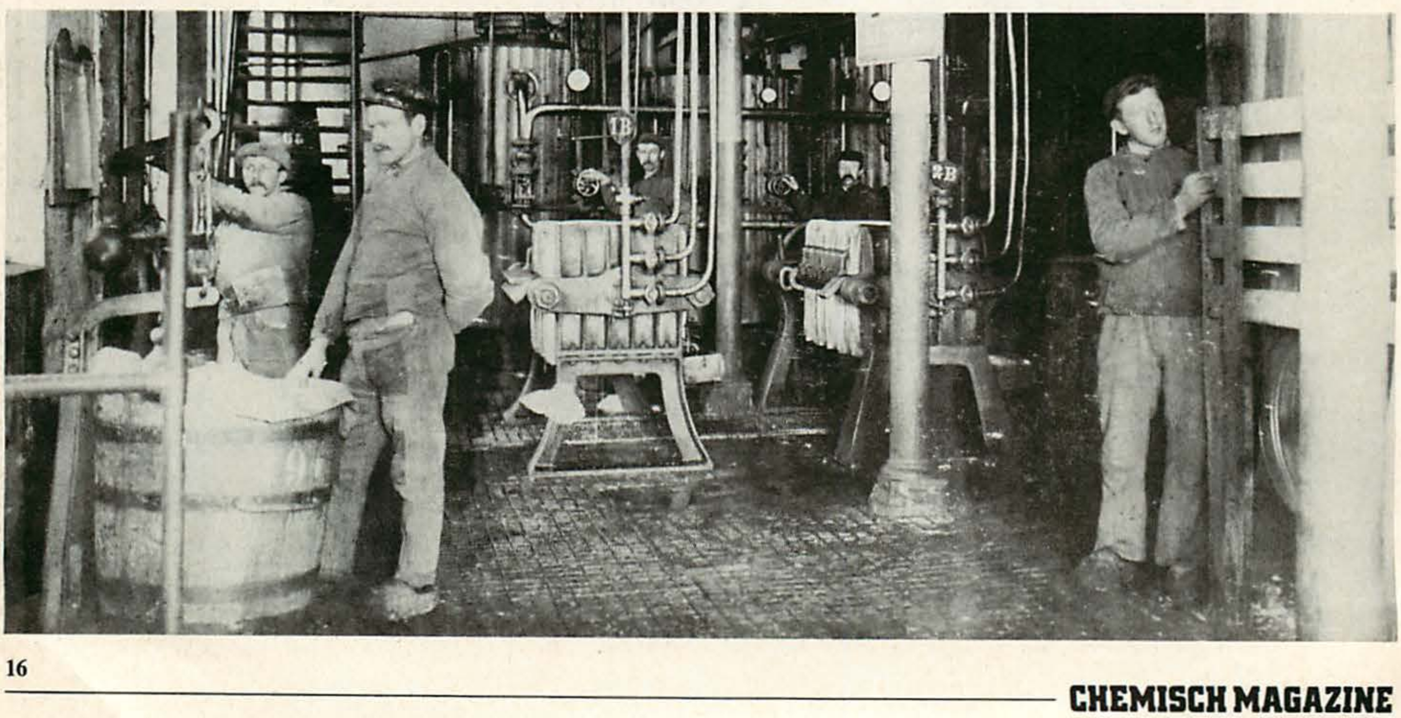
The Dutch chemical industry at the beginning of the Twentieth Century is fairly craft-oriented and strongly related to agriculture. There are a lot of small companies which only supply the Dutch market with their products, only a few products being exported. New inventions, new growing markets and changes in feed-stock changes the structure of the European chemical industry. For the Dutch chemical industry this has big consequences, because of its central position in the European trade line. It now operates worldwide and is almost completely dependent on exports with the biggest client being itself.

Ernst Homburg

The output of the Netherlands chemical industry is 1 to 2% of total world chemicals production. This is a very large percentage for such a small country. Nor was the Dutch trading position very different in this respect at the beginning of this century. A foreign observer came to the conclusion in 1914 'that the number of chemical companies in Holland, despite the nearly complete absence of natural resources, was relatively large and that, even under these unfavourable circumstances, the chemical industry of this country played an important role in world trade'.

This does not mean, however, that little has changed in the last seventy years. On the contrary! Both the international structure of the Netherlands chemical industry and its position in Western Europe have changed out of all recognition. The average staffing in 1912 was thirty employees per company, whereas it has now risen to at least 250 employees per company, a number of companies having thousands of workers in their employ. In 1912 even the largest companies had a totally national character, whereas the current chemical scene in the Netherlands is completely dominated by a number of large multinational companies, the four largest – DSM, AKZO, Shell and Dow – being jointly responsible for about 58% of the total turnover.

YEAST PRODUCTION. This represents the situation at the beginning of the century. It is still one of the staple products of Gist-Brocades, one of the world's largest yeast manufacturers.



The Netherlands chemical industry is now closely linked to that of its neighbours. Common feedstock supply channels, common pipeline networks and interlinked capital flows dominate the picture. This situation too is in stark contrast to that existing at the beginning of this century.

The development of the chemical industry in the Twentieth Century can be summarised as a series of trends as follows:

□ the replacement of natural by synthetic materials;
□ the replacement of extraction (from vegetable or animal substances) by synthesis (from coal tar or mineral oil components);
□ the replacement of coal by mineral oil and natural gas as feedstock;
□ the increasing interlinking and interdependence of manufacturing processes, industrial concerns and national economies.

For the Netherlands – as the gateway to Europe – these trends had a particularly favourable effect. The Dutch chemical industry gained ground on those of all the other highly industrialised countries except Italy and Japan. The per capita turnover of this industry is, after the USA, the highest in the world.

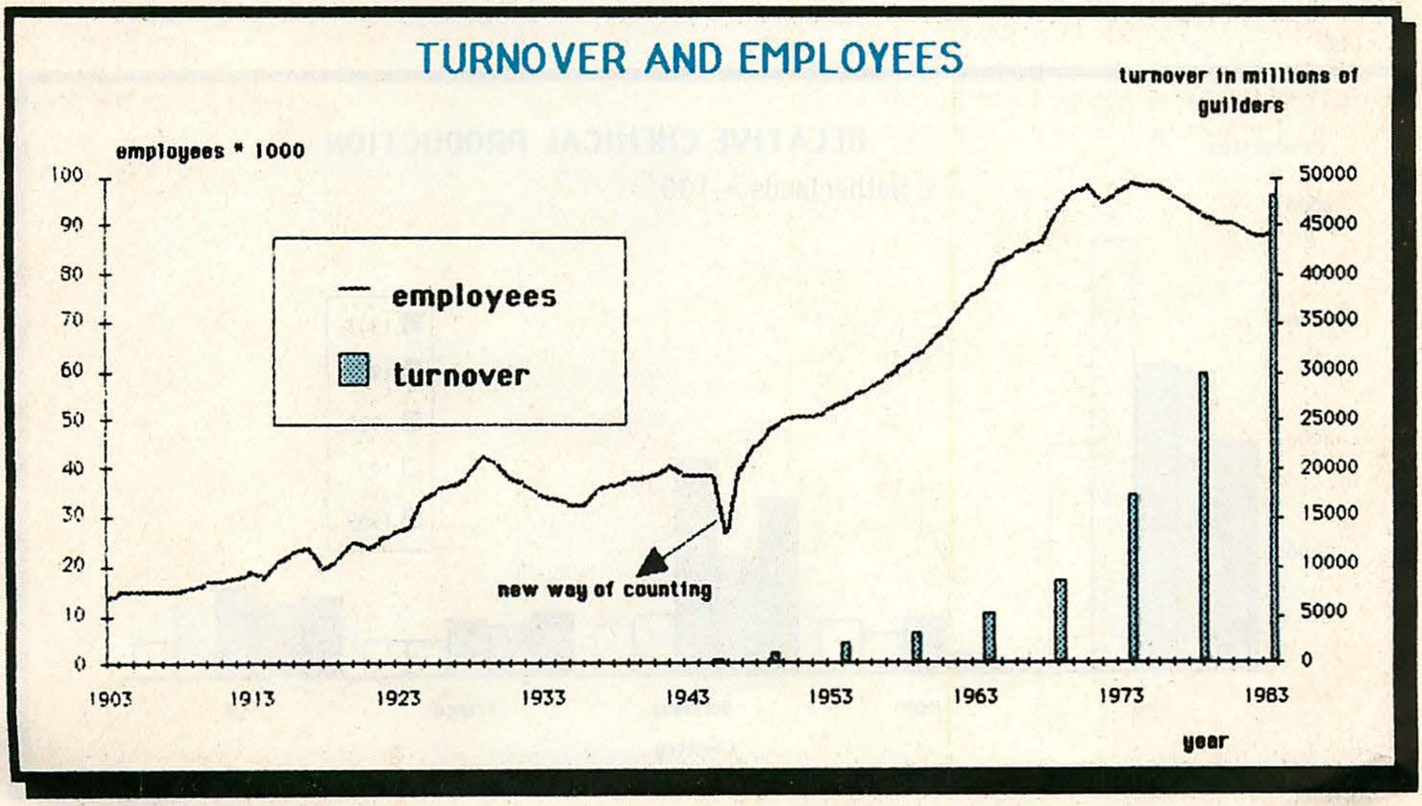
Before the first world war

The Dutch chemical industry at the beginning of the Twentieth Century could in no way be compared with the highly developed chemical industry in Germany, where a number of large multinational chemical companies already existed which were carrying out a great deal of research and were performing very advanced syntheses in their manufacturing processes. Dutch industry at that time was still fairly *craft-oriented* and was based on extraction processes from agricultural crops and animal products. Next to this orientation towards agriculture overseas (colonial) trade (oil seeds and quinine) was important.

Halfway through the nineteenth century the *garancine* industry was the strongest sector of the Dutch chemical industry. Dutch garancine (a colouring material made from madder) was awarded three medals at the World Exhibition in London in 1862. Later, the oil and fat processing industries (candles, soap and margarine), the starch industry and the sugar industry became strong sectors. But also at that time these industrial sectors were not considered to belong to the chemical industry in the strictest sense.

In comparison with the chemical industry, the sugar industry was surprisingly large, in 1912 10,000 workers being employed in 28 factories during the sugar beet harvest. The entire chemical industry in the strictest sense, on the other hand, provided work for about the same number of workers but these were spread over 420 factories. Other important products produced by the chemical industry included sulphuric acid (used in the manufacture of garancine, candles and, later, fertiliser) and white-lead for the paint industry. Gas processing was also on the increase, one of its products

THE GROWTH OF THE DUTCH CHEMICAL INDUSTRY in terms of numbers of employees and of turnover. At the beginning of the Twentieth Century growth in both respects was evenly balanced but in the sixties the situation changed drastically as a result of expansions of scale and automation in the chemical processing industry.



being ammonia, which was used in fertiliser manufacture. This had already become an important sector of the chemical industry, which was clearly linked to agriculture. However, coal tar aromatics were exported to Germany, there being as yet no advanced organic and synthetic chemicals industry in the Netherlands.

1914-1929

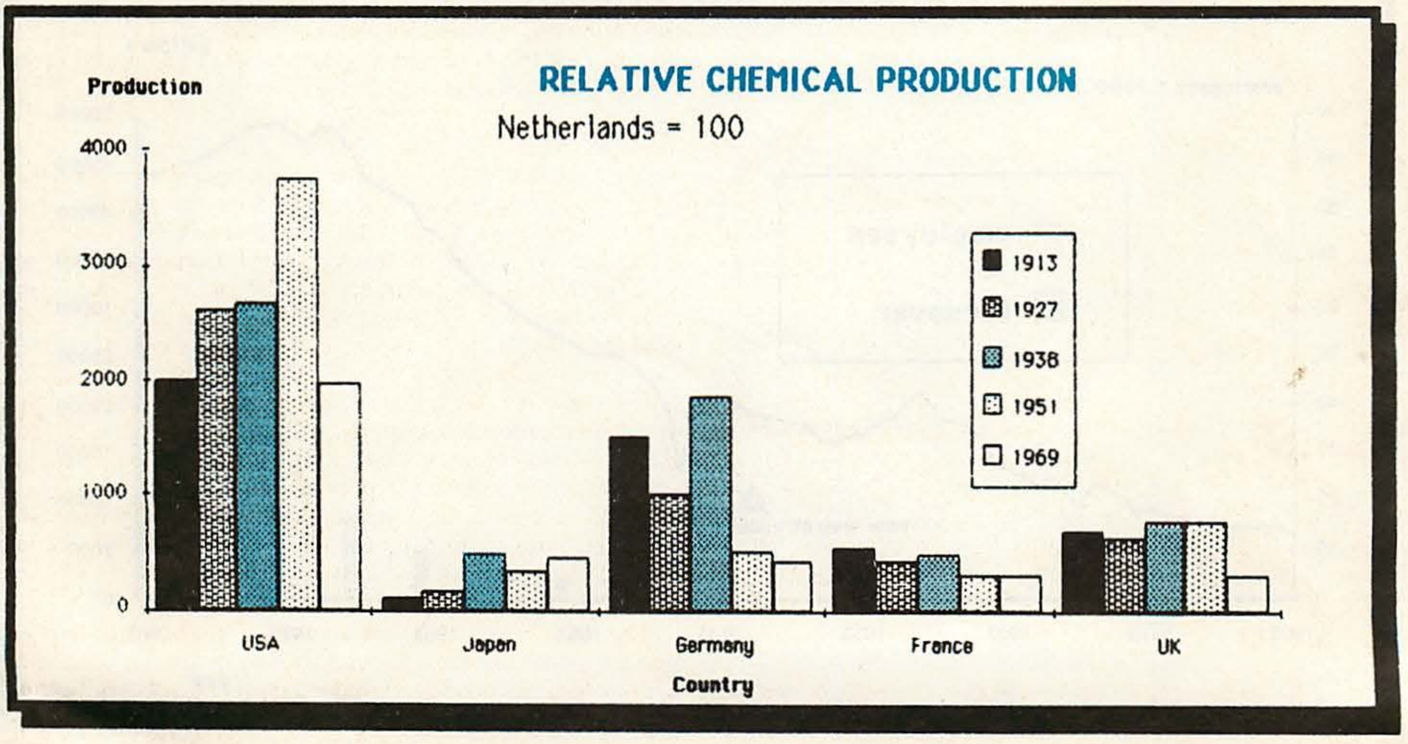
The First World War had a great impact on the chemical industry, 228 new companies being set up between 1914 and 1917 and 352 companies undergoing expansion. This rapid growth was largely due to the blockading of imports. This had the additional effect of allowing imaginative planners to give full rein to their grandiose plans for the future of the industry in the Netherlands. The chemical industry had come of age. Important participants in this planning phase were the Delft Professor, *Steger,* and the professor-cum-industrialist, *Hondius Boldingh.* These two had already unfolded their plans before the war began, their central objective being the reduction of the dependance of the chemical industry from agriculture. The Twente salt deposits and the Limburg coalfields also had to be exploited for their chemical potential.

Coal production rose enormously during the war and a salt shortage induced the KNZ (now AKZO) to exploit the Twente salt deposits. Enka (now also AKZO) commenced production of rayon from cellulose in 1913. Steger was also behind the launching of Hoogovens in 1918 to supply the Netherlands' needs for iron, which was in short supply at the time. Hondius was one of the founders in the same year of the VNCI (Vereniging van de Nederlandse Chemische Industrie)-*the Netherlands Chemical Industry Association.* For the first time the chemical industry had become an industry in its own right and not just an industrial statistic.

The reconstruction process which started in the 1914-1917 period continued throughout the subsequent crisis years. Although many small ventures which had just been set up soon collapsed again, some of the larger companies producing iron, rayon and salt kept going. After 1924 there followed until 1929 another period of strong growth, stronger than that of industry as a whole. Internationally, the Dutch chemical industry was also gaining ground, so much so that it could rightly claim to have made a deep market penetration. As a construction material wood was replaced by metal, butter by margarine and cotton by artificial silk. Rayon production increased within ten years from 200,000 to five million kilogrammes. DSM expanded coke production, Hoogovens becoming an important coke consumer.

A characteristic feature of the closing phase of a period of expansion is an intensified *of process concentration* within a particular sector of industry. In the twenties this was to be seen in such sectors as the rayon, foodstuffs and pharmaceuticals. Van den Bergh, with interests in Britain, and Jurgens, geared to the German market, merged in 1927 to form the Margarine Unie after a very expensive period of rivalry. Two years later the Unilever concern was formed after a merger with Lever Brothers. In the rayon sector Enka acquired HKI of Breda and, at the same time, a majority interest in the Vereinigte Glanzstoff Fabriken (United Artificial Silk Factories) and changed its name to AKU. Within the greatly expanded pharmaceutical industry the Brocades

THE TURNOVER OF THE DUTCH CHEMICAL INDUSTRY as compared with a number of other highly industrialised countries (the Netherlands = 100). The switch from coal to oil and gas as feedstock was one of the factors responsible for market gains from the sixties onwards.



concern was formed out of a large number of smaller pharmaceutical companies. The two largest chemical companies of the period before the First World war, the 'Gouda' and 'Apollo' candle factories, merged in 1929 (they are now part of the Unilever group).

The chemical industry continued to become increasingly export oriented. This also led to the establishment of research laboratories. Philips, BPM (Shell) and Enka were the leaders in this field. Companies employing a relatively large number of chemists also included Jurgens, Vondelingenplaat, Calvé, Organon and the ACF(1). Turnover rose in the twenties to about 200 million guilders and the number of workers rose from 21,000 to 26,000.

1929-1945

The 1929 crisis ushered in a second period of reconstruction for the chemical industry. Many companies had to go out of production and others introduced *severe rationalization measures*. The number of workers in the chemical industry dropped by many thousands. Not until 1935/1936 did business pick up again and the work force grow again, the latter being practically restored to the 1929 level by 1939. Even companies which had survived the crisis had severely cut their work force levels, the level at AKU, for example, having fallen from 8000 to 4000. The crisis hit the Netherlands chemical industry harder than those of other highly industrialised countries and considerable ground was lost to the German chemical industry (IG Farben).

This difficult period led to an *increased interest in research*. Research into new markets and new products finally provided the means for tackling the crisis. Shell introduced synthetic detergents, Philips introduced thermohardeners, Organon was the first in Europe to market insulin and Océ van der Grinten was the first to introduce photo-sensitive paper. DSM carried out a downstream integration by adopting the

GLUEWORKS at the beginning of this century. Bones are being unloaded for the manufacture of glue.

Haber-Bosch ammonia synthesis, the patents for which had recently expired. Out of the ethylene released during ammonia manufacture ethanol and ether was produced. The large quantities of energy (coal) which DSM produced led to the formation of links with salt-mining concerns, KNZ employing energy-intensive electrolysis to produce chlorine, caustic sodium and hydrochloric acid from salt.

Shell took a number of crucial decisions in this period. It started up its first refinery in Rotterdam in 1936 and in a quest for knowledge invested in the United States. There petrochemical technology was much further developed than in Europe, where all processes were still based on coal. This made Shell the only company in the Netherlands with a knowledge of catalytic and cracking processes. Via MEKOG, Shell entered, on strategic grounds in the fertiliser manufacturing field, to familiarise itself with gas processing techniques. The total turnover of the chemical industry between 1929 and 1939 rose by 62 million guilders to 262 million guilders.

The Second World War brought difficult times for the chemical industry. The destruction of plant, feedstock problems, shortages of materials and confiscation crippled the industry. Production was geared to war needs. DSM manufactured synthetic rubber and calcium carbide was also produced. For scarcity reasons, synthetic materials had to replace natural materials. Gist commenced penicillin production and a unique agremeent between Shell, Gist and Naarden International led to the production of Vitamin C by the synthetic route. This marked the official entry of synthetic processes into the chemical industry. Nevertheless, the Netherlands were still lagging a long way behind Germany, the Dutch chemical industry being still mainly based on extraction and simple chemical processes. However, the incentives for new developments were already in evidence. After the war petrochemical technology came into its own, thus reducing the organic chemicals industry's dependence on coal (for the production of aromatics) and natural products (for the production of aliphatics).

1945-1973

After the Second World War a third period of reconstruction set in, which was characterised by the rise of *petrochemical technology*. Initially, the changes were not very great, but the sixties witnessed a revolutionary revolert alleration in the chemical industry. This post-war transformation was much more far-reaching in character than its two predecessors. In 1949 the small private company still dominated the scene, 45,000 workers being spread over 1000 to 1500 companies. Fertiliser, rayon, paint and soap manufacture still represented important sectors. The share of the chemical industry in total industrial turnover in 1955 was still not much higher than the prewar level.

In the reconstruction of the chemical industry Marshall Aid, the Allies' reports on the giant German chemical concerns and government initiatives played a role.

The Dutch Government realised that industrialization and exports were of vital importance to the Netherlands. From 1949 onwards it initiated a number of *industrialization plans* in which the chemical industry was specifically mentioned. It created favourable conditions for private investors and was supported by the trade unions in its moderate wages and prices policy.

Shell resumed its refining activities in the Port of Rotterdam in 1950. Meanwhile, because of the Allies' ban on the resumption of the successful coal hydrogenation process in Germany, the latter was compelled to switch to oil as the feedstock. This resulted in the launching of a joint venture between Shell and BASF in Germany in 1955, the Rheinische Olefinwerke, which marked the official start of a post-war period of international co-operation in the form of joint industrial ventures.

After 1953, the pace of industrial growth rapidly increased, investments experiencing a particularly strong upsurge. The incidence of *joint ventures* is a typical symptom of industrial growth in its early phases. A number of other Dutch companies now also sallied out this kind of co-operation into the new field of petrochemical technology, AKU, Ketjen and DSM entering into joint ventures with Goodrich, Cyanamid and Dow respectively, to name only a few examples. The Americans, who were particularly in evidence, injected an impressive amount of capital and special knowhow into the Netherlands economy. In return, America was presented with a favourable working environment and access to the Common Market, which was formed in 1957.

In this period the basis was laid for the feedstock revolution of the sixties. Hitherto, coal had been the feedstock used in the chemical industry but Shell (on the basis of the experience gained in the USA!), Caltex and Esso started to refine the more easily recoverable mineral oil in Rotterdam.

By 1959 the Netherlands already occupied third place after the USA and Germany in terms of the chemical industry's per capita turnover. Exports, as a percentage of turnover, began to rise from 46% in 1955 to 56% in 1960. The sixties were characterised by a growth so massive that the sky alone seemed to be the limit. The revolutionary switch to oil and gas as the principal feedstocks had become a fact. The construction of the refineries attracted many chemical companies, a large number of which again being American. These companies were largely concentrated in one area because they were dependent on each other either as supplier or as consumer. In other words, *the chemical industry was its own largest consumer.*

With the Dutch coal mines closed, DSM rapidly expanded its activities in the chemical field, using the gas bubble under the Netherlands as its feedstock. It became one of the fastest growing chemical companies in the world.

It was in this period that the Dutch chemical industry acquired its typical character as an industry heavily based on

THE LAUNCHING OF OIL REFINERIES AND LARGE CHEMICAL COMPANIES in the Netherlands in the sixties. Huge investments were made particularly by the USA, leading to the creation of a network of chemical companies which are dependent on each other as either supplier of consumer.

THE LAUNCHING OF CHEMICAL COMPANIES IN HOLLAND

OIL REFINERIES

YEAR	COMPANY	LOCATION	COUNTRY
1950	Shell	Pernis	Holland
1948	Chevron	Pernis	USA
1960	Esso	Botlek	USA
1963	Gulf	Europoort	USA
1967	BP	Europoort	GB
1968	Mobil	Amsterdam	USA
1974	Total	Sloe-area	USA

CHEMICAL FACTORIES

YEAR	COMPANY	LOCATION	COUNTRY
1950	Shell	Pernis	Holland
1960	Dow	Botlek	USA
1960	Dupont	Dordrecht	USA
1960	Hercules	Zwijndrecht	USA
1961	Chemische Industrie Rijnmond	Botlek	USA (partly)
1961	DSM	Geleen	Holland
1962	ICI	Rozenburg	GB
1964	Esso chemie	Botlek	USA
1964	Petrochemie AKU	Delfzijl	USA (partly)
1965	Dow	Terneuzen	USA
1965	Marbon	Amsterdam	USA
1966	Hercules	Middelburg	USA

Shell Nederland Chemie B.V.

Shell Nederland Chemie B.V. is one of the largest chemicals manufacturing and marketing operating companies of the Royal Dutch/Shell Group. The head-office is incorporated in the Business Organization situated in Rotterdam. The manufacturing sites are located at Moerdijk and Rotterdam-Pernis. The Business Organization is dealing with marketing, finance, planning, product development and market research. The range of products includes: base and industrial chemicals, speciality and fine chemicals, plastics, resins and synthetic rubbers, agrochemicals and animal health products. The majority of the production is for export.

Benelux Organization

Shell Nederland Chemie B.V., Belgian Shell N.V. (Chemicals) and Shell Luxembourgeoise (Chemicals) form together the Shell Chemicals Benelux Organization which operates from the head-offices in Rotterdam and Brussels. While marketing is thus effectively coordinated, the three companies retain their independent status.

Research

Shell's achievements in petrochemicals are the result of the research done in laboratories of Shell Research in the United States, Canada, in the United Kingdom, in France and The Netherlands. The largest research institute outside the United States is the Koninklijke/Shell Laboratorium Amsterdam in The Netherlands.

A new chemical research centre is to be built at Louvain-la-Neuve, near Brussels. It will be managed by a new company, Shell Research Belgium SA, and will be operational in 1987. The new laboratory will serve the market by the development of new and existing Shell products such as epoxy resins, polyurethanes, polypropylene and expandable polystyrene. The laboratory will also provide customers of Shell Companies with technical support and opportunities for practical assessment of the suitability of existing products and formulations in new envisaged applications.

Customer-oriented

With sales proceeds of nearly $ 8 billion, the Royal Dutch/Shell Group ranks eighth among world chemical manufacturers. With an unrivalled spread of marketing operations, emphasis is given towards the customer. This policy of getting closer to the customer will help to develop a two-way relationship with those who use Shell products. Shell Chemicals are now responding more specifically to certain customer requirements, with a higher degree of differentiation between those relating to outright commodities on the one hand and to more specialised products on the other. Although chemicals represent only some 15% of the Shell Group portfolio, chemicals research effort amounts to some 40% of the Group total.

The Shell Group has the advantage of efficiency and a worldwide presence. Shell Nederland Chemie B.V., therefore, have the resources to translate the current and anticipated needs of a market into the development of products.

Shell Nederland Chemie B.V.
19, Hofplein, 3032 AC Rotterdam
P.O. Box 2960, 3000 CZ ROTTERDAM
Telex: 30502

bulk chemicals manufacture. Before the Second World War Germany had been the centre of both the bulk and fine chemicals industries. Now from the sixties onwards the centre of gravity of the bulk chemicals industry moved to the Netherlands, whilst Germany retained its leading position in fine chemicals. A large integrated chemical complex arose in North West Europe in which the Netherlands played an essential role.

In 1970 the Netherlands overtook Germany in terms of per capita chemicals production. A typical feature of this period was the large number of mergers. Just as in the twenties, this was a sign that the expansion phase was coming to an end. The most important merger was certainly that which led to the formation of the AKZO concern in 1969 out of KZO and AKU, KZO having already absorbed Ketjen, KNZ, Sikkens and Organon in an earlier phase.

The turnover of the total Netherlands chemical industry rose from 340 million guilders in 1948 to 13,000 million guilders in 1973.

1973-1986

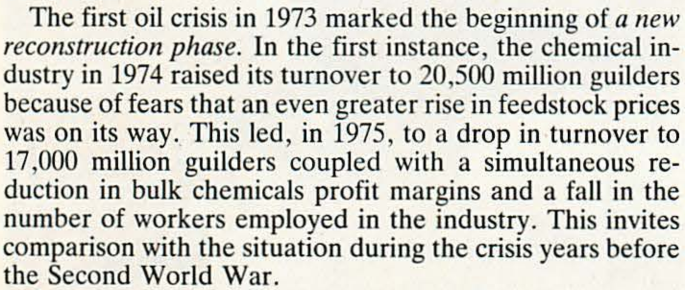
The first oil crisis in 1973 marked the beginning of *a new reconstruction phase.* In the first instance, the chemical industry in 1974 raised its turnover to 20,500 million guilders because of fears that an even greater rise in feedstock prices was on its way. This led, in 1975, to a drop in turnover to 17,000 million guilders coupled with a simultaneous reduction in bulk chemicals profit margins and a fall in the number of workers employed in the industry. This invites comparison with the situation during the crisis years before the Second World War.

Between 1975 and 1977 investments began to flow in again, but the second oil crisis in 1978 nipped in the bud any chance of real improvement. This left a country with a heavy bulk chemicals commitment like the Netherlands with a huge problem. An additional problem arising from this situation was the increasing competition in bulk chemicals production being experienced from the Middle East and Eastern Europe. These problems induced many companies to intensify their innovatory efforts. DSM, a typical manufacturer of bulk chemicals, is a good example of such a company. This concern decided to diversify at the beginning of the eighties. It also went into fine chemicals, biotechnology and oil and gas production. This was, therefore, a case of both upstream and downstream integration. Other Dutch companies also endeavoured to manufacture products with a higher value added.

After 1983 the Dutch chemical industry entered a new *period of recovery,* a symptom of such a period seeming to be the increasing extent to which concerns make approaches to one another to start new projects. DSM contacted two Japanese companies with regard to the synthesis of 'Aspartam' (a sweetener manufactured by means of a biotechnological process) and the manufacture of an extremely strong polyethylene fibre. Philips and Dupont are jointly engaged in the production of compact discs. Enka has for some years now again been investing in a high-risk project, the Twaron fibre, the counterpart of Dupont's Kevlar. Enka has also entered into co-operation agreements with several other companies; for example, with a Japanese company for the manufacture of a carbon fibre.

Another striking feature is the large number of investments which the Dutch chemical industry has been making in America in recent years. Barely twenty years ago investments were all moving in the opposite direction.

THE IMPORTANCE OF THE CHEMICAL INDUSTRY TO THE DUTCH ECONOMY. Because of its favourable geographical location, this industry is almost entirely export-oriented.



The future

In the years to come the internationalization of the chemical industry can be expected to continue. After successive periods of intensified *interlinking and market concentration* (within the Dutch chemical industry between 1880 and 1914, within the Western European chemical industry between 1924 and 1929 and within the American-European chemical industry in the sixties), co-operation will now become really worldwide (Europe, USA, the Far East and the Middle East). How this will affect the world share of Dutch production is not clear, although it is certain that large Dutch concerns such as DSM AKZO, Shell and Unilever will continue to play a large role internationally. The increased financial strength of Dutch companies makes diversification into the high-value fine chemicals industry much more feasible now than it ever was before, whereas the profitability of the bulk chemicals industry continues to depend heavily on the price of its principal feedstock, mineral oil. Finally, biotechnology is another sector with important growth potential for the Netherlands.

Sources

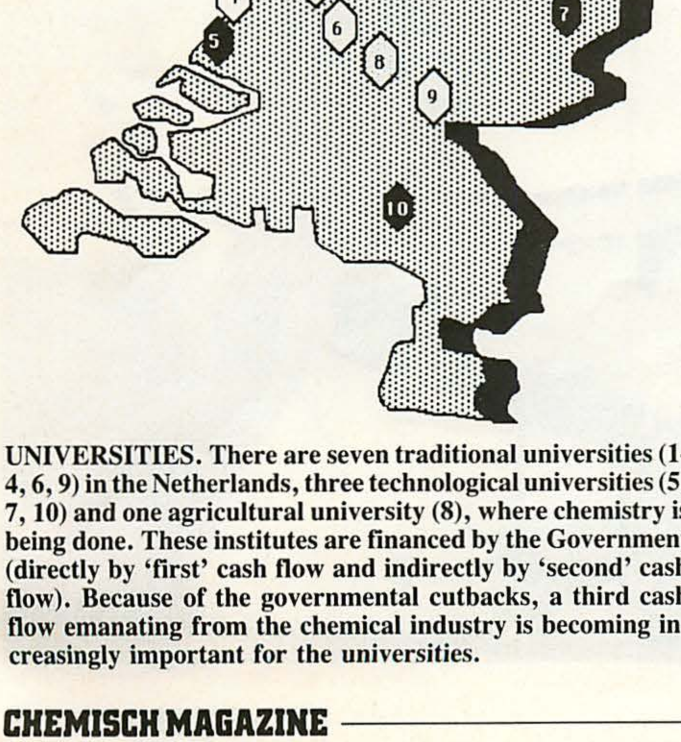
Reference 1
Hutter, J.J. 'Nederlandse Laboratoria 1860-1940: Het Arbeidsveld van Wetenschappers' (Dutch Laboratories 1860-1940: The Scientists' Field of Operations), Tijdsch. Gesch. Gnk. Natuurw. Wisk. Techn. (Journal on the history of Medicine, Natural Science, Mathematics and Technology), 9 (1986).

Further References
Everwijn, J.C.A. (Ed.) 'Beschrijving van Handel en Nijverheid in Nederland' (Description of Trade and Industry in the Netherlands) (3 vols), The Hague, 1912.
Koopmans, H., 'Vijftig Jaar Scheikundige Nijverheid in Nederland' (Fifty Years of Chemical Industry in the Netherlands), Delft, 1967.
Mittmann, D., 'Die chemische Industrie im nordwestlichen Mitteleuropa in ihrem Strukturwandel' (The Chemical Industry in North Western Europe in Terms of its Structural Change), Wiesbaden (1974).

CHEMICAL RESEARCH AT DUTCH UNIVERSITIES: HIGH QUALITY BUT LOW BUDGETS

Chemical research at Netherlands universities is experiencing something of a dilemma; the quality of the research, even by international standards, is good, sometimes very good. In contrast, the budgets for personnel and equipment are much too low to ensure that this quality will continue to be maintained in the future.

Fridus Valkema



UNIVERSITIES. There are seven traditional universities (1-4, 6, 9) in the Netherlands, three technological universities (5, 7, 10) and one agricultural university (8), where chemistry is being done. These institutes are financed by the Government (directly by 'first' cash flow and indirectly by 'second' cash flow). Because of the governmental cutbacks, a third cash flow emanating from the chemical industry is becoming increasingly important for the universities.

Whoever reads the latest report of the *'Accent'* committee (a committee of the KNAW – the Royal Netherlands Academy of Science) on chemical research at the universities will become aware of a remarkable contradiction. On the one hand, the committee is relatively glowing in its praises on research groups which are doing excellent work. On the other hand, it gives voice to its fears that, if funding is not improved, chemistry teaching at the universities will not be able to maintain its usual high standards and that this might lead to the ultimate departure of the chemical industry from our shores. Such a drastic step will probably not be taken, but the committee's words underline the gravity of the situation.

The Accent committee (ACC), the chemistry sub-committee of the above-mentioned KNAW, has to draft proposals for a further division of tasks between the various university chemical research groups. Until now all departments and chemistry subfaculties have tried to cover the whole area of chemistry as comprehensively as possible in their research and education programmes. At least ten years ago, the Netherlands chemical world had already come to the conclusion that a certain degree of *specialization* was desirable at each university. By means of a step-by-step approach involving a series of assessment phases, the ACC, by employing a process of natural selection, tried to create a certain degree of balance between the courses given at the universities.

This approach was, however, rather drastically impeded in the eighties by cuts in government expenditure in the Netherlands. In an attempt to reduce the annually increasing government deficit, the Netherlands Government decided that university education ought also to accept its share of the burden. The consequence has been that there have been severe cutbacks in the number of course places, in the salaries of research students and in investments in new equipment. Without recourse to proper planning or to a well considered line policy, the universities had to economise in whatever way possible. As vacancies arose, it was in many cases no longer possible to fill them, not even when they were for research students for groups involved in important work, the cuts usually following a pro rata pattern.

In this year of 1986, this government policy is a cause for concern as to the future of university chemistry teaching in the Netherlands.

The Accent committee gives the following four reasons for this concern:

1. too few research facilities;
2. too few decision-making prerogatives for crown-appointed tutors;
3. excessively long procedures for the appointment of university personnel;
4. too low a salary level for top-grade research workers.

In the committee's opinion, the remedies are obvious:

1. The general level of advances for the purchase of instruments will have to be raised.
2. Adequate technical facilities and clerical support should be provided to research groups.
3. The standard of university administration must be greatly improved.
4. University salaries should be less mechanically uniform.

PROF. DR. H. van der PLAS, chairman of The Accent Committee, on the one hand, praises researchers, who are doing internationally speaking excellent work, but, on the other hand, gives voice to its fears that, if funding is not improved, chemistry teaching at the universities will not be able to maintain its usual high standards.

Excellent research establishments

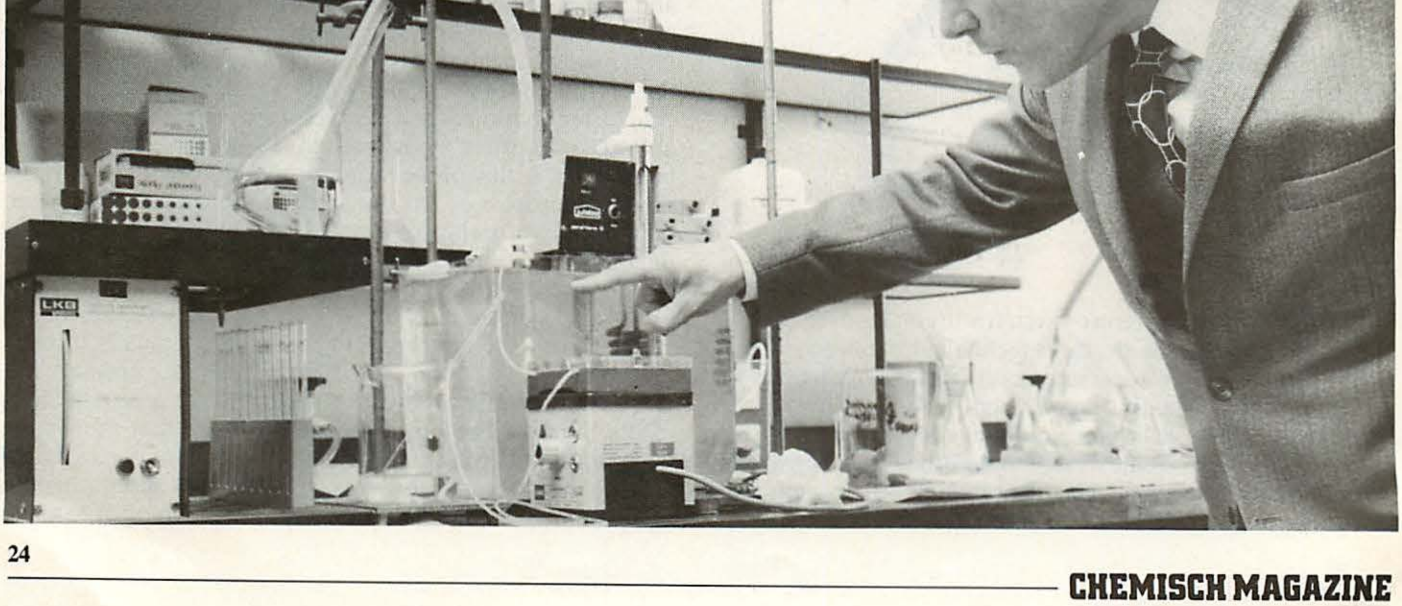
The committee has made what is by Dutch standards a revolutionary proposal for the improvement of the quality of chemical research. The effectiveness of chemical research and the productivity of the research worker must both be raised. In order to achieve this, research establishments specialising in a particular field of chemistry would have to be set up. This would involve using internationally recognised groups as the nuclei of such establishments, which would have to focus their research efforts on basic research and on the renewal of fundamental knowhow.

The research establishments would, furthermore, have to have sufficient scope for independent research and tutors from other universities would have to have the right to spend part of their time there in their own research.

Meanwhile, the Accent committee's report has been quite widely criticised, particularly the *'Michelin star'* assessment. People are afraid that these groups will attract all the attention (and, therefore, all the money) and that other high-quality groups will ultimately go by the board.

Old equipment

As already mentioned, one of the greatest concerns relates to the equipment situation in university chemistry education and research. The Amsterdam professor of inorganic chemistry, Prof. K. Vrieze, referred to it at the KNCV summer conference in 1984 as an 'intolerable situation'. On that occasion his calculations showed that expenditure on chemical equipment and accessories had scarcely risen at all between 1973 and 1983. In that period, however, inflation



PROF. K. VRIEZE (University of Amsterdam) warned at the KNCV summer conference in 1984 about the equipment situation in university chemistry education and research. 'The ease with which universities have reduced their budgets is indicative of their obsolete conception of chemistry as still being at the bunsen burner and test tube stage.'

MINISTER DEETMAN of Education and Science maintains that universities must set their own priorities if they want to have extra money for equipment. This means economising in personnel and using the extra resources for the purchase of equipment.

made everything twice as expensive. The situation is, therefore, intolerable, in Vrieze's opinion, because it is virtually impossible to replace largely obsolete energy-intensive equipment. In Vrieze's words: 'The ease with which university establishments have reduced their budgets is indicative of their obsolete conception of chemistry as still being at the bunsen burner and test tube stage'.

Minister Deetman, the Minister of Education and Science, has so far offered chemists little comfort. He maintains that universities must set their own priorities if they want to have extra money for equipment. His point of view boils down to the fact that general and technical universities will have to economise still further on personnel and then use the resulting extra resources for the purchase of instruments.

In view of the above, it is remarkable that the Minister can still see his way clear to allocating extra money for para-university research. Most of this research is conducted in natural physical and a few biological research establishments. In 1985 the Minister allocated ten million guilders extra for this research, an amount that will increase to f 30 million in 1990.

Chemistry in the Netherlands has no para-university research establishments and, therefore, is not eligible for this extra money.

Nor is the *Chemical Research Foundation* in the Netherlands (SON), a *'second cash-flow'* organization, any particular source of comfort to the chemist. SON's investment budget for 1986 has been set at 1.8 million guilders, 100 000 guilders lower than in 1985 (SON's total budget is about 20 million guilders per annum). In 1986 SON received 15 million guilders worth of applications for investment subsidies.

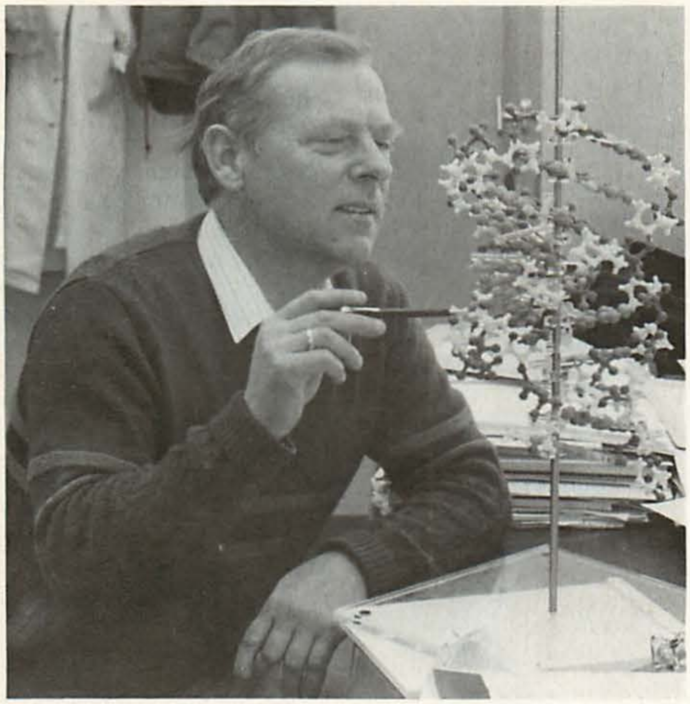
This spring a combined ACC and SON commission investigated this situation. The investigation comprised a quantitative inventorisation of current problems and desired development trends for the next five years. Although the results are not yet known, preliminary conclusions indicate an arrears in new instruments of tens of millions of guilders.

Rays of Light

Netherlands university chemical groups, therefore, present a sombre overall picture, although there are some rays of light owing particularly to the efforts of the Ministry of Economic Affairs, the chemical industry and the TNO.

Unlike the Ministry of Education, the Ministry of Economic Affairs is clearly fully aware of the importance of high-quality university education and research and, consequently, of high-quality graduates.

In order to understand the background of the current Economics Affairs policy, let us return for a moment to 1979. In that year the then Cabinet presented an *Innovation Paper* containing proposals for the development of promising fields such as those of biotechnology and information technology. As a result of this paper, a committee led by Shell's former top man, Gerrit Wagner, embarked on the task of advising on the industrial policy to be followed by the Government. The committee came up with a list of promis-



PROF. J.H. VAN BOOM: 'Support from Economic Affairs usually means co-operation with one or more industries and this curtails freedom to do fundamental research work.'

ing fields offering new opportunities for the Netherlands industry. This finally resulted in a number of promising product/market combinations for Netherlands industry. However, these new fields often crossed the boundaries between different areas of expertise.

It is perhaps best to cite a concrete example. DSM spent a number of years looking for possible ways of manufacturing fine chemicals using micro-organisms. One of the options was the manufacture of hydroxylated aromatics using the fungus *Aspergillis Niger.* It seemed a promising field but DSM lacked the necessary knowhow, nor did they themselves have the facilities for generating it. Both the Agricultural University of Wageningen and the TNO, on the other hand, did have the specific knowhow on Aspergillis systems needed by DSM, so that the latter approached Economic Affairs with a research proposal, which on this occasion has been adopted, Economics Affairs paying up to 45% of the research costs. At the same time the university, in this case the Agricultural University of Wageningen, and the TNO are being provided with an opportunity to develop an idea originating within industry and, in so doing, are being allowed to appropriate a useful piece of fundamental data. The company, for its part, is obtaining a better perspective of the idea's potential.

Within the general framework of the *'Innovation-Oriented Research'* Programmes (IOP), a number of such projects have meanwhile developed, smaller and medium-sized companies also being involved.

A condition insisted on by Economics Affairs is that the universities and the other establishments also pay a substantial part of the research costs themselves.

An important IOP for the chemical industry is that covering biotechnology; other IOPs of equal relevance to the industry cover membranes, polymers and their composites, carbohydrates, technical ceramics and trial projects involving catalysis and paint. These IOPs have a maximum duration of eight years.

The examples given below serve to illustrate the amount of money being pumped into research by Economic Affairs:

Target Area	Guilders
Biotechnology	50 million until 1990
Membranes	25 million until 1992
Polymers and Composites	12 million until 1988
Carbohydrates	12 million until 1992 + 4 million from the Ministry of Agriculture and Fisheries.
Technical Ceramics	29 million until 1992
Catalysis	2 million
Paint	2 million

These programmes have given university chemical research a considerable boost over the last two years, although the actual selection of the fields to be covered has often been a bone of contention, since the relevant establishment must guarantee for a certain period of years that it is prepared to invest to a commensurate extent in the research being supported by Economic Affairs.

For many university chemists this support is a welcome boost to depleted budgets. Others, such as the Leiden organic chemist, Van Boom, consider it an *encroachment on university freedom.* Support from Economic Affairs usually means co-operating with one or more industries and this, in van Boom's opinion, curtails his freedom to do fundamental research work. Economic Affairs' reply to this is: *'You don't have to join in if you don't want to'.*

In any case, the result is that the Ministry of Economic Affairs' hold on the general and technical universities is being strengthened at the expense of that of the Ministry of Education and Science. Needless to say, other ministeries, such as those of Health, Town and Country Planning and the Environment, also support university chemical research, although to a lesser degree than Economic Affairs.

Third Cash Flow

The drive to create *communication networks* between industry, universities and other research establishments etc. has had another effect. Unlike five years ago, university chemists are now much more ready to carry out research projects in co-operation with industry, either in the form of *contact research* in which industry contacts a research establishment for advice or in the form of *contract research* in which an industry contracts to pay one or more research workers. The consequence of this has been that the cash flow from industry to the universities is larger than a few years ago. In view of the great importance of the chemical industry in the Netherlands and of the research which the multinationals in the Netherlands are performing, chemical research is benefiting particularly from this 'third cash flow'.

University chemists have consequently obtained more insight into the *commercial potential of their discoveries* and more and more chemists are examining the possibilities of commercialising some of their research results. It is, therefore, sometimes possible to earn extra money from their research by way of the royalties specified in licensing contracts. Needless to say, much has still to be done to heighten the commercial awareness not only of universities but also of research workers in the Netherlands. A survey carried out by the Licentec Foundation at the beginning of 1986 indicates that the universities usually have no expertise in this sector, the researcher who wishes to commercialise some of his research results often has to find his own way to the most eligible companies and then has to conduct his own negotiations with them. This means that the researcher rarely derives the maximum benefit from his work. The Netherlands universities are still virtually giving their knowhow away, in the opinion of Dr. F.A. de Jonge, Director of the Licentec Foundation (the Foundation mediates between university research workers and industry and, in addition, advises the Government and industries on the transfer of knowhow).

The TNO (the Netherlands Organization for Applied Scientific Research) is also increasingly seeking forms of cooperation with general universities and technical universities. The TNO encourages its employees to become supernumerary professors and is prepared to support graduate research and practical training projects.

To summarise, university chemical research in the Netherlands is experiencing something of a dilemma at present, with severe cuts being imposed by the Ministry of Education, on the one hand, and more money being received from the Ministry of Economic Affairs and the chemical industry, on the other.

It is still unclear what the long-term effect of this process will be on the quality and quantity of chemical research. It is remarkable how enthusiastically many chemists are now cooperating in research projects in which industry is involved. They have in any case already been allowed to come face to face with chemistry in industry in the course of their practical training.

'Chemists have solutions' is one of the mottos of the *American Chemical Society*. This probably also applies to the problems with which university chemistry in the Netherlands is now confronted.

THE LABOUR MARKET FOR CHEMISTS

In the next few years both the supply and the demand aspects of the labour market for academically trained chemists will undergo great changes. As a result of the reduction in the length of the degree courses, several hundred extra chemists will have to be absorbed by the labour market in the years 1986-1989. This extra supply will probably be assimilated without many problems because of increasing industrial demand. Meanwhile, unemployment seems to have stabilised at a level of 500 chemists. The situation for those at the HBO level (senior technicians and senior laboratory personnel) is far less clear. Among those who have completed their HLO (Higher Laboratory School) training the degree of unemployment is relatively high as compared to graduates. However, here too, demand appears to be recovering.

Maarten de Hoog

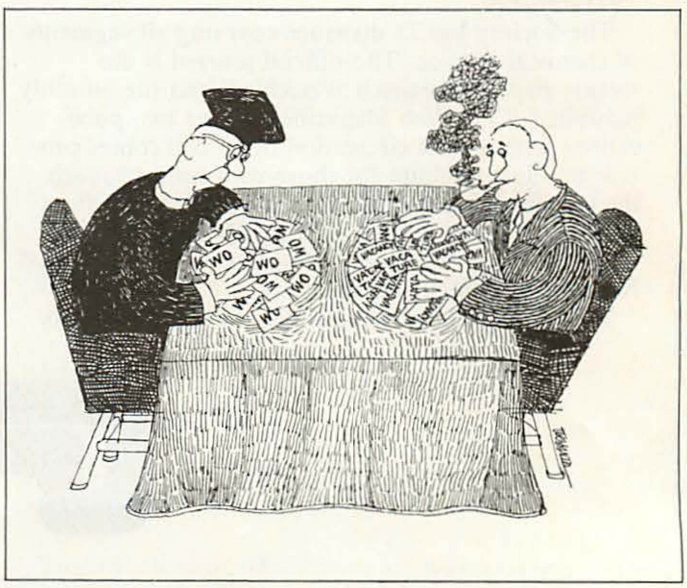
In 1983, approximately 10,750 chemists were employed. Of the 55% of the above employed in industry a little more than half (52%) are employed by the five largest industrial employers of chemists: Philips, AKZO, Unilever, Shell and DSM. These companies, all Dutch in origin, have large research laboratories in the Netherlands and require large numbers of chemists to run them. Owing to this particular set-up, decisions made by these large companies have a far-reaching effect on the whole labour market. Currently, half of the total number of graduate chemists are taken on by these five employers as a whole.

Supply

As at 1st December 1984 2655 students were registered as students of chemistry at the universities proper and 1929 as students of chemical engineering at one or other of the three technological universities. The number of first-year students on 1st December 1985 amounted to 456 for chemistry and 430 for chemical engineering. These figures have remained reasonably constant over the last ten years. There seems to be a tendency for the current great interest in chemical engineering at the expense of chemistry. In the academic year 1983-1984 the number of graduates amounted to 291 for chemistry and 206 for chemical engineering. The Ministry of Education's prediction for the next ten years allows for a slight increase until the year 1988 (a rise to 554 for first-year students of chemistry and 409 for first-year students of chemical engineering) as a result of the constantly increasing interest in university education. From that year onward, however, the ranks of first-year students will thin out, according to the predictions, as a direct result of the current drop in the child population. The serious effect of this drop, which is already being felt at primary and secondary level, will, therefore, also be felt at university level after 1989. The effect at the latter level will, however, be offset to a certain extent by the growth in the numbers of women attending universities.

Over the last ten years the percentage of women students has risen from 10% to 40%. In chemistry this percentage is, however, still far from being reached, although more and more women have been taking up chemistry in the last few years. The percentage of women first-year students in chemistry amounted in 1984 22% and in chemical engineering 13%.

Although it is possible to predict the numbers entering universities with some degree of accuracy, few reliable forecasts can be made as to the numbers leaving, i.e. graduates. A radical re-organisation of university education took place in 1981, one feature of which involved reducing the length of



the degree course from one of 5 or 6 years to one of 4 years. With the first new-style students graduating in June 1986, it is still not clear how many of them will be allowed to continue their studies into the Second Phase. The percentage of those doing so will vary from 30% to 70% in the case of chemistry. The number of those pursuing a continuation course (the Second Phase) will, of course, greatly affect the number of people coming on to the labour market. If the Second Phase is abandoned, an excess of several hundred chemists will have to be absorbed by the labour market. On the other hand, if the Second Phase does get off the ground successfully, the annual numbers will remain unchanged.

Demand

Great changes can also be expected in the next few years on the demand side of the labour market. In the years before 1985 the demand for chemists reached an all-time low as a result of the economic recession. As has already been mentioned, the policy of the five large employers has a great influence on the labour market. In the years 1984-1985 the large companies, especially Philips, AKZO and DSM, decided to expand their research activities, motivated by the economic recovery and a desire to concentrate more on the manufacture of know-how-intensive products. The increased demand of these large companies for graduate labour was, therefore, due partly to a restoration of existing demand and partly to an expansion of scale to cope with the larger amount of research now required to meet the change in product demand.

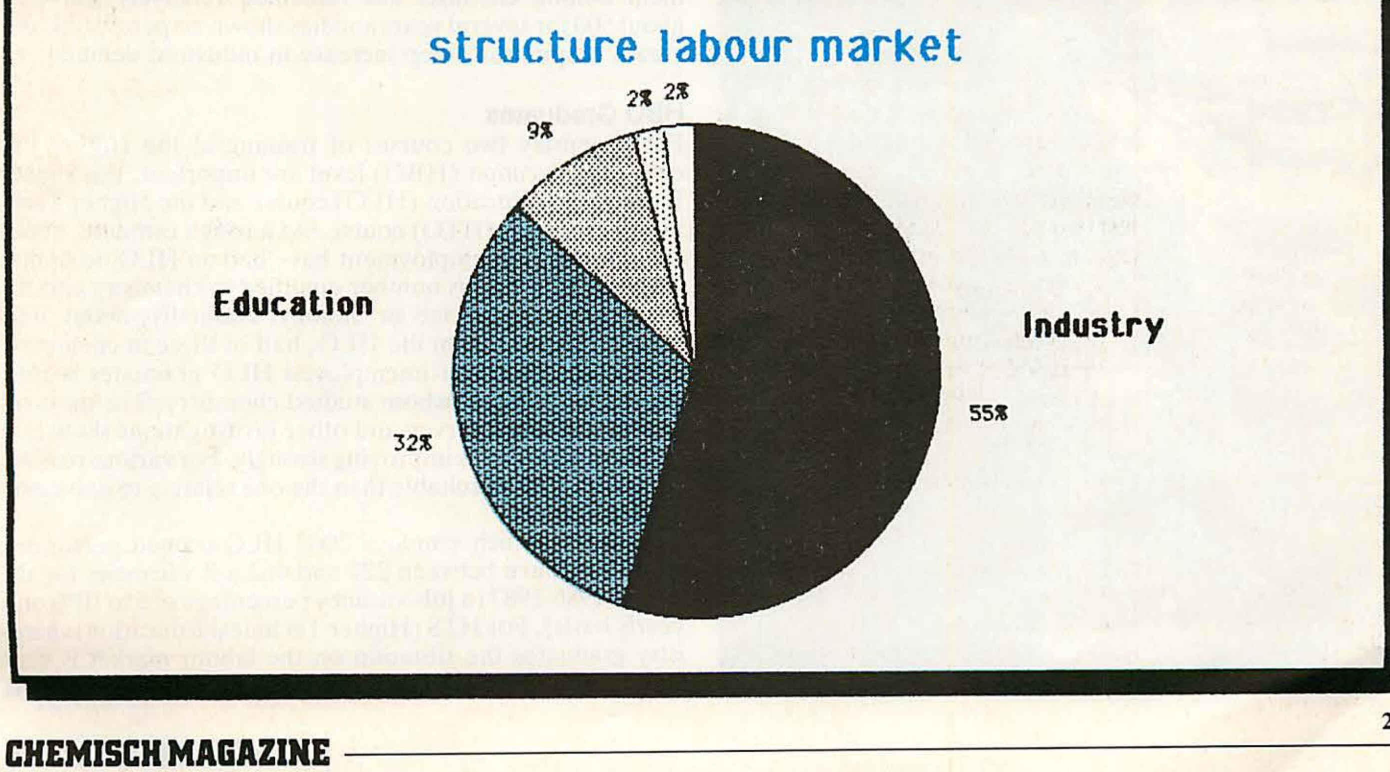
In the years 1986-1987 the 'Big Five' expect to engage a total of between 377 and 570 chemists to join their total complement (as at 1st October 1985) of 2339 chemistry graduates. A large increase in the number of job vacancies is also to be seen in the rest of the industry. Reactions to the last job-vacancy questionnaire were received from 306 industrial employers (including Philips, AKZO, Unilever, Shell and DSM) who employ a total of 3062 chemists between them and who, together, expect to have to fill a total number of between 504 and 877 job vacancies, which represents a vacancy percentage of 8-14%. In spite of the fact that the data supplied in reaction to the questionnaire cover only about 65% of all chemists employed in the industry, the trend still clearly seems to be in the direction of a large rise in the number of job vacancies.

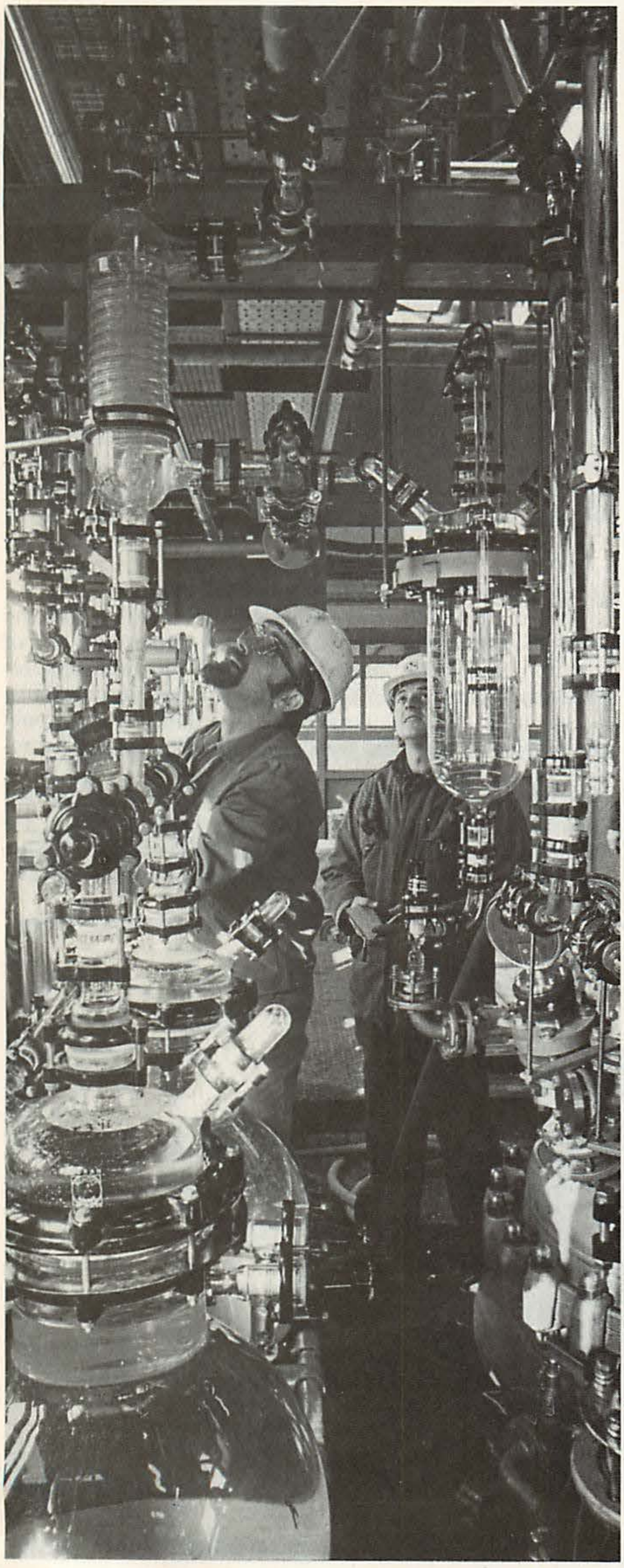
On a stable labour market a job vacancy percentage of 4-4.5% due to natural causes is normal, so that *8-14% represents a large expansion in the number of jobs in the industry*. For chemistry as a whole this replacement percentage means that approximately 400-600 graduates are required to fill the job vacancies. The number of graduates in the last few years has, therefore, been sufficient to satisfy the demand for replacements. In order to determine whether this job explosion will lead to a shortage of chemists, the situation in the other non-industrial sectors employing chemists, together with the existing labour pool, will now be reviewed.

Job vacancies in the Non-industrial Sectors

The situation in the non-industrial sectors seems to be the opposite of that existing in industry. There is no question of growth here and staff are replaced to only a limited extent. An estimated total of 1500 chemists are employed in university teaching. As a result of cutbacks in education, the only places available are for temporary assistants, who are re-

THE LABOUR MARKET for Chemists. Most chemists are employed in industry. A quarter of all Dutch chemists are employed by one of the five largest chemical companies. Nine percent is employed by governmental institutes, 2% by work in hospitals and 2% in area's other.





THE INCREASED DEMAND of the large companies for graduate labour is partly due to their expanded research activities. 306 industrial employers employing a total of 3062 chemists, expect to have to fill a total number of between 504 and 877 job vacancies.

placed every four years. The assistants in permanent service, most of whom were engaged in the period 1960-1975, are, therefore, relatively young, so that relatively few vacancies arise as a result of the reaching of the normal retirement age. On account of the uncertainties surrounding the continuation courses and the number of postgraduate places available, it is not possible to state how many vacancies will occur.

In secondary education also, a sector in which a total number of 1350 chemistry graduates are employed as teachers, no further expansion in the number of jobs is expected. It is more likely to be a question of a decrease, owing to the drop in the child population.

Approximately 450 chemists teach at *Higher Vocational Schools*. This includes 25 Laboratory Schools, Higher Technological Schools, Higher Agricultural Schools, Teachers Training Colleges etc. 42 schools employing a total of 256 chemists replied to a job-vacancy questionnaire and forecast a total number of job vacancies varying from 1 to 15. Reorganisation currently taking place in this sector should lead to the creation of fewer schools for a higher average number of pupils but probably a lower number of teachers.

In the remaining sectors of the labour market, including public services, hospitals, engineering bureaux etc. (totalling 13% of the total number of chemists employed), the pattern is constantly changing, with many people being taken on in one sector while many are being dismissed in other sectors.

As already mentioned, the general level of unemployment among chemists has remained relatively stable at about 500 for several years and has shown no perceptible decrease despite the steep increase in industrial demand.

HBO Graduates

For chemistry two courses of training at the *Higher Vocational Education* (HBO) level are important, the Higher Laboratory Education (HLO) course and the Higher Technical Education (HTO) course. At a rough estimate, about 20,000 people in employment have had an HLO or similar training. Half of this number qualified in chemistry and the other half in medicine or biology. Annually, about 1000 people graduate from the HLO, half of these in chemistry. The total number of unemployed HLO graduates is 1661 (May 1985), 703 of whom studied chemistry. The most recent job-vacancy survey and other investigations show that the labour market is improving strongly. For various reasons this picture is less reliable than the one relating to university graduates.

Industry, which employs 2062 HLO-trained personnel, expects to have between 221 and 462 job vacancies for the period 1986-1987 (a job-vacancy percentage of 5 to 10% on a yearly basis). For HTS (Higher Technical Education) chemistry graduates the situation on the labour market is very favourable. The size of the group is estimated to be 4200. As compared with the existing number of 1961 HTS chemistry graduates employed in industry, the number of job vacancies is expected to be between 511 and 816 (13–21% job vacancies on a yearly basis).

Future

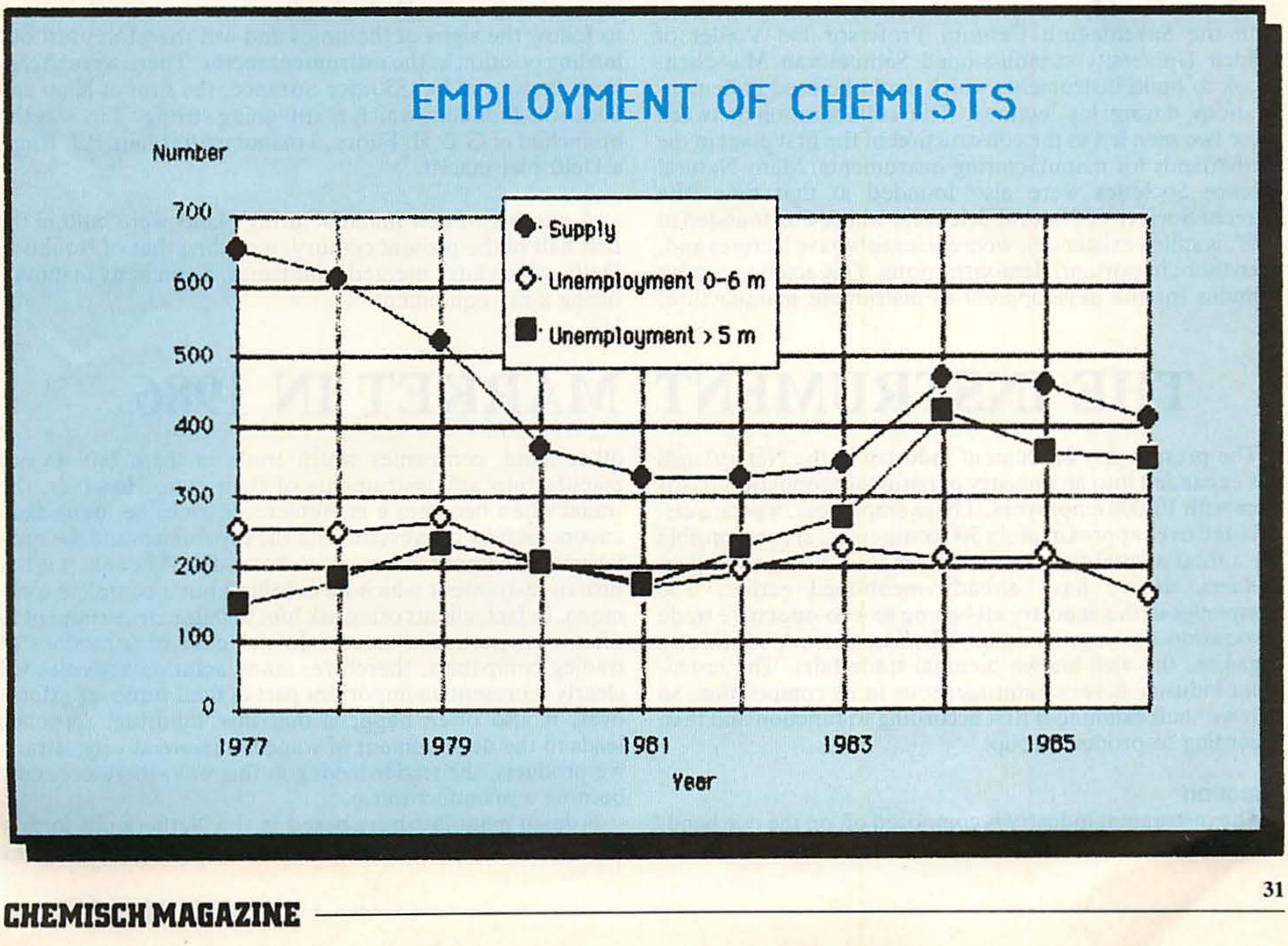
If we now lump all predictions together, the following picture seems to emerge. In the next few years industrial demand will be very strong but in later years, when the large companies have completed their recovery programmes, the number of job vacancies can be expected to fall again. My personal expectation is that the percentage of job vacancies in the larger companies will be about 6% in 1988, thus reflecting a slight annual increase in research. In small and medium-sized companies I expect to see an increase in the number of job vacancies in the near future as a result of the increased introduction of (government-sponsored) technology. The time will come when the government will be able to make no further cuts in university education and research. Chemistry seems to be one of the sectors in which growth is essential and there is expected to be no shortage of chemists in the next few years.

EMPLOYMENT OF CHEMISTS and chemical engineers. An increase in industrial demand is responsible for the decrease in unemployed chemists.

Employment Market Survey

The *Royal Dutch Chemical Association* (KNCV) has been studying the chemical labour market for almost twenty years and a separate market survey commission (Commissie Arbeidsmarkt Chemici) has been working in this field for the last ten years. The use of a vacancy questionnaire has proved invaluable during this survey. This questionnaire is sent every two years to all employers of chemists of whose companies the KNCV has a record. This survey was held for the ninth time in 1985 and its results are being published in the summer of 1986. Only a few of these results were known at the time of writing this article. The figures and predictions reported are, therefore, of a temporary nature and the author accepts complete responsibility for their interpretation.

The vacancy questionnaire included questions about numbers of chemists employed, numbers of newly engaged employees and estimates of the expected maximum and minimum numbers of job vacancies. By holding an identical survey every two years it has been possible to create a reliable and universally applicable method for predicting the number of job vacancies in the Netherlands.



INSTRUMENTS IN THE NETHERLANDS

'The Dutch are the Chinese of the West' is a well-known and oft-heard expression describing our reputation as traders. Trading also plays a prominent role in the Dutch instrument world. Approximately 10,000 people now work in this sector of industry in the Netherlands, being employed by 500 companies which together are responsible for a total turnover of more than four thousand million guilders.

Ed de Jong

In the Sixteenth Century scientists often made their own measuring instruments. Many important practitioners of the Natural Sciences were then living in the Netherlands, so that even at that early stage excellent instruments were being manufactured in our country. Antoni van Leeuwenhoek made microscopes of a quality unsurpassed in his time. The mathematician, astronomer and physicist, Christiaan Huygens, even cut the lenses for his own telescopes. In fact, Galileo made his famous discoveries with a '*Dutch Telescope*' constructed by Lippershy, the Dutch optician.

In the Seventeenth Century Professor De Volder of Leiden University commissioned Samuel van Musschenbroek to build instruments which could be used in demonstrations during his lectures. The collaboration between these two men led to the construction of the first plant in the Netherlands for manufacturing instruments. Many Natural Science Societies were also founded at that time (the Utrecht Society of Natural Sciences, which was founded in 1777, is still in existence), where scientists gave lectures and, even more important, demonstrations. This acted as a great stimulus for the development of instrument manufacture, Leiden expanding to become the undisputed world centre of the instrument manufacturing industry.

The advent of the Industrial Revolution served only to heighten the need for analytical instruments and this certainly could have been the launching pad for an extensive instrument industry in the Netherlands, particularly as this was the home of such prominent scientists as Buys Ballot, Donders, Kamerlingh Onnes, Van 't Hoff, Röntgen, Van der Waals and Zeeman. However, unlike Germany and Switzerland, in the Netherlands we were not quick enough to follow the signs of the times and we, therefore, lost our leading position in the instrument sector. There were exceptions, however. In 1830, for instance, the firm of Kipp and Sons was founded, which is still going strong. This was the brainchild of G.B.H. Filbry, a manufacturer, and P.J. Kipp, a Delft pharmacist.

A number of new manufacturing plants were built in the first half of the present century, including that of Nonius in Delft, which later merged with Enraf, a company manufacturing x-ray equipment.

THE INSTRUMENT MARKET IN 1986

The present-day instrument industry in the Netherlands has expanded into an industry of national economic importance with 10 000 employees. These employees, who are distributed over approximately 500 companies, are responsible for a total annual turnover of about *four thousand million guilders,* as we have already mentioned earlier. The companies in this industry all belong to a co-operative trade association bearing the name '*Het Instrument*', which also organises the well-known biennial trade fairs. The instrument industry is very heterogeneous in its composition, so that we shall examine it first according to function and then according to product group.

Function

The instrument industry is composed of, on the one hand, companies which manufacture instruments and, on the other hand, companies which trade in them but do not manufacture any instruments of their own. However, the trader often becomes a manufacturer, since he, more than anyone, is fully conversant with the capabilities and the limitations of the products in which he trades. After all, it is not just an instrument which he is selling but a complete technique. In fact, clients often ask him to tailor an instrument to their own particular needs. In the case of a number of trading companies, therefore, manufacturing activities wil clearly represent an important part of their turnover. Moreover, it also often happens that this 'tailoring' approach leads to the development of some commercial very attractive products, the trader having in this way, therefore, now become a manufacturer.

Foreign manufacturers based in the Netherlands form a separate group. Since their function is purely that of sales companies, they are classed as trading companies for the purpose of the present article.

Product Groups

We shall now examine the Netherlands instruments industry in terms of the products which they manufacture. For this purpose it will be convenient to use the grouping employed by 'Het Instrument', which had divided the industry into the following sectors:

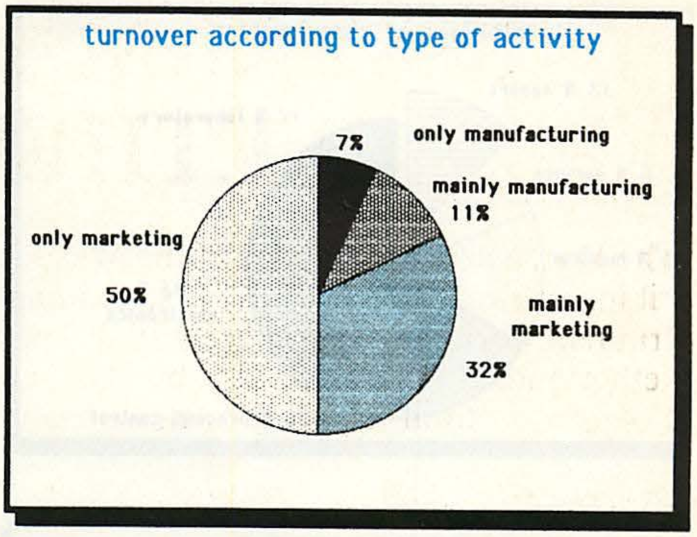
1. *Laboratory Sector*: Companies supplying instruments and accessories for chemical analysis, medico-biological investigations and scientific and technological research. This includes reagents, glassware and laboratory equipment.
2. *Electronics Sector*: Companies supplying instruments for measuring and analysing electrical phenomena and capacities. This includes instruments for the electrical, telecommunications and data-processing industries.
3. *Process Control Sector*: Companies supplying instruments for regulating and controlling chiefly industrial manufacturing processes, including their automation.
4. *Medical Sector*: Companies supplying instruments used in the examination of patients and also for surgical and therapeutical purposes. On the other hand, the apparatus used in medical laboratories is classed as belonging to Sector 1.

It shoud be noted that Sectors 2 and 3, if combined, account for 57% of the total turnover, while the turnover figures for Sections 1 and 4 are very similar at 20% and 17% respectively. However, if we examine the turnover only of the manufacturing companies, we obtain a completely different picture, process control instruments now representing the largest percentage of the turnover, with the medical sector now also enjoying a very large share.

Another part of the total turnover is derived from the provision of *service*, which plays a very important role in the marketing of instruments in the Netherlands. The client expects the supplier to provide not only information and advice but also good installation work and after-sales service. Comprehensive service agreements are often drawn up to cover preventive maintenance and any running repairs. The income earned in this way already amounts to 6% of the total turnover of the instrument industry.

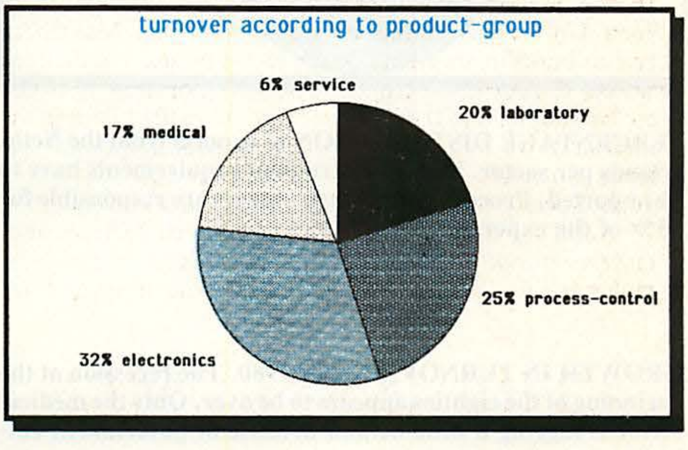
Sources of supply

Although the Netherlands instrument industry can by no means be termed insignificant, 80% of the Netherlands total instrument requirements have to be imported from abroad. A close study of the sources of these imports reveals that a good 60% of them come from other countries in Europe. A surprising fact is that Germany has now lost its position as the leading supplier, imports from this source having dropped in the periode 1980-1985 from 44% to 24%. 20% of our imports come from Britain, while France, Switzerland and Scandinavia each provide about 6%, Italy bringing up the rear with only 2%. The USA's share has greatly increased in the last few years and now amounts to about 32%. Imports from Japan are, of course, slowly but surely beginning to creep up and are now 3%. Close scrutiny of exports of instruments of Netherlands manufacture reveals that process control instruments account for good 45% of the total.



TRADING plays an important role in the Netherlands instruments industry. Being called the Chinese of the West, more then 50% of the turnover is gained in marketing.

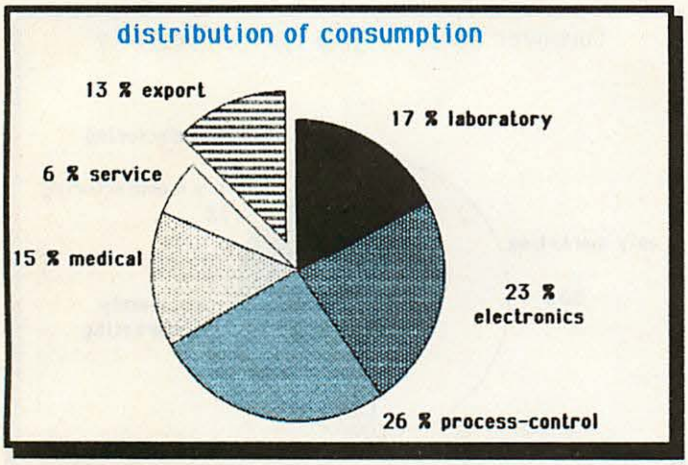
TURNOVER according to product group. The electronics and process control sectors account for 57% of this. If the manufacturing companies are considered alone, process control represents the largest sector.

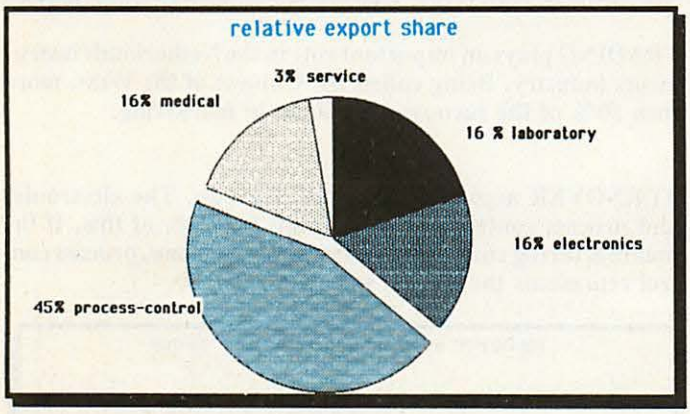


Developments in Turnover since 1980

In 1981 the co-operative trade association 'Het Instrument' conducted a survey of the instrument industry and it was from this survey that the data for this article were obtained. During this survey members of the association were asked about their turnover prospects. The average opinion throughout the various sectors was that an actual increase in turnover of 11.6% per year was attainable in spite of the prospect of a depression then already apparent. Although the next survey will not be completed until some time in 1986, we can already obtain an idea of current trends in the instrument industry on the basis of the turnover figures for the years 1981-1985.

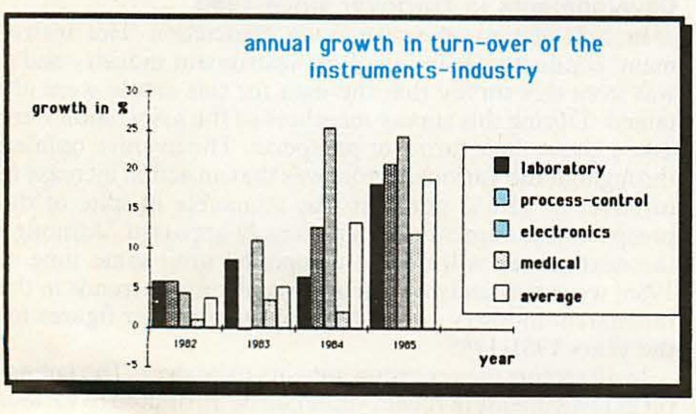
In all sectors the recession appears to be over. The failing-off in investments in recent years can be attributed to various





PERCENTAGE DISTRIBUTION of exports from the Netherlands per sector. 80% of instrument requirements have to be imported. Process control instruments are responsible for 45% of the exports.

GROWTH IN TURNOVER since 1980. The recession at the beginning of the eighties appears to be over. Only the medical sector is lagging a little behind because of government cutbacks.



factors, one of which is the cautious attitude of employers, who are inclined to wait and see how permanent the recovery is going to be, while striving to improve profits on the short term and to putt off to the longer term any idea of expanding sales. Furthermore, the instrument industry appears to be in a transitional phase, investment programmes in many cases being still several years away from fruition.

The laboratory sector attributes its increasing turnover mainly to the stricter requirements imposed by government inspection authorities for soil investigation, biotechnology and laboratory automation. This sector depends to a great extent on research and will, therefore, benefit from the recovery in company profit margins but will, at the same time, suffer setbacks as a result of the restructuring of companies in the medical and public service sectors.

The electronics industry is flourishing as a consequence of the increasing importance of data communications and microcomputers. It is expanding rapidly as a result of the proliferation of new fields of application and its continuing appeal to users.

Companies in the process control sector are faced with increased investment commitments as a result of the stricter legislation governing waste disposal or the environment in general; the increase in automation and the introduction of stricter requirements in the food and luxury goods industry also entail larger investments.

The development of the medical sector is lagging behind that of the other sectors, mainly because of government cutbacks in the health sector.

Nevertheless, morale is high because automation is on the increase and new instruments are being developed.

Present and future trends

The Netherlands instrument industry has been completely restored to health after a few difficult years. The total turnover of more than four thousand million guilders will increase at an annual growth percentage of approximately 18%. Against our country's high import quota can be set the extremely important role played by manufacturing. Many promising small companies are currently starting up as a result mainly of the joint efforts of large companies and the universities but also to some extent because of the advent of the *'Science Parks'*. Important stimuli continue to be provided, firstly, by *environmental needs* and, secondly, by developments in *biotechnology*. The first arises out of the increased importance attached to ensuring acceptable standards for the quality of life and the second is due to the very rapid development of a large number of new technologies at the interface between biochemistry and bioprocessing.

There are a number of major Netherlands companies in the fermentation industry. However, biotechnology in the Netherlands is also making great strides in the food and luxury goods industry, the genetic refinement of agricultural and horticultural crops, medical diagnostics and biological waste processing and water purification.

SOURCES
1. Instrument Sector Report, 'Het Instrument', 26/5/81
2. Jubilee edition to markt the occasion of the 25th anniversary of the founding of 'Het Instrument', 6/4/81
3. Lecture given by Dr. A. van der Zwan, 30/9/85
4. Survey of Trends, 'Het Instrument', November 1985

THINK GLOBAL: ACT LOCAL

The fact that a successful company can be built up in the Netherlands has been proved by *Chrompack*. This company was set up in 1969 by Kees Boodt, who was then an employee of Dow Chemical Nederland. From the very beginning, Chrompack specialised in the manufacturing and marketing of supplies for *chromatography*. Although they initially started with the production of packed columns for gas chromatography, their activities expanded very rapidly. In 1972 they started the resale of accessories for use in chromatography and then set up their own manufacturing plant. In this way Chrompack rapidly built up a reputation as a manufacturer and supplier of high-grade chromatography supplies to whom people could also turn for advice on specific applications.

In 1974 they began to manufacture HPLC columns. Half a million guilders were also invested in the development of apparatus for drawing fused-silica columns on site. Hence Chrompack built up a cast-iron reputation by concentrating their efforts on manufacturing and innovative activities in a specialized field.

Chrompack devotes a great deal of attention to the export market. Of their 180 employees, 120 work in the Netherlands, the rest being distributed throughout the company's branches in Belgium, France, Canada, Britain, Germany, Italy and the USA. Chrompack considers it important that local branches should be left free to work in their own way and that the head office in the Netherlands should restrict its own role to one of simply indicating in broad outline the sales policy to be followed.

As university courses were insufficiently geared to practice, Chrompack throughout Europe have very successfully organised training courses in gas and liquid chromatography.

Since 1983 they have also applied themselves to the development of peripheral apparatus such as auto-injectors, column-switching systems and hydrogen protection systems.

The development of new products still has top priority, 15% of the turnover being invested in R & D. The research laboratory occupies 30% of the total area of the company's premises and 20% of all personnel are engaged in R & D work! New products are, therefore, on the way and it is certain that the current turnover of 28 million guilders will increase at the rate of 25% per annum until 1990.

CONSTRUCT LOCAL: SELL GLOBAL

Because of the international character of the company, *Philips Analytical*'s figures deviate somewhat from those presented by 'Het Instrument'. The latter processes only the results of Netherlands sales companies and regards Philips as a trading company. In reality, the situation is different. Philips Analytical is now one of the three largest manufacturers of analytical measuring instruments in the world.

It is a historical fact that Philips started with the manufacture of pH-measuring instruments and, shortly afterwards, x-ray diffraction and x-ray fluorescence measuring instruments, and they are now market leaders in this field. At quite an early stage they began to manufacture electronic microscopes, and analyses of elements and structures still form the two major activities of the Analytical Division. By taking over *Pye-Unicam*, they also acquired know-how in fields such as spectrophotometry and separation techniques. In addition, the American company, *EDAX*, was also recently acquired, together with its energy-dispersing x-ray fluorescence instruments. An OEM contract is also shortly to be drawn up with a well-known ICP company for the supply of sequential spectrometers.

For the Netherlands all this will have an enormous impact on the labour market. Development and production of the element analysis and structure analysis instrument groups will be centred in the Netherlands and provide work for thousands of people. What is more, the Philips National Laboratory is situated in the Netherlands, where fundamental research for the whole of the Philips organisation is carried out. At this laboratory many new analysis techniques are developed to serve their own requirements which can be subsequently marketed by the Analytical Division. Of the instruments manufactured in the Netherlands, 95% are earmarked for export, a situation completely different from that affecting the average instrument company.

THE NETHERLANDS, A FERTILE BREEDING GROUND FOR BIOTECHNOLOGY

Five years ago the Netherlands Government launched an extensive programme to stimulate development work in the biotechnological industry and to create a fertile breeding-ground for innovation, which resulted in an impressive biotechnological infrastructure. A brief review of this programme wil now be given.

Jos van den Broek

In 1981 the Netherlands Government initiated an *Innovation-Oriented Research Programme for Biotechnology* (IOP-B), which was the first of its kind in the Netherlands. The purpose of the IOP-B is to co-ordinate and stimulate all biotechnology-related research with a view to exploiting the commercial potential of new developments. A Planning Commission for Biotechnology (PCB) was appointed to develop and carry out this programme. This Commission is composed of both academic researchers and representatives from industry.

The programme's central aims are as follows:

1. A revaluation of the role of research and development in a productive and competitive industrial environment.
2. The setting of priorities for various research activities which are expected to have a potentially successful application or will fulfil a need.
3. The establishment of a communicating link between the biotechnological industry and researchers at universities or other academic institutions.

The Government contributed 70 million guilders towards the programme for the first five years. This enabled the PCB to stimulate and guide research activities at universities and other academic institutions, to supply funds to innovative enterprises via the Ministry of Economic Affairs and to build up a *biotechnology communications network*.

A Planning Bureau for Biotechnology was set up to co-ordinate the activities of the PCB and a number of separate subcommittees were created to cover a number of different fields of application. Not only industrial companies, universities and research establishments but also government bodies are represented on these subcommittees.

Impetus

The PCB has provided the impetus for developing biotechnology-related research over a wide field. The total number of man-years spent on biotechnological research at universities and research establishments increased from 750 in 1982 to 950 in 1984. In 1985 an additional 250 researchers entered the field as a result of the expansion of biotechnological research and development, two-thirds of whom were university graduates.

About half of all available IOP-B funds are set aside for the financing of contracted research. In such projects the industrial partner, as the body invested with the chief responsibility, indicates the actual research activities to be funded.

Biotechnological research is centred in various research establishments, each focussing on a particular theme within the context of the IOP-B's industry-oriented programme. A brief account will now be given of the most important activities pursued by industry, the universities and other research centres in the field of biotechnology. This account does not, however, claim to be exhaustive.

Universities

The Technological University of Delft and the State University of Leiden, in order to pool their expertise, have jointly set up *the Biotechnology Centre Delft Leiden* (BDL). At this centre, in which both the biosciences and technology have a place, attention is focussed on biochemistry, cell biology, genetics, microbiology and technological disciplines. Priority areas are micro-organisms with an important industrial application, bioprocess- and reactor technology and downstream processing.

A new multidisciplinary centre for medicinal research was recently opened in Leiden, the *Centre for Bio-Pharmaceutical Studies* (BFW). This centre has joined forces with the BDL in the field of plant cells biotechnology.

In Leiden too a *Bio-science Park* has been established as a centre for industrial development and scientific research. Because of its close proximity to the university – both mentally and physically – this Science Park offers potential opportunities for close co-operation between individual companies, the universities and industry. The biotechnological companies, *Centocor, Molecular Genetics and Promega,* have meanwhile established themselves there. Centocor hopes very shortly to start a brand-new plant (representing an investment of 18 million guilders) for the production of monoclonal antibodies in the course of the current year. Meanwhile, building activities at the proposed Mogen site are in full swing. The Leiden authorities are also negotiating with other prospective clients.

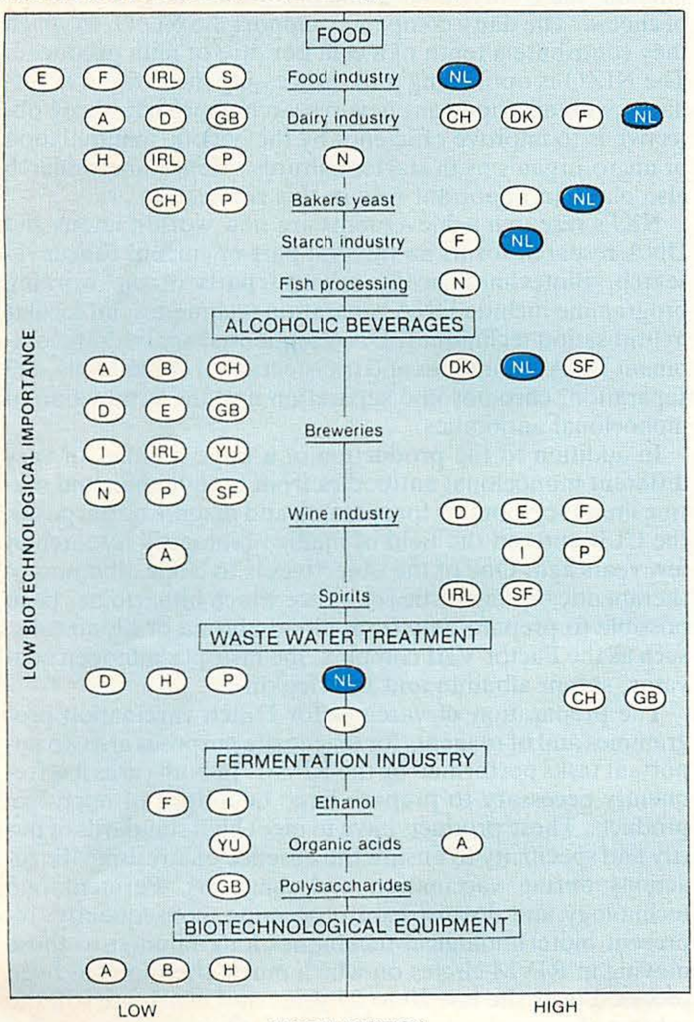
The *University of Groningen* has also set up a biotechnology centre, where research will focus on the chemical and genetic aspects of industrial chemicals, the processing of domestic waste and the dairy industry. Priority projects include the study of micro-organisms of potential interest to industry and enzyme and protein engineering. Here too, as in Leiden, a science park has been established, where industrial companies are able to pursue their development activities in an academic atmosphere.

At the *Agricultural University of Wageningen* many research groups are either directly or indirectly engaged in biotechnological work. Moreover, a special co-ordinator has been enlisted to supervise this work. At Wageningen the main burden of the research is laid on the improvement of cultivation techniques, the needs of the food industry and the treatment of agricultural waste. Priority areas in the industrial field include micro-organisms, enzymology, bioprocessing and reactor technology, downstream cleaning methods and water treatment.

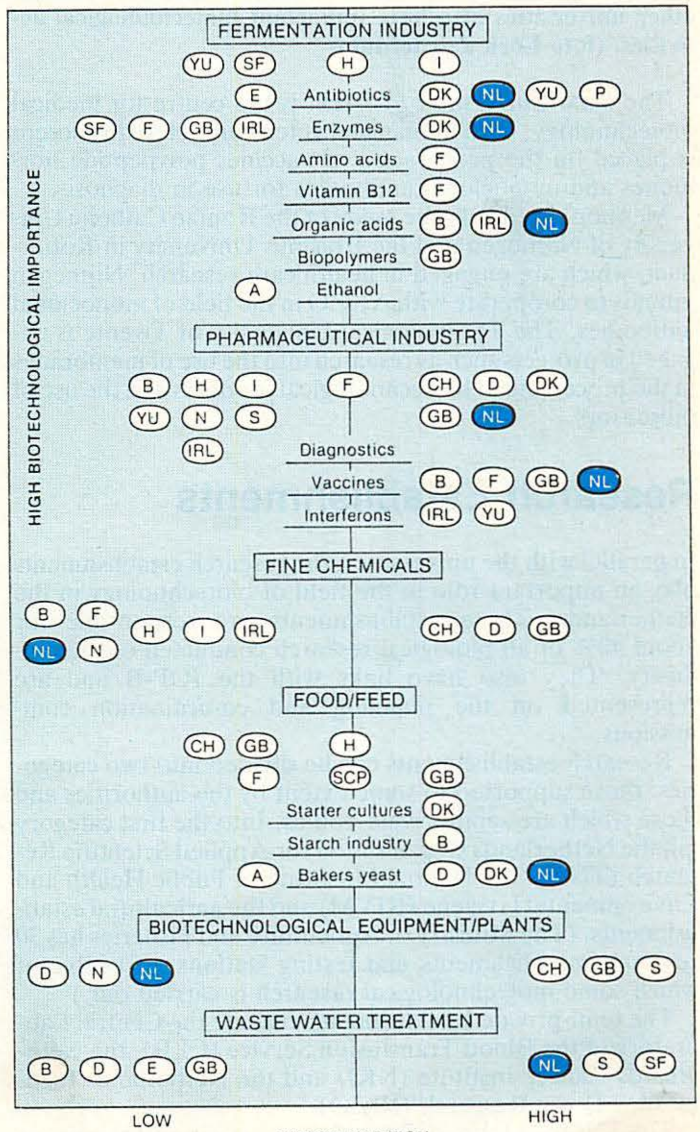
The two universities in Amsterdam have combined forces to establish the *Amsterdam Biotechnology Centre,* which is intended to serve as a microbiological and genetic base for the benefit of the fermentation industry, public health and the environment. The research priorities of this centre will be in the fields of biotransformation techniques, the biotechnology of plant cells, micro-organisms of potential importance to industry, monoclonal antibodies and enzymology. Much work is also being done in co-operation with the Netherlands Cancer Institute.

BIOTECHNOLOGY IN THE NETHERLANDS. Low-tech (left) and high-tech (right) biotechnological export position of the Netherlands within Europe. Strongholds are the fermention, pharmaceutical and food and feeds industries. Source: E.H. Houwink.

Portfolio chart of low-tech. biotechnology in Europe



Portfolio chart of high-tech. biotechnology in Europe



THE BIOSCIENCE PARK near the University of Leiden, where three biotechnological companies, Centocor, Mogen and Promega, have meanwhile established themselves. Most other universities also have important biotechnological activities. (foto Loek Zuyderduin)

The *State University of Utrecht* is the centre for medical biotechnology, both human and veterinary. Here the accent is placed on the preparation of vaccine, polypeptide hormones and monoclonal antibodies for use in diagnosis.

Mention should also be made of the Roman Catholic University of Nijmegen and the Erasmus University in Rotterdam, which are engaged in health care research. Nijmegen intends to co-operate with AKZO in the field of monoclonal antibodies. The Technological University of Twente is engaged in projects such as research into the use of membranes in the processing of biotechnological products and the use of biosensors.

Research Establishments

In parallel with the universities, the research establishments play an important role in the field of biotechnology in the Netherlands. These establishments are responsible for about 40% of all biological research conducted outside industry. They also have links with the IOP-B and are represented on the planning and co-ordination commissions.

Research establishments can be divided into two categories: those supported to some extent by the authorities and those which are semi-private bodies. Into the first category fall the Netherlands Organisation for Applied Scientific Research (TNO), the National Institute of Public Health and Environmental Hygiene (RIVM) and the agricultural establishments. (The Ministry of Agriculture and Fisheries has 30 research establishments and testing stations, at twelve of which some biotechnological research is carried out.)

The semi-private establishments include the Central Laboratory of the Blood Transfusion Service (CLB), the Netherlands Cancer Institute (NKI) and the Netherlands Institute for Dairy Research (NIZO).

The TNO is a large organisation employing 5000 persons in the fields of fundamental and applied research. Although the TNO budget is partly funded by subsidies, 49% of the budgeting needs are covered by revenues earned from research projects commissioned by Government and industry. To ensure that the available manpower is exploited as efficiently as possible, five years ago an interdepartmental biotechnology co-ordination was set up to co-ordinate all research within TNO covering this field; at the same time, it serves to ensure that all programmes drawn up cater sufficiently for the needs of industry (particularly those of medium-sized and small companies).

The biotechnological activities of the TNO have greatly increased in recent years. As compared with 1984, the number of staff engaged in this field of research has risen by 48%, whilst the research budget for biotechnology has grown by 43%. TNO's biotechnological projects cover a large field – from recombinant DNA research on the cells of mammals to research into the breakdown of polysaccharides during the malting process – and are focussed on public health, food industry, fermentation technology and environmental aspects.

The Netherlands dairy industry has traditionally been an intensive one with the emphasis heavily on cheese production, the Netherlands being the world's largest exporter of cheese. The dairy companies support the NIZO, to which they contribute a tenth of a cent per litre of milk produced. The NIZO is optimising milk-processing methods in accordance with an important new research approach whose objective is to improve efficiency by the genetic manipulation of micro-organisms in starter cultures. Membrane research also plays an important role in this connection.

NKI's research achievements are new world-famous and DNA research forms an integral part of current cancer research. Biotechnologically relevant parts of the working programme include DNA separation techniques, molecular hybridisation techniques, DNA sequential analyses, recombinant DNA techniques and transfection of animal cells, cell separation, chromosome separation and the production of monoclonal antibodies.

In addition to the production of a large number of very different monoclonal antibodies from both human and murine immunoglobulins for research and diagnostic purposes, the CLB entered the field of medico-biological research of few years ago. One of the objectives is to clone albumins of therapeutic or diagnostic relevance which hitherto has been possible to prepare only from blood plasma or blood cells, such as the Factor VIII complex, the histoplasminogen activator, serum albumin and Interleukin-2.

The preparation of vaccines for Dutch vaccination programmes and of reagents for diagnostic purposes are two important tasks performed by the RIVM. In both cases it is frequently necessary to prepare large quantities of microbial products. These products have to meet high standards of purity and specificity to ensure the absence of any aspecific reactions during vaccination and diagnosis. Fermentation technology and downstream processing, consequently, represent biotechnological techniques long familiar to those moving in RIVM circles on which much attention has been focussed over the last 20 to 25 years and which are still the subject of current research. The RIVM has, for instance, an eminently effective procedure for breeding animal cells on a large scale in activated systems. Moreover, the RIVM conducts research on peptide vaccines and inactivated vaccines.

The primary function of the *Central Veterinary Institute* (CDI) is to uphold the interests of the Dutch veterinary world. CDI's biotechnological research is focussed on the development of vaccines and the production of monoclonal antibodies. One line of research pursued relates to the production of synthetic peptides for the detection and reconstruction of antigenic determinants.

The 'Schoonoord' Institute of *Animal Husbandry Research* (IVO) develops diagnostic field tests for Third World countries on the basis of monoclonal antibodies; it recently devised a pregnancy test for cows. The Royal Tropical Institute (KIT) also makes many reagents and monoclonal antibodies for diagnostic field tests.

The *Institute for the Application of Atomic Energy in Agriculture* (ITAL) specialises in developing regeneration procedures for various horticultural crops, extending the range of genetic variations and selecting and propagating key characteristics so as to arrive at better (for example, more resistant) agricultural crop varieties. Further projects include research into the production of fine chemicals from plant cell cultures and bio-insectides.

At the *Institute for the Genetic Improvement of Horticultural Crops* (IVT) efforts are being made to adapt recent developments in the field of somatic cell genetics for application in the genetic improvement of horticultural crops. The use of monoclonal antibodies in the detection of viruses, bacteria and hormones in plants is one of the directions which research is taking at the *Institute for Research into Plant Diseases,* another agricultural establishment located in Wageningen. With its agricultural university and its many research establishments and testing stations, this town is the central point for agricultural research in the Netherlands.

Industry

A relatively large number of prominent companies engaged in biotechnological activities are located in the Netherlands. Owning to the limited size of the domestic market, these companies are internationally oriented. The major markets for biotechnology have been extensively developed in the Netherlands, viz. health care, food, agriculture, fine chemicals, the environment and (also constantly increasing) instruments.

Human and Veterinary Health Care

Human and veterinary health care is of a high standard in the Netherlands. Because of the high population density of the Netherlands (in terms of both man and beast), a relatively large and fertile market has been created which is eminently suitable for the introduction of innovations.

AKZO-Pharma is one of the pioneers in the field of diagnostic tests. Organon, AKZO-Pharma's largest operating company, manufactures medicines, oral contraceptives, diagnostic aids and psychopharmaceutical products. Organon was the first to launch an improved form of *pregnancy test* based on monoclonal antibodies. Intervet, another operating company, specialises in the field of veterinary medicines such as vaccines for poultry and hormone preparatives for veterinary use. It produced the first commercial biotechnological product in the world, a *veterinary vaccine against infectious diarrhoea* in pigs and calves. Diosynth, another of AKZO-Pharma's companies, has invested in a major expansion of its fermentation production facilities with a view to obtaining a feedstock for the production of steroids by newly developed microbiological manufacturing routes. Organon Teknika recently acquired the three American companies, General Diagnostics, Nuclear Medical Laboratories and Litton Bionetics. Organon Teknika's latest biotechnological development is *an antibody test for the AIDS virus.*

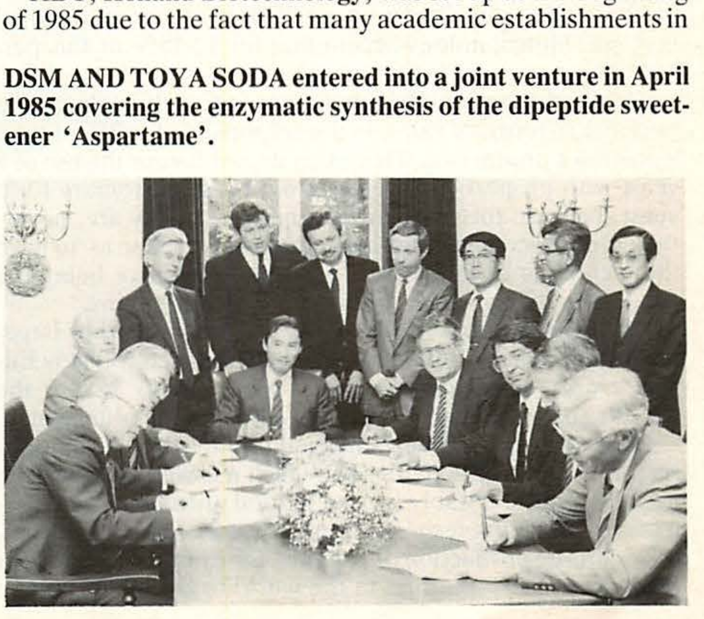
Gist-Brocades operates in such fields as those of veterinary vaccines, antibiotics and steroids. One of Gist-Brocades' most successful research achievements has been the optimisation of *penicillin manufacture.* As a result of improvements in mould formation and process conditions, operating efficiency has been increased threefold to fourfold over a period of fifteen years. The company co-operates with other organisations in many fields. For instance, Gist-Brocades and the Central Laboratory of the Blood Transfusion Service have agreed to work together to establish an economic route for the manufacture of the coagulant, Factor VIII.

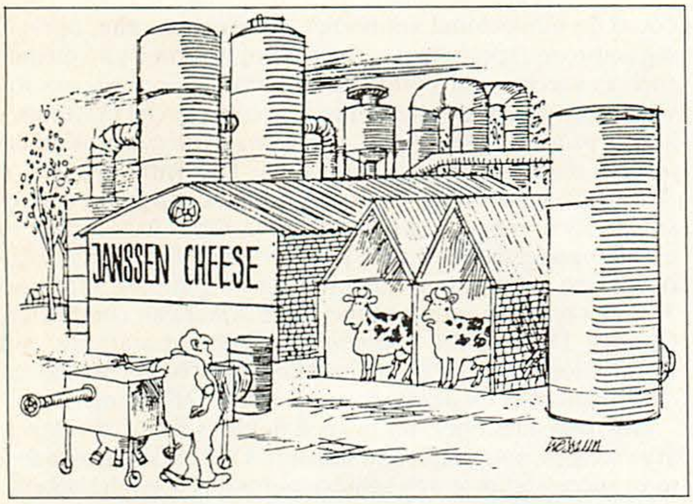
Duphar, one of Solvay's companies, is active in the vaccine field. In co-operation with bodies such as the State University of Utrecht, research is being carried out to develop veterinary vaccines against corona viruses. Duphar is Europe's largest manufacturer of influenza vaccine.

In April 1984 **Promega,** one of the Promega Biotech, USA, group, was launched, the first biotechnological company to come to Leiden. It will shortly move to the BioScience Park but for the time being is operating from hired accommodation on university premises. In the near future Promega will be developing its own products in the Netherlands, *restriction enzymes* in the first instance but also other molecular-biological products at a later stage.

HBT, **Holland Biotechnology,** was set up at the beginning of 1985 due to the fact that many academic establishments in

DSM AND TOYA SODA entered into a joint venture in April 1985 covering the enzymatic synthesis of the dipeptide sweetener 'Aspartame'.





the Netherlands were insufficiently exploiting the commercial potential of their biotechnological research. HBT will in the coming years be engaged in the manufacture and sale of reagents for use in recombinant DNA research and monoclonal antibodies for use in human diagnostics.

Centocor Europe, a member of the American Centocor biotechnology group, will open its new establishment in Leiden's Bio-Science Park towards the middle of this year. The aim is to develop and market biotechnological products for *in vivo medical applications.* Most of the new products will be monoclonal antibodies for routine injection into humans. They will be used in the first instance for in vivo diagnoses of heart and vascular diseases and cancer. Plans for the therapeutic application of monoclonal antibodies are in an advanced stage.

Food and Luxury Goods Industry

Dairy companies, breweries and the other concerns making up this industry in the Netherlands are run on modern lines, have an international name and enjoy a prominent share of the world market in their field. The Netherlands food industry contributes about 25% to the gross national product, biotechnology accounting for 12-15% of this percentage.

The world-famous **Heineken** beer is fourth in the world rankings in terms of sales, being responsible for 7% of total world beer production. Heineken do not favour the use of a yeast with properties differing from those customary for a yeast, because this could affect the taste. They are, nevertheless engaged in recombinant DNA research so as 'to have the technique at their finger tips', the objective being the production of papain to break down the albumins.

Gist-Brocades are very experienced in the field of large-scale fermentation processes. In the food sector Gist is Europe's *top yeast manufacturer.* This company is also the world's second greatest producer of commercial enzymes.

Unilever is also actively engaged in the agricultural foods sector. One of the activities for which it is well known is the use of enzymes, notably *lipases,* in food processing. Furthermore, continuous fermentation processes are being developed, for the production of yoghurt, for example. Unilever's researchers were the first in the world to clone the genetic information for a plant albumin in yeast, namely the sweet-tasting albumin, *thaumatine.* Unilever and Gist-Brocades were jointly successful in reproducing the genetic information for chymosine in yeast, chymosine being an enzyme which is used for the curdling of milk in cheese production. Biotechnology consumes at least 10% (8.5 million guilders) of Unilever's total research programme and employs 70 people.

Naarden International is an independent Dutch company operating in the field of aromatic and flavouring essences and is one of the world's market leaders. This company's biotechnological research and development work is chiefly centred in two fields: firstly, applicational research on industrial enzymes, the formation of special enzyme complexes, the development of new industrial processes in which these enzymes can be employed and the commercialisation of the developed enzymes together with the relevant knowhow; secondly, *microbiological aroma production.* One of the most important fields in which Naarden has performed a great deal of research is the application of enzymes in brewing. An equally important field is that of enzymes for the starch and alcohol industries. This manufacturer of aromatic and flavouring essences has obtained international patent cover for the enzymatic treatment of liquid wheat starch waste.

Agriculture and Horticulture

The drive for increased productivity in agriculture and horticulture, together with the excellent facilities which are available for the practical application of the research achievements of university and other researchers, has led to the creation of a unique innovational environment in these two market sectors in the Netherlands. This environment is essential for the application of new biotechnological break throughs. A biotechnology co-ordination commission appointed by the *National Agricultural Research Council* (NRLO) co-ordinates the agriculture-oriented aspect of the government-initiated Innovation-Oriented Research Programme for Biotechnology (IOP-B).

In vitro techniques to obtain cell cultures for plant cultivation and propagation have developed rapidly over the last fifteen years. Various seed improvement- and other centres apply these methods in the selection of improved and homogeneous plant varieties.

Vanderhave is a leading company, both nationally and internationally, in the genetic improvement, production and sale of agricultural *sowing seeds.* A third of the 550 employees are engaged in research focussed on the development of new varieties of sugar beet, grass, maize, grain, sunflower, onion and brassica, an activity in which biotechnology is playing an ever increasing role.

Nunhems Zaden, a producer of vegetable seeds, is a medium-sized company actively engaged in plant biotechnology research. **Zaadunie,** a company employing 1200 people, develops, produces, processes and sells vegetable and flower seeds and young plants. This seed improvement company has also recently commenced construction of a plant biotechnology laboratory.

Research workers at Unilever's research laboratory in the

United Kingdom have successfully developed methods for the selection and regeneration of homogeneous plant varieties, with a view to the improvement of oil palm plantations in South East Asia.

In January 1985 **Molecular Genetics** signed an agreement to establish a plant biotechnology company in the Netherlands under the name of Mogen International. Mogen has been given a site in the Bio-Science Park in the vicinity of the State University of Leiden. This company is concentrating its efforts on the development of new plant varieties of agricultural interest to Western Europe and the rest of the world.

Multiplan Holding BV, which is in the process of being launched, is one of the companies of the ACF Chemiefarma NV group. This company is engaged in a number of agricultural activities of a biotechnological nature. In the field of tissue culture it is engaged in the cultivation of ornamental plants for the domestic market and tropical plants in the ACF tradition such as quinine, spices and cardamom. *Somaclonal techniques* are also being developed with a view to the genetic improvement of these tropical plants. Multiplan Holding has concluded joint working agreements with American companies intending to establish themselves in the Netherlands.

Environment

The biotechnology of environmental conservation is in an advanced stage of development in the Netherlands. It is a field in which several important innovations also having an impact on the international market have already been developed. Many Netherlands-based companies have succeeded in securing a prominent international position for themselves.

DSM have already for some years been operating the second largest aerobic/anaerobic *waste water treatment* plant in Europe especially designed for the processing of nitrogen compounds. The company recently developed a method for removing urea from waste water, making use of a countercurrent, multi-stage, fluidised-bed enzyme reactor.

Gist-Brocades developed an anaerobic reactor operating according to the fluidised-bed principle. There are plans to erect a total of six reactors at the operating site and to develop post-treatment fluid-bed reactors for nitrification purposes. An important breakthrough in the field of waste water treatment was the development of the *upflow anaerobic sludge blanket* (UASB) reactor, which represented the joint efforts of various universities and the sugar manufacturer CSM. This work was taken over by Gist-Brocades. At least 40 such plants have now been constructed in the Netherlands and elsewhere.

De Ruiter Milieutechnologie has accumulated a vast fund of experience and knowhow in such fields as *soil conservation* (e.g. microbiological soil decontamination) and *air pollution* (e.g.air purification by microbiological means). In co-operation with the IWACO engineering bureau, a land reclamation optimisation study is being carried out on a semi-technical scale on soil contaminated by oil, on the one hand, and phenols, on the other. Bodemsanering Nederland BV, with the co-operation of DSM, is working, as part of a test project in land reclamation, on soils contaminated with such substances as polycyclic aromatics.

Zegwaard, a waste processing company, and the Institute for Storage and Processing of Agricultural Produce (IBVL) some years ago initiated a project for *treating organic waste.* The project was supported by the Netherlands Government and the EEC. The anaerobic two-stage reactor which they developed will be built in the 'Westland', a large market-gardening region, where it will be used to convert rejected vegetables into biogas.

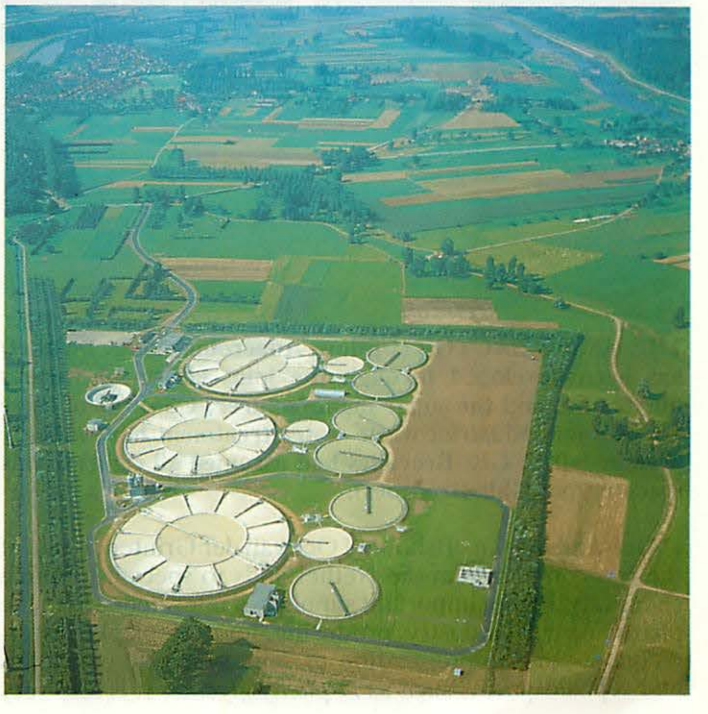
Industrial Chemicals

The Netherlands exports considerable quantities of chemicals, many prominent biotechnological companies contributing to this trade.

AVEBE is Europe's largest manufacturer of potato flour. The company's researchers recently developed a cleaner biotechnological process for the production of fermentation broths. Other biotechnological developments include the enzymatic production of cyclodextrines from starch and the start-up of an anaerobic waste water treatment unit. **Glucona,** a joint venture between AKZO and AVEBE, is the world's largest supplier of *gluconates.* These are the product of enzymatic and fermentative processes with starch as the feedstock. This company was one of the first in Europe to operate enzymatic processes.

CCA Biochem is the world's largest producer of lactic acid and its derivatives by the fermentative route.

AEROBIC/ANAEROBIC WASTE WATER TREATMENT by DSM, especially designed for the processing of nitrogen compounds. Recently a method for removing urea from waste water has been added to this second largest installation in Europe (foto DSM).



THE UASB REACTOR (Upflow, Anaerobic Sludge Blanket) has been developed through the joint efforts of various universities and the sugar manufacturer, CSM. 42 of these UASB's for industrial waste water treatment have already been installed. Gist-Brocades had assumed all rights to this reactor (foto Gids-Brocades).

Océ-Andeno, an offshoot of Océ van der Grinten, is one of the few companies in the Netherlands to specialise in fine chemicals. It is an important supplier of intermediates to the pharmaceutical industry, producing, for example, key intermediates for the preparation of semi-synthetic penicillins and cephalosporins such as *D-phenylglycine.* It is also very actively engaged in research into new methods for the preparation of optically active compounds, particularly enzymatic processes. The commercialization of these processes is expected to be completed within the next three to five years.

DSM is an international industrial concern with its head office in Heerlen. Its most important sphere of operation is in chemistry and its strategic efforts are being increasingly directed towards the development of new, high-value products and the manufacture of knowhow-intensive specialty chemicals. As far as the diversification towards the latter is concerned, biotechnological processing methods are intended to play an important role. In the recent past one of the developments was an enzymatic process for the preparation of optically active amino acids. Using DSM's enzymatic process, a series of *D- and L-amino acids* of high optical purity can be produced on the basis of simple commercially readily accessible feedstocks. For the development of biocatalysts for this purpose DSM are engaged in a long-term joint research project with the Danish company, NOVO.

The production of peptides is another field in which enzymatic processes are becoming increasingly important. DSM and the Japanese company, **Toya Soda,** entered into a joint venture in April 1985 covering the enzymatic synthesis of the dipeptide sweetener *'Aspartam'.* It was recently decided to build an 'Aspartam' plant in the Netherlands and this will come on stream in 1987.

However, DSM is engaged in even more biotechnological projects. For instance, in a joint project with researchers from the Universities of Amsterdam and Wageningen the possibilities are being gauged of halogenating aromatic compounds stereo- and region-specifically by means of enzymes. Work is also been done on the biodegradation of lignin and so on.

Royal Dutch Shell is also interested in micro-organisms. In a microbiology-related study 90 researchers are investigating topics such as the possible use of bacteria in metal extraction, detoxification of spent metal catalysts and enhanced oil extraction.

Instruments

The innovatory approach has benefited the Netherlands' position as a manufacturer of biotechnological instruments. In addition to instruments used in the environmental sector many other types of instrument are also developed by Dutch companies.

Gist-Brocades is actively engaged in the development and construction of reactors in accordance with the fluidised-bed principle which are intended specifically for use in anaerobic waste water treatment. The sugar manufacturer, CSM, developed the upflow anaerobic sludge blanket (USAB) reactor and Gist-Brocades has taken over this development activity.

ClairTech was set up by the Technological University of Eindhoven and two other participants for the purpose of marketing an advanced biofilter, *Bioton.* **Van Tongeren International BV,** which is operating in the same field, manufactures and develops biofilter equipment in which micro-organisms scavenge gaseous waste streams.

Applikon Dependable Instruments have developed a complete range of instruments for use in biotechnological processes: fermenters, on-line analysers, computerised control systems for bioprocesses, biosensors and sterile samplers. **Contact Flow** specialises in the design and construction of fermentation systems which are employed to produce bacteria and cell cultures in the human and veterinary health sector. This company is, furthermore, intensively engaged in the development of computerised control systems for use in bioprocesses. **Bio-Intermediair** is a young company specialising in the production of monoclonal antibodies. For the large-scale production of relatively pure monoclonal antibodies efficient fermentation systems are needed, synthetic media being employed for the breeding process. Bio-Intermediair possesses considerable expertise in this particular area.

The application of *membrane technologies* to biotechnological instruments is expected to lead to a series of breakthroughs. In downstream processing they could possibly prove to be safer and cheaper than classical technologies such as evaporation and crystallisation. The importance which the Netherlands attaches to membrane technology is underlined by the fact that a special Innovation-Oriented Research Programme on the subject (IOP-M) has been set up.

Wafilin specialises in the production of hollow membranes and in the design and construction of membrane filtration units for the food, chemical, environmental and medical sectors. **Membrane Technology Consultants** BV is an advisory engineering bureau in the membrane technology field. It is a small company which is also engaged in research into membrane systems for use in biotechnology.

A small but important aspect of instrument research is that focussed on the development of suitable *biosensors.* Netherlands research establishments, universities and industrial companies are co-operating to an increasing extent in this field, particularly with respect to medical biosensors, a specialised area in which Netherlands research is playing a leading role. Both **Honeywell Medical Electronics** and **Sentron** (a joint venture between Cordis Europa NV and NOM) are actively involved in medically oriented research into the subject of biosensors.

Fertile Breeding Ground

In the last few years the number of biotechnological projects has increased enormously in the Netherlands as far as the research establishments and universities, on the hand, and industry, on the other, are concerned. By setting up a Planning Commission for Biotechnology the Netherlands Government has actively contributed to this development. One of the most important tasks which had to be fulfilled to ensure success was the creation of an intensive *biotechnological communications network.* Only five years after the Government first launched the Innovation-Oriented Research Programme for Biotechnology a closely knit network now already seems to have been created. The idea of the Netherlands as a fertile breeding ground for biotechnology is no longer an Utopian dream but has become a living reality.

COMPUTERIZED BIOPROCESSOR, controlling up to 31 parameters with separate modules, developed by Applikon Dependable Instruments. This company raised its R & D expenditure from a quarter of a million guilders in 1984 to half a million in 1985, which is 4% of its total sales of its equipment for biotechnological processes (foto Applikon).

Sources

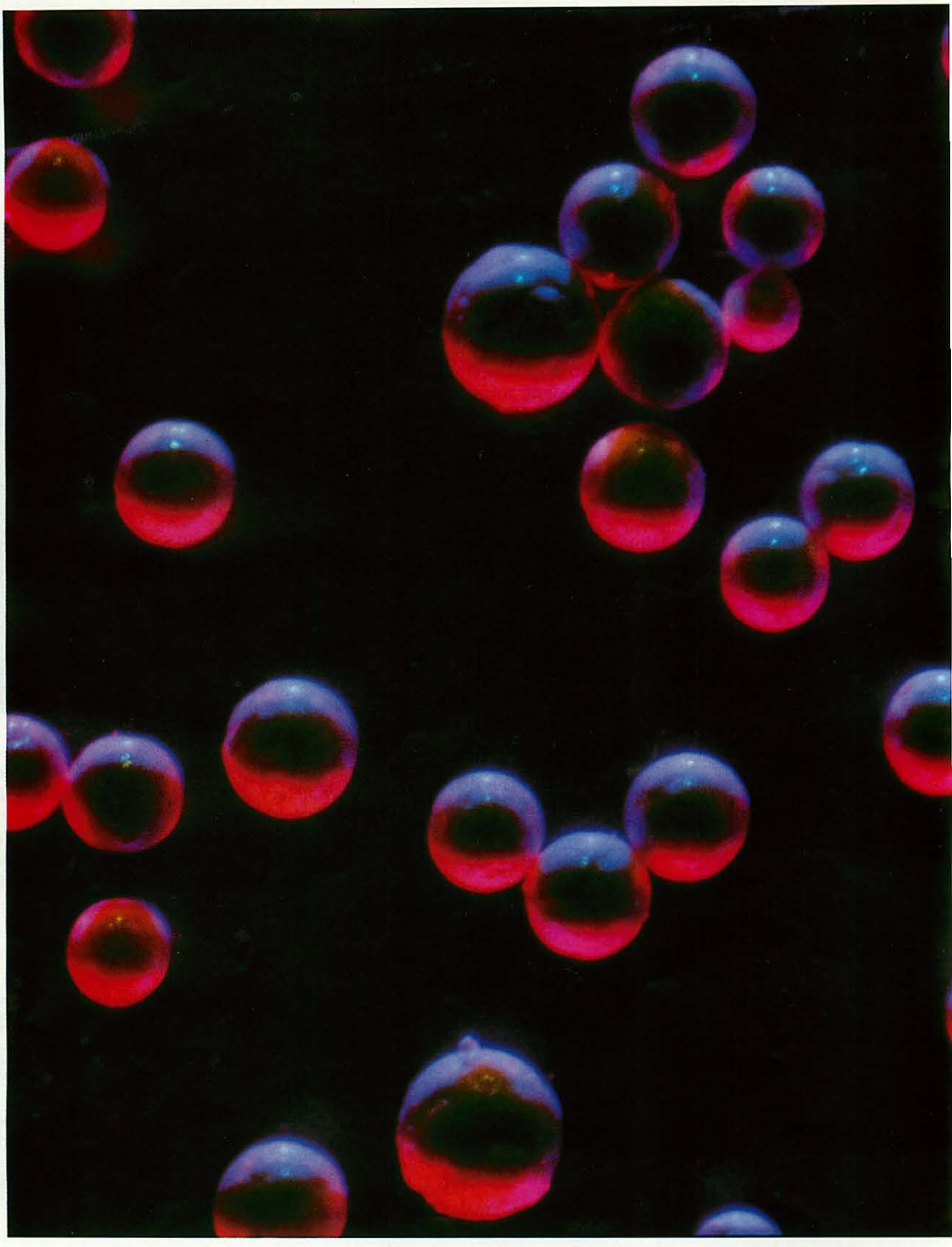
Biotechnology in the Netherlands: A Strong Foundation – A Shining Future, Parts I and II, Ministry of Economic Affairs, Commission for Foreign Investments in the Netherlands, 1985.

Biotechnologie in Nederland, themanummer Nederlandse bedrijvigheid in de biotechnologie (Biotechnology in the Netherlands: Special Issue on the Dutch Biotechnology Industry), Vol. 2, No. 4, 18 December 1985.

Biotechnologie in Nederland, themanummer Associated Dutch Biotechnology Centers (Biotechnology in the Netherlands: Special Issue on Associated Dutch Biotechnology Centres), Vol. 2, No. 2, 20 June 1985.

Biotechnologie in Nederland, themanummer Instituten actief in de biotechnologie (Biotechnology in the Netherlands: Special Issue on Research Establishments working in the field of Biotechnology), vol. 2, No. 2, January 1986.

Biotechnologie in Nederland, themanummer Biotechnologie in de gezondheidszorg (Biotechnology in the Netherlands: Special Issue on Biotechnology in Health Care), Vol. 1, No. 6, December 1984.

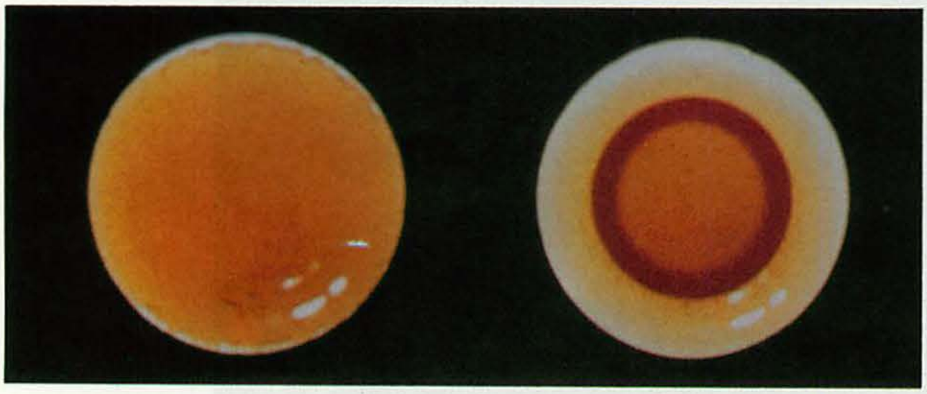


THIS IS

This is a photograph, taken through a powerful microscope, of the secret behind spotless white tablecloths, immaculate tenniswear, sparkling white shirts. What you see are enzymes, the basis of today's "biological" detergents. These enzymes act as catalysts, helping to break down spots and stains, making them easier to remove. Enzymes do useful work in other areas too. They are used in the manufacture of many products, from softdrinks and fruitjuices to textiles, from leather to cosmetics, from beer to paper.

Gist-brocades is a major supplier of such enzymes, as well as being one of the world's

THE ANATOMY INDUSTRIAL CHEMICAL



◄ A PREGNANCY TEST based on monoclonal antibodies has been launched by Organon. Two monoclonal antibodies ensure that only hCG is detected, normally found in pregnant women on about the first day of expected menstruation. Left: hCG present; right: hCG not present. (foto Akzo)

FLEXICOKER. Esso, has, just like Shell, decided to modernise its refinery. The flexicoker part of the modernisation project converts the heaviest oil residues into lighter fractions. The investment in the whole project will be $ 1000 million. (Foto Esso)
▼

OF

HOLLAND

HYCON. Shell is investing $ 350 million in a process to convert the heaviest crude oil fractions into high-grade products. This HYdrogen CONversion process is only part of a total investment programme. Hycon installed situated in Shell's Pernis Refinery of Shell, as seen by the computer. (foto Shell) ▸

THE TWARON PLANT. In this AKZO plant, the polymer for the extra strong fibre Twaron, the counterpart of Dupont's Kevlar is synthesised. ENKA has since 1984 become a go ahead company within the AKZO group after having been the lame duck for the preceding ten years. (foto AKZO) ◂

▲

MEMBRANE FILTRATION for dairy products at NIZO (the Netherlands Institute for Dairy Products). The dairy companies support this research institute by contributing a tenth of a cent per litre of milk produced.

THE ENGINEERING OF OIL PLATFORMS is a major activity of engineering bureaux. Here, John Brown Engineers and Constructors were involved in the engineering for Kotter and Logger Field Offshore Platforms for Conoco.

▼

FINE CHEMICALS. DSM wants to earn about one-third of its turnover from the production of fine chemicals by 1990. This resulted recently in the manufacturing of optically active amino acids. (foto DSM)

▼

COMPUTERS IN DUTCH CHEMICAL RESEARCH

Chemistry without a computer is almost unthinkable in the Netherlands. Computer aids are employed more or less everywhere; chemometry, computerassisted organic synthesis, molecular modelling, artificial intelligence and crystallography are just a few examples of its use. Computer networks which in the near future will link universities in the Netherlands with one another and with their colleagues abroad are also high on the list of priorities. A short survey of Netherlands activities in this field is given in this article.

Gerard Kleijwegt

In the past few decades digital computers have appeared in chemical research laboratories at an incredible rate. Scientists from many areas of chemistry realised at an early stage the enormous potential that the use of computers has to offer them and, consequently, many of them nowadays regard a computer as an utensil as common as, for instance, a telephone, a pocketcalculator or a notepad.

Computers have not only given a considerable impetus to traditional areas of chemistry (for instance, by making previously impracticable quantum chemical calculations a matter of hours or even minutes), but they have also given rise to the development of entirely new methods and techniques (*e.g.* artificial intelligence, molecular modelling, reaction retrieval) and, indeed, new disciplines (for instance, chemometrics).

We shall identify some strongholds of 'computational chemistry' in the Netherlands in the course of reviewing some important applications that computers have found in chemistry.

Early applications

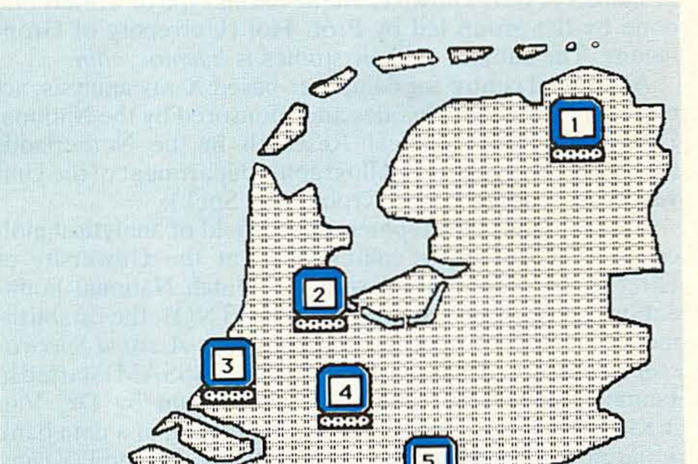
Computers found their earliest application in theoretical chemistry. Nowadays software for *quantum chemical* (using either *'ab initio'* or semi-empirical methods) and *molecular dynamic* calculations is widely available.

With such programs fairly complex systems can be treated. Well-known research groups in this field are found at, for instance, the Universities of Groningen (Prof. Nieuwpoort and Berendsen) and Nijmegen (Prof. van der Avoird).

Theoretical chemistry, when applied to large or otherwise complex systems, often requires the use of so-called *'supercomputers'*. At present, two such 'number crackers' are available for academic research workers in the Netherlands: a Cray 1 (at the Shell Research Laboratory in Rijkswijk) and a Cyber 205 (at the Academic Computer Centre in Amsterdam).

Crystallography is another area which has been benefitting from the application of computers for quite a long period now. Major improvements in crystallographic theory were readily implemented in the form of new programs on

Computers in Chemistry



RESEARCH ESTABLISHMENTS with strongholds in 'computational chemistry'. These and other establishments are being connected to national and very likely also to international computer networks in the near future.
1 molecular modelling/molecular graphics on large biomolecules, 2 an Cyber-205 supercomputer, 3 a Cray-1 supercomputer, 4 CASSAM and chemometrics, 5 CAOS-CAMM and chemometrics, 6 Artificial Intelligence. There are many more 'computational activities'.

increasingly powerful computers. Determination of the crystal structures of organic and inorganic compounds containing up to several dozens of atoms is nowadays carried out more or less routinely in most laboratories. Major contributions to the progress made in this area in the Netherlands have been made, amongst others, by Profs. Beurskens (University of Nijmegen), Drenth (University of Groningen) and Schenk (University of Amsterdam).

An entirely new 'dimension' was added to crystallographic research in the 1970's when *large bio-molecules* became the subject of structural investigations. Initially, the models were fitted manually and optically to electron density maps obtained from experiments.

Later, when software and hardware tools for *molecular modelling* and *molecular graphics* became available, these established a revolution in this area. Although the elucidation of the structure of a protein still constitutes a long-term enterprise (several years), the work involved has been greatly facilitated and ways of manipulating models and performing calculations (and, more importantly, visualising their results) previously not even dreamed of have become available. A well-known example of this type of work is that done by the group led by Prof. Hol (University of Groningen). The subject of their studies is *haemocyanin*.

A national centre for computer-based X-ray analysis, accessed by Dutch universities and sponsored by the National Foundation for Chemical Research in the Netherlands (SON), is run by the crystallographic department of the University of Utrecht (Prof. Kroon, Dr. Spek).

An analogous development in the field of analytical molecular spectroscopy is taking place at the University of Utrecht. In collaboration with the Dutch National Foundation for Applied Science Research (TNO), the establishment of an expertise centre for *Computer-Assisted Spectroscopic Structure Analysis of Molecules* (CASSAM) started in January 1986. This CASSAM centre (run by Dr. Van 't Klooster, Dr. Cleij and others), consisting of a data bank with reference spectra (mainly MS, NMR, IR and UV) and computer programs for spectral interpretation, will be accessible (via a national computer network) for scientists and teachers at universities and governmental and industrial laboratories in the Netherlands. Its two main functions are:

(i) to provide spectral reference data and the (interactive) use of computer programs for the identification or structure elucidation of organic compounds;

(ii) to collect valuable spectral reference data, initially for further development and optimisation of the data bank, but eventually to exchange such data with data banks in other countries.

Results from current research projects at Utrecht (e.g. concerning the application of artificial intelligence in spectral interpretation) will be implemented in the CASSAM centre.

Altough only a relatively small part of the CASSAM users consists of organic synthesists (most of the users being in the areas of public health, food and environmental research), the two centres CAOS/CAMM and CASSAM coordinate their activities.

These centres illustrate the fact that links between computers at various laboratories (i.e. networks) are becoming increasingly important. In the autumn of 1985, the Assembly of Dutch Academic Computer Centres announced plans to establish a network that would connect all of their computers (*SURFnet*) and, thus, make local computing facilities available to scientists throughout the country. As international communication is also becoming more common, the next logical step would be to 'plug in' to one of the European networks, *EARN* (the existing European Academic Research Network) and/or the more recent *RARE* initiative (Réseau Académique et de Recherche Européenne).

DR. H. VAN 'T KLOOSTER is one of the men behind CASSAM, Computer-Assisted Spectroscopic Structure Analysis of Molecules, which consists of a database with reference spectra and computer programs for spectral interpretation. The research activities of Van 't Klooster cover Chemometrics, a new discipline in Analytical Chemistry.

National Computing Facilities

The powerful capabilities of molecular modelling ensure that this technique is used not only by crystallographers, but also by, for instance, pharmaceutical chemists (drug design) and organic chemists. For the latter category in November, 1985, the *CAOS-CAMM Centre* was opened (CAOS = Computer Assisted Organic Sythesis; CAMM = Computer Assisted Molecular Modelling). This centre, which is situated at the University of Nijmegen and run by Dr. Noordik, provides hardware and software facilities for both CAOS and CAMM.

The organic chemistry laboratories of all Dutch Universities have been (or will shortly be) linked to it, and industrial laboratories are likely to participate in the future. Organic chemists are now able to use the computer at three levels:

(i) as a means to understand the properties (e.g. reactivity) of a compound (using molecular modelling and molecular mechanics);

(ii) as an aid in the study of reactions (*i.e.* how to convert one compound into another);

(iii) as an aid in synthesis planning (*i.e.* how to make a given compound).

It is expected that these new techniques will fundamentally change the *modus operandi* of the synthetic chemist.

Analytical chemistry

Analytical chemistry may well be the area that has profited most from the computer revolution. It has even given rise to the emergence of a new sub-discipline: *chemometrics.* Just naming some recent developments and techniques clearly demonstrates the progress that has been made in this field of chemistry:

– automated data-acquisition;

– automated data-processing;

automated data-processing;

– automated identification of compounds, for instance, based on ^{13}C-NMR spectral data *(vide supra)*;

– classification (*e.g.* of wines) using pattern recognition techniques;

– optimisation of analytical procedures (using, for instance a simplex method);

– application of Robotics in sample-preparation and sample-handling;

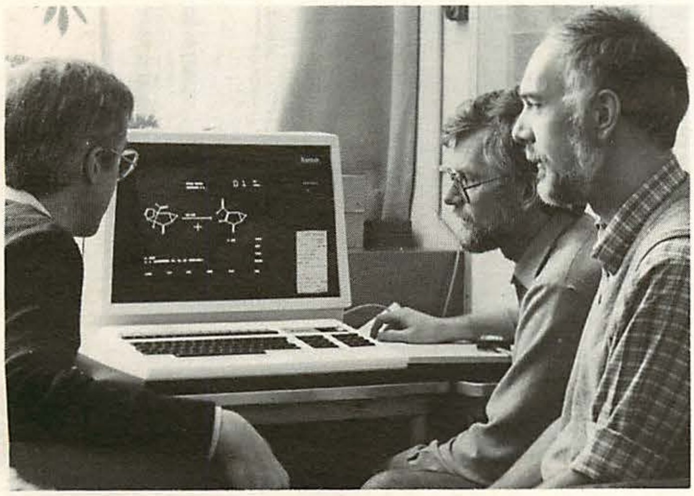
– the use of LIMS (Laboratory Information Management Systems) to manage the data produced in analytical and pharmaceutical laboratories.

Strongholds of the use of computers in analytical chemistry in the Netherlands can be found at the Universities of Nijmegen (Prof. Kateman and Dr. Vandegiste) and Utrecht (Dr. Van 't Klooster).

A 'technique' that has been applied in analytical chemistry, but also has a tremendous potential for application in other areas, is *Artificial Intelligence* (AI). The most important characteristic of AI is that knowledge, rather than numeric data, is processed. AI is the cornerstone of the so-called *'expert systems',* which are expected to be of importance in the future in all areas where 'intellectual expertise' plays a role. Knowledge is 'extracted' from experts and translated into relatively simple 'if...then'-type rules which constitute the 'knowledge base' (as opposed to 'data base'). Expert systems will not replace experts, but they will aid non-experts, facilitate newcomers to ingaining expertise and guarantee that expertise is preserved, for instance upon the retirement of an expert.

An interesting initiative in this respect is that of the University of Limburg. The latter intends to initiate a Research Institute for Knowledge Systems (RIKS), where AI-related research would be concentrated.

CAOS-CAMM (Computer Aided Organic Synthesis Computer Aided Molecular Modelling) was started in 1985 at the Roman Catholic University of Nijmegen. All Dutch universities are (or shortly will be linked to it). At the terminal the people who started CAOS-CAMM, from the left to the right Dr. H. Ottenheym, Dr. T. Klunder and Dr. J. Noordik.



Other applications

Owing to space limitations, only selected topics can be treated in a survey like this. There are, of course, many more applications of computers in all fields of chemistry. To name but a few:

(a) in chemical education, where students are made familiar with several applications of computers in 'real-life' research;

(b) literature retrieval and literature data base management;

(c) chemical wordprocessing;

(d) computer-controlled synthesis (*e.g.* using a so-called 'gene machine');

(e) simulation of spectra (*e.g.* NMR, EPR) etc.

An important development is the significant shift from large (main-frame) computers to the smaller *personal computers* (PC's). The latter have become cheaper and more powerful over the years, and software (even for molecular modelling purposes!) is abundant. Despite decreasing budgets for academic research, many Dutch chemists nowadays have a PC on their desk; Apples (the II Series and the Macintosh) and IBM's (and compatibles) seem to be favourites.

Of course the present proliferation of computers in general also has several disadvantages. Two of these are:

(i) the lack of standardisation (both in hardware and software);

(ii) the fact that 'the wheel is re-invented thousands of times', which is due to a lack of information and poor communication.

In order to tackle this type of problem, the *Royal Netherlands Chemical Society* (KNCV) in 1985 established a Computer Division. In this division both academic and industrial chemists from all areas are represented. Moreover, the evolution of nationwide facilities intrinsically contributes to the solution of the first type of problem.

From the above it will be clear that computers are playing an increasingly important role in Dutch chemical research, and this tendency is not likely to change (on the contrary!).

Acknowledgement

Contributions to this text by Dr. Jan Noordik – University of Nijmegen – and Dr. Henk van 't Klooster – University of Utrecht – are gratefully acknowledged.

CHEMISTRY TEACHING IN THE NETHERLANDS

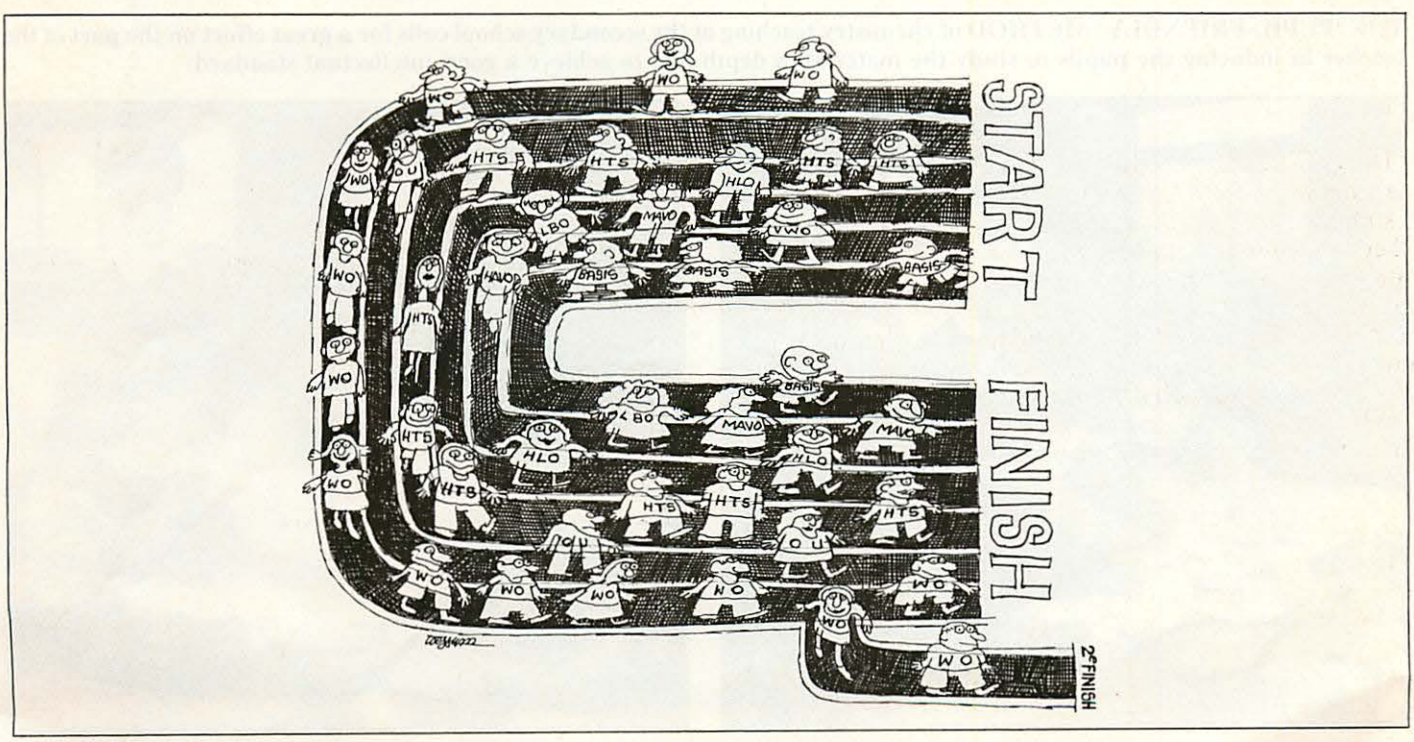
The importance of the chemical industry to the Netherlands will be evident from the other articles appearing in this issue. To guarantee the future of chemical enterprises it is essential that a sufficient number of trained personnel be available at all levels. However, not only do chemistry teachers have to train considerable numbers of people for direct employment in the chemical industry; they also have the equally important task of providing ordinary citizens with a fair picture of an industry with which they will often be confronted.

Wouter Jongepier

Current trends in chemistry teaching have their origin in the developments taking place in industry and society. The face of the Netherlands chemical industry is largely determined by the activities of five large companies: Shell, Philips, Akzo, Unilever and DSM. An important feature of these companies is that they have many facilities for training new staff themselves. An endeavour has, however, been made in the Netherlands in recent years to give strong support also to the *smaller 'high-tech' companies*. This has necessitated modifying the existing educational system to include such additional facilities as a limited number of vocational training and refresher courses specifically tailored to the requirements of such firms.

Just as in other western countries the trend in the Netherlands is from bulk chemicals to fine chemicals, to more *knowhow-intensive-products*. This imposes greater demands on employees at all levels.

Not only does the chemical industry make an important contribution to the prosperity of the Netherlands but it is also seen as a potentially serious threat to the environment. This problem is made all the more acute by the fact that the Netherlands is very densely populated and also that the large industrial regions of bordering countries are so close by. The Netherlands public has to contend with PCBs, acid rain, contamination of the soil under residential areas and the question of lead or no lead in petrol, to name just a few burn-



ing topics. Despite the high average educational level of the population as a whole, many people obviously find it difficult to form their own concrete opinions on problems of this nature. Industry has the responsibility of keeping the public informed of the former's activities in a frank and honest manner. Such openness will, however, have a purely negative effect if the information supplied is insufficient to allow an individual to arrive at his own independent conclusions. According to Prof. D. Thoenes (Technological University of Eindhoven), the private citizen relies increasingly on technology for his needs while at the same time finding it increasingly difficult to fathom its 'mystique'. It is the task of the chemistry teacher to reverse this dangerous development.

Since the end of the sixties the Netherlands community has strongly advocated the need for all its members to have a fair and equal share in the country's prosperity and there has been a parallel trend towards equality of opportunity and equality of development potential in the field of education. The great changes which have taken place in primary and secondary education over the last fifteen years have been partly based on such principles.

In tertiary education a similar development has manifested itself under the banner of *'Higher Education for Many'*. The explosive growth of the student population and the desire of successive governments to reduce the budget deficit have, however, led in the eighties to the focussing of particular attention on the importance of increasing the *effectiveness and efficiency of higher education*. An indication will be given below of the ways in which chemistry teaching in the Netherlands at its various levels has adapted itself to the previously mentioned changes in industry and society.

Since 1968 many committees have been set up to initiate sweeping reforms in the teaching of chemistry. Students have found chemistry to be a dull and boring subject lacking in any vitality. The result has been not only a threatened falling-off in the numbers of chemistry students but also a residual negative feeling about 'chemistry' in the minds of former students who have decided to enter other professions. The first new-type syllabuses were introduced in 1975 or thereabouts. By the current year of 1986 almost all syllabuses have been revised.

The 'basic school' (4–12 years)

Very recently all kindergarten and primary schools in the Netherlands were combined to form one 'basic school'. The 'basic school' has a larger number of pupils than any other type of school in the Netherlands. Chemistry is not taught as a separate subject here but is grouped to form one combined subject also including elements of physics, biology and geography. Developments in English-speaking countries have served as a basis for the design of this *'General Science'* syllabus. As abstract notions such as atoms and molecules cannot be readily conveyed to such young minds, the syllabus confines itself to the terms 'chemical substances' and 'chemical reactions'.

General Science has the following objectives:

– to teach pupils to recognise the physical character of the natural objects and phenomena with which they are surrounded in their daily lives;

– to inculcate a useful elementary knowledge of phenomena affecting the daily life of children and to teach them to learn things for themselves from the experience gained during their own experiments;

– to provide pupils with a clear idea of the nature of scientific phenomena and their interrelationship;

– to teach pupils a few (elementary) thought and behaviour patterns;

– to inculcate a sense of responsibility into the child's approach to nature and the environment.

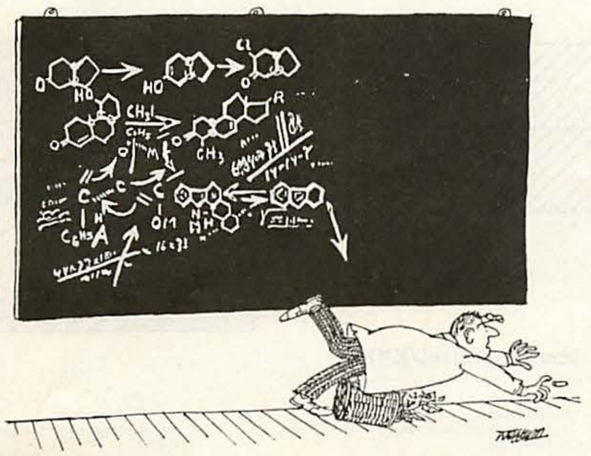
THE 'PUPIL-FRIENDLY' METHOD of chemistry teaching at the secondary school calls for a great effort on the part of the teacher in inducing the pupils to study the material in depth and to achieve a good intellectual standard.

The need for a child to conduct his or her own experiments is, therefore, central to this method. For the youngest age group this means, for example, feeling the difference between a handful of salt and a handful of sand. Older children make their own photograms and their own soap, determine the properties of plastics and use red cabbage juice as an indicator of basicity and acidity. This type of 'discovery learning' requires great flexibility on the part of the teaching staff.

The secondary school

According to the present system, the children go from the *'basic school'* to the LBO *(Junior Secondary Vocational School)*, MAVO *(Junior General Secondary School)*, HAVO *(Senior General Secondary School)* or VWO *(Pre-university School)*. Attendance at these schools is compulsory until the age of seventeen. Schools at this level are also earmarked for change in the near future, as will be explained in more detail later.

The MAVO provides training for the more practically oriented occupations and also serves as a basis for further education. Chemistry courses at such schools have, however, been traditionally based on the HAVO and VWO syllabuses, whose objective is the detailed study of a particular field of knowledge, as the current practice at the universities. This set-up clearly presents many problems for MAVO pupils. Nor is a knowledge of formulae and the comparison of chemical reactions particularly relevant for people who will subsequently be concerned with the chemical industry much more as customers than as practitioners. In the new syllabus to be introduced in 1986 the emphasis will be more on acquiring a knowledge of chemical substances and their reactions. Bohr's atomic model, the term 'mol', gas laws, carbonic acids and esters have all disappeared from the syllabus. They have been replaced by indications of state in formulae, reaction rates, electric cells, titration and plastics. The objective is to find common ground with the *pupil's daily experience,* which entails a multi-disciplinary approach. More time is set aside for *practical work and independent study projects,* with less emphasis on studying to pass examinations. Another problem here is that teachers often have had no specific training in chemistry themselves.



The situation encountered at the HAVO is to some extent the same as that encountered at the MAVO. Here too the chemistry course has been recently modified, the main objective being to simplify the transition to higher education. Teaching is now based more on the readily identifiable and applicable aspects of chemistry combined with practical work. The new topics now dealt with include: hard water, electric cells, the properties of gasoline and plastics, food conservation and iron corrosion. Abstract theories on such matters as electron configurations, gas vapour density, the principles of Le Chatelier and Van 't Hoff and the reaction of alkanols with phosphorus trichloride have, however, been omitted.

The VWO course in chemistry was the first one to be revised, in the mid-seventies. The new set-up constitutes something of a challenge for teaching staff in that some of the pupils have their first and last encounter with chemistry in their third year, whereas others will be taking their final examination in this subject and will probably go on to study it at the university.

The new syllabus places a strong emphasis on *fostering an understanding of the subject* in the pupil rather than on the accumulation of factual data and 25-30% of the pupil's time is devoted to practical work. The syllabus for the third year is tailored to the needs of pupils who will not be studying chemistry in subsequent years. The syllabuses for the fifth and sixth years, on the other hand, have been designed with the examination specifically in view. In the examination the pupils are confronted with what are for them new problems, which they have to solve with the aid of the data supplied. Hence, their preparation for the examination does not consist of committing a series of facts to memory. It has been found in practice that the independent performance of a project and the study of a 'special subject' provide good training for this examination. Special subjects dealt with at the VWO include: chemical processes occurring at interfaces, chemical engineering, biochemistry, catalysis, polymers, complexes, energy, environment, soil chemistry and chemistry in relation to blood pressure. These subjects serve to flesh out and re-emphasise the basic course material in the context of its application to science, technology and the community. Retraining of the teachers formed an important part of the preparatory work for the introduction of the new syllabus.

Chemical technology has always been given very little coverage in chemistry courses. In 1984 it became compulsory for the VWO sixth year to devote eight hours of course time to industrial chemistry. The Laboratory of Chemical Engineering at the Delft University of Technology reacted to this development by devising course material and a retraining course for teaching staff. The accent of the course is on design, which is the essential part of a technologist's work.

According to the provisions of the relevant education act

the syllabus must contain the following subjects:
- the general features of the process industry: large-scale production;
- continuous and batch processes and their determining features;
- the representation of process steps in a block diagram;
- the proper selection of a particular type of reactor;
- various economic and societal constraints and effects.

In the Delft course syllabus these aspects are incorporated in the design of a methanol plant. This also clearly underlines the fact that the technologist is constantly searching for the most efficient process route on the basis of the available economic evaluations.

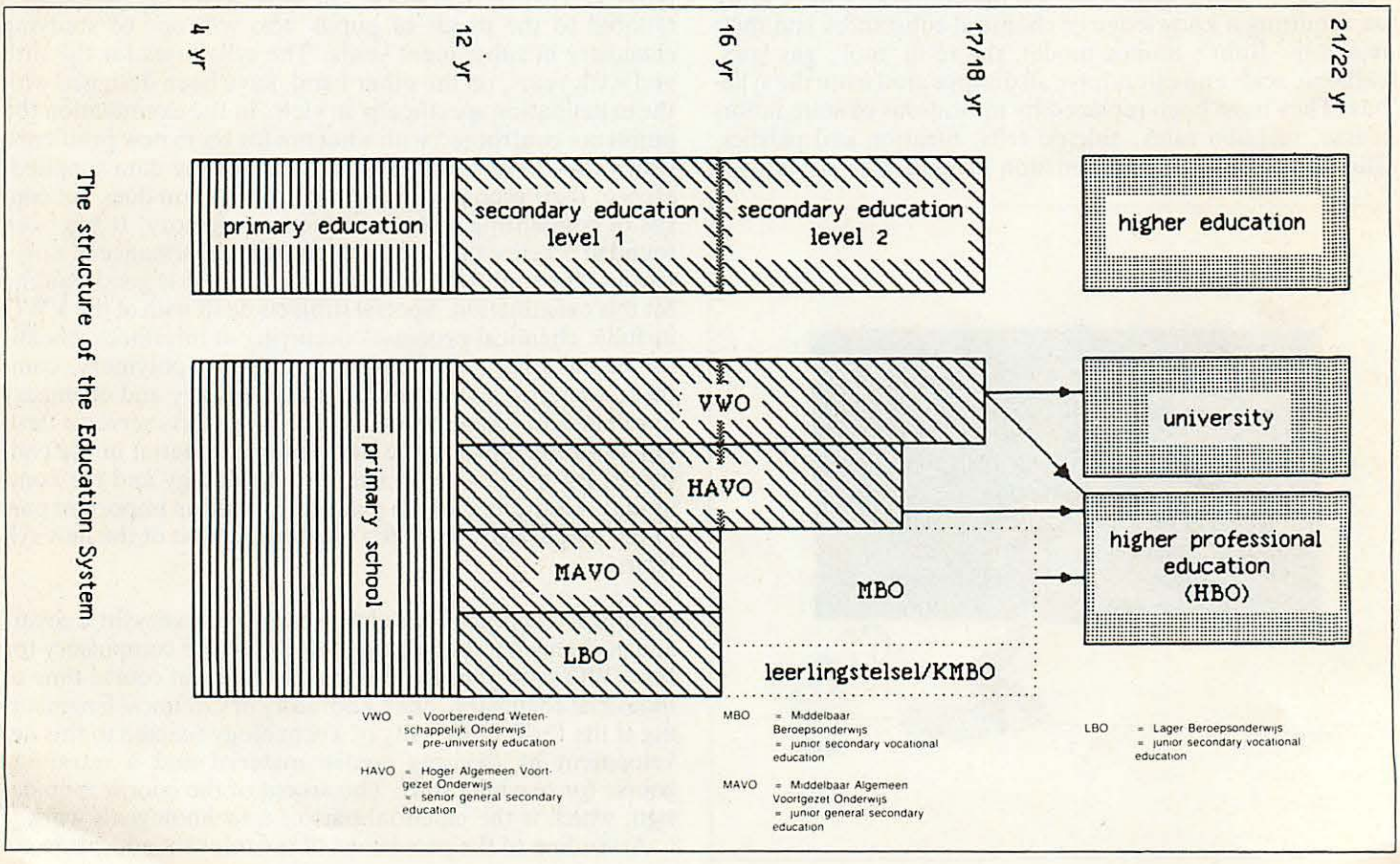
Methanol is prepared from natural gas, one of the few raw materials which the Netherlands possesses in abundance. It is an important feedstock for the chemical industry and, moreover, plays a role as an alternative fuel for automobiles. This topic was chosen in the hope that it would successfully capture pupils interest. Since the main emphasis is placed on process optimization, a lot of calculation work is involved. However, this is kept as simple as possible.

It will be evident from the foregoing that there is a strong bias in chemistry teaching in the Netherlands in favour of understanding the environment and accumulating sufficient knowledge to be able to solve problems independently. This *'pupil-friendly'* method calls for a great effort on the part of the teacher in inducing the pupils to study the material in depth and to achieve a high intellectual standard.

The *International Chemistry Olympics,* in which the Netherlands has been taking part since 1980, provides an excellent opportunity for a comparison of the achievements of top students from different countries. Since in many other countries 'learning by rote' still occupies a central position in the educational system, the strongly data-oriented set tasks are usually a traumatic experience for the Netherlands participants. And yet each year they manage to score well, particularly in the practical section. However encouraging this may be, the fact remains that the number of these good students that will be going on to study chemistry at university is still very small, unfortunately. They obviously often have very little regard for university chemistry courses and the role of chemistry in society. Chemistry is felt to be a less exact science than physics and, moreover, the latter is considered to be 'more firmly rooted in society'. What is more, the frequently repeated use of formulae is considered to be boring.

At a future date the above-described types of school will be combined; there will be a junior secondary school (VBAO) for all schoolchildren aged from twelve to sixteen years and the HAVO and VWO will probably be combined to form the new senior secondary school. The VBAO, in particular, offers interesting possibilities for making chemistry courses available to a wider range of pupils. Under the present system 40% of the pupils receive no further edu-

THE EDUCATION SYSTEM IN THE NETHERLANDS. Above: Primary School. Junior Secondary School and the (future) Senior Secondary School. Below: The present system. Higher vocational schools, where laboratory practice is taught, are rather rare (Source J.B.M. Laauwen).



cation in chemistry after leaving the 'basic school'. On the other hand, of those who do, 59% give it up at an early date, so that, in the last analysis, only 25% of pupils take the final examination in chemistry. After all, the objective of the VBAO is not to prepare people for a subsequent academic study but to prepare them to function in society.

It is the intention, therefore, not to teach chemistry separately but to combine it with physics, biology, geology, astronomy, pharmacy and agriculture into one subject entitled *'Exploration of Nature'*. Common to all these component parts will be the methodology, the scientific method. In the case of chemistry it is essential that all pupils are given three years' instruction in this subject. Below-average students will no longer have to abandon the course. This approach may, however, give rise to the following two questions:
Does this system give the best pupils the necessary scope?
Will the pupils really obtain an insight into the methodology; will they fully perceive the underlying link?

The difference in ability between one pupil and another will partly be catered for by operating on the basis of optional subjects revolving around a fixed nucleus. The better students can, for instance, take molecular theory as an optional subject. After these three years of General Science there will, of course, have to be a transition in the senior department to specialisation per subject in order to prepare the pupils for university education. It may well be a further ten to fifteen years before the new subject of 'Exploration of Nature' is universally introduced into junior secondary schools.

Laboratory schools

A major group of chemists in the Netherlands is that of *laboratory assistants*, who work mainly in quality control laboratories. A smaller number work in product development and a few work in laboratories engaged in fundamental research. Rapid developments in analysis instruments and automation have drastically changed the work of the last group in recent years. These changes can also be seen at the laboratory schools which have traditionally provided a full-scale vocational training course. *The Netherlands is one of the few countries where laboratory practice is taught in separate schools.*

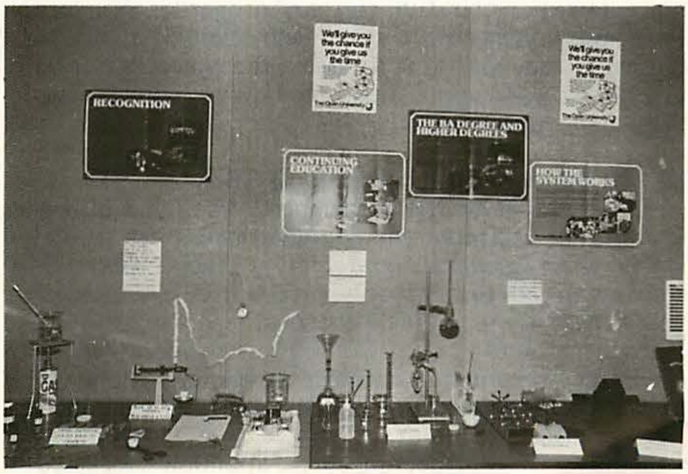
When this type of education was re-organised in 1981, the opportunity was taken to adapt it to the new demands being voiced from the field. We now have the Intermediate Laboratory School (MLO), which is linked to the MAVO, and the Higher Laboratory School (HLO), for which a HAVO-certificate is a prerequisite. The MLO course lasts three years followed by a year of training in practice. The Short MLO Course, where great emphasis is placed on the teaching of manual skills, lasts for two years followed by six months of training in practice. The HLO course lasts for four years, including one year of practical training and a pre-graduation assignment in industry. An MLO graduate should be able to perform accurate and normally largely standardised analyses without supervision. The HLO graduate is employed in more sensitive determinations and participates in the development of new methods and techniques. 73% of the graduates have a degree in chemistry (the remainder having degrees in medicine and biology). 53% of these graduates end up in R & D work.

In the work of the HLO graduate the emphasis has shifted from obtaining data manually to processing data obtained with the aid of advanced technical instruments into effective information. He is furthermore employed in the installation of quality control systems. This entails an ability to analyse and creatively solve complex problems. This calls for a more detailed knowledge of the processes into which the analytical results will be fed back. Although the skills of the HLO graduate have been developed to a high cognitive, creative and social level, they remain within the realms of practical applicability. This distinguishes the HLO graduate from the academically qualified analytical chemist, whose work lies more in the field of exploratory research.

Ideally speaking, the laboratory schools should be offering a large number of courses supplying training for specific occupations. However, it became obvious during the re-organisation period that the government was in favour of precisely the opposite, namely a limited number of courses covering a wide range of occupations. This has led to greater emphasis being placed on the need for further on the job training. There have also been major changes in the content of courses. Whereas previously minimum use was made of the library, an independent literature investigation now forms an important part of the course. Furthermore, rapid developments in instruments design have increased the importance of practical training in industry. During this training the students are given the opportunity to work with the most up-to-date instruments.

More groundwork will also have to be done at the HLO in order to give students a basic knowledge of problem-solving techniques. In this way contacts can also be improved with medium-sized and small companies, which are suffering a great shortage of trained personnel. The intention is to set up projects for solving analysis problems, testing and improving instruments and performing analyses on waste water. The projects should have a duration of three to six

THE OPEN UNIVERSITY started up in 1984, the British version serving as a model. Unlike the traditional universities, it covers the themes of nutrition and toxicology, ecology and business administration. The object of the last theme is to channel more people with a scientific background into higher management.



months. According to J.B.M. Laauwen (the project leader for the re-organisation of laboratory schools) there is only a slow increase in research projects at the HLO at the present time because such schools wish first to put their own house in order in the aftermath of the recent re-organisation. Another problem is that they have traditionally always had many more contacts with large companies than with medium-size and small companies.

As a result of developments in the continuous monitoring of chemical processes there is no longer any clear dividing line between the operating spheres of measurement and control technicians, on the one hand, and analytical chemists on the other. In addition to the measurement of pressure, temperature, pH etc., the measurement of concentrations has become increasingly important. Instruments are being used for this duty which previously were only to be seen in the laboratory. The analytical criteria have, however, changed, operational reliability and speed of analysis having replaced high sensitivity and accuracy. Moreover, those who design and use such instruments require a different type of training. They must be familiar with both the analytical methods of the chemists and the problem-solving techniques of the technologist.

The Van 't Hoff Institute in Rotterdam has introduced, in consultation with the industry, a curriculum to provide the particular type of training needed and has termed it the HLO analytical process and laboratory instrumentation course. Although this was originally geared to the process industry, it was also found to cater excellently for the needs of laboratories seeking personnel capable of developing analytical instruments and data-processing systems. For this reason the following two versions are now available:

1. *Analytical process instrumentation.* In addition to the purely chemical subjects, this course also covers analytical instruments and their application in the process industry; automation and its possible applications; principles of process technology; legislation affecting waste products, safety and electronics. The student is also taught how to assess the reliability of instruments in certain situations and (under supervision) to develop or to automate measuring instruments.

2. *Analytical laboratory instrumentation.* In this course the student is introduced to analytical instruments; specifications of instruments and their components; data processing; automation of instruments; and properties of materials. He is also taught how to select instruments designed for a particular function, how to assess the potential for automation in certain applications and how to keep up with developments in this field.

Higher Schools of Technology (HTS)

The HTS, like the HLO, belongs to the ranks of Higher Professional Education. In the Netherlands there are eleven HTSs where *chemical technology* is taught. About 1400 students attends these schools and about 250 graduate every year. There are about 4000 chemical technologists with an HTS background working in the Netherlands. At the HTS there are two separate chemical technology courses, one with a process engineering bias and one with a product engineering bias.

In the process engineering course attention is focussed on mechanical engineering, materials handling aspects, measurement and control techniques and process technology. In the product engineering course, on the other hand, the emphasis is on materials engineering and the techniques involved in such applications as the production and processing of plastic materials, semi-conductors, textiles, paper etc. A certain amount of time is also devoted to mocular chemistry, instruments and construction techniques, corrosion and surface treatment.

PROF. A. ZUUR of the University of Leiden, and others, have introduced an experimental form of 'Practical Work by Laser Vision' for an introductory Open University course on natural sciences. He is also an advocate of teaching 'General Science' at the senior secondary level instead of chemistry, physics and mathematics.

The first two years of the four-year course are spent in the assimilation of basic knowledge, which is put to practical use during the periods spent working in industry in the third year, when the student works in three different plants for a total of ten months. Here he is given tasks allowing him scope to work on his own initiative and to obtain experience in the methodology of problem-solving.

The purpose of the practical year is to allow the student to familiarise himself with the operations of the process industry, a quality control laboratory, an engineering contractor or a public authority. The size and cost of chemical plants, together with the measurement and control problems and safety aspects involved, invest the chemical industry with a complexity which cannot possibly be simulated in the classroom. This makes a year on the job an indispensable part of the course. It also allows the student to obtain a clear picture of the working sphere within which he will himself later be operating.

In the last year of the course the student's basic knowledge is extended by the inclusion of specialised subjects based on the practical experience of the teachers and current industrial topics such as water purification, energy conservation, food processing technology, biotechnology and coal gasification.

Both the HLO and the HTS are involved in the scale up at present taking place in Higher Professional Education. The objective of this exercise is to end up with a score or so of large establishments (catering for a minimum of 2500 students). The government believes that a large-scale higher professional education system is capable of playing a larger role hand in hand with the existing university system. She also believes that such a system can keep pace with current technological developments only if the relevant knowhow and expensive instruments are concentrated in a limited number of large-scale establishments. As a result of their integration the HLO and the HTS will in future form the sector *'Technology and Natural Sciences'*, thus breaking the link hitherto existing between the HLO and the MLO.

The Universities

In the Netherlands about 10 000 graduate chemists are employed, about 4000 of whom are technologists. About 40% of the latter group are process engineers, the remainder being product engineers. About 550 chemists graduate annually, which is approximately equal to the number of people annually leaving the industry. More than half of the Netherlands' chemists work in industry, almost a third in teaching establishments and about 9% in (semi-)government establishments. About two-thirds of the chemists employed in industry work for one of the five large multinationals. However in recent years medium-sized and small companies have also been taking more chemists into their employment as a consequence of the introduction of an increasing number of scientific procedures into traditionally craft-based industries such as the paint industry. The result is that personnel with a 'Higher Professional Education' background threaten to be edged out of their jobs by academically trained chemists.

In a review of the Netherlands university system it has to be borne in mind that there are no private universities in the Netherlands. The form and content of the courses is largely determined by law. All establishments are funded out of the state education budget via a number of complicated apportionment rules.

1986 will be a particularly interesting year for the universities because in September the first batch of graduates from the newly enacted *two-phase system* will be entering the job market. A chemist graduating from a Dutch university receives the title of *'doctorandus'* or *'Ingenieur'* (roughly comparable to the American Master's Degree). Both degrees can lead to a doctor's degree after about four years of supervised research.

Until 1982 it was customary to take much more than five years for the Master's programme. The average was $7^1/_2$ years but extended periods of up to ten years were not uncommon. The student explosion in the sixties and seventies, however, created a situation in which university education would have become too expensive if such practices were to continue. Furthermore, successive Ministers of Education were convinced that it was not necessary to give all university students a five-year course. Hence, in 1982 a new system was introduced consisting of a *First Phase* of four years, after which a limited number of graduates could follow a broader multi-discipline course in a two-year *Second Phase*. The duration of the First Phase is limited to six years. Once this period has elapsed the student is obliged to leave the university whether he has gained his degree or not. Although there are ways of circumventing this strict rule, the average stay at the university is nevertheless expected to be shortened to $5^1/_4$ years.

The Second Phase was originally intended to have the ob-

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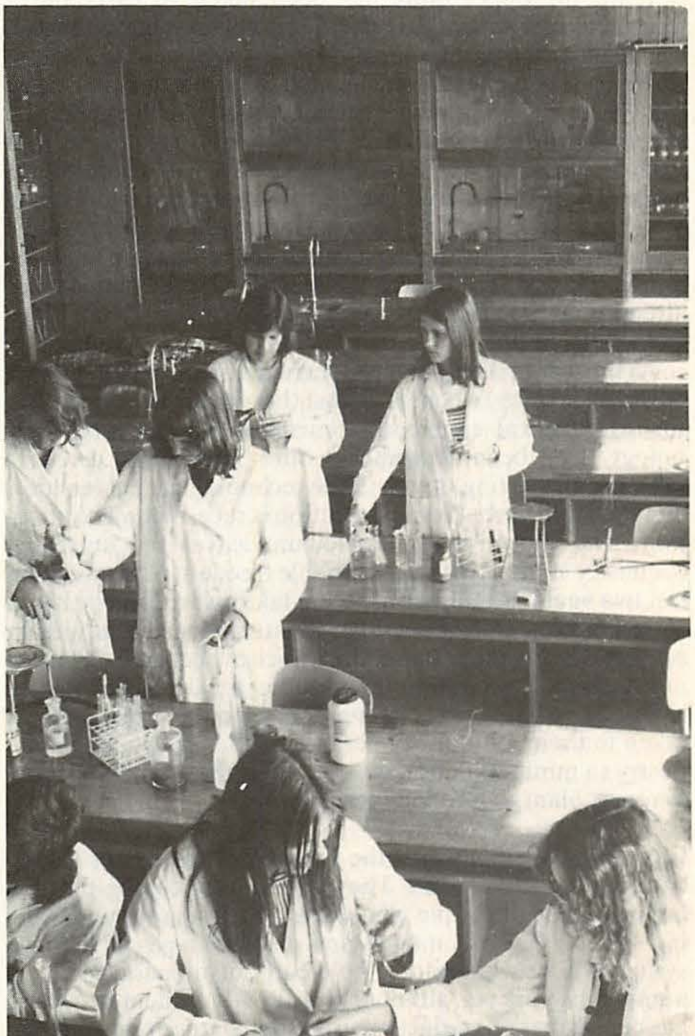


jective of teaching the basic subjects in more detail, of building up a broader knowledge and of providing instruction in multi-disciplinary subjects. In industry too there was a need for graduates with more than a First-Phase background.

The plan was to employ the First-Phase graduates principally in starting positions in technical and commercial or economic planning departments or controlled product development. To fill the more senior research and technical design positions there was a preference for people with rather more independent research experience and a broader educational background. The two-year research or design course in the Second Phase was felt to be very suitable for education to a level between the First-Phase graduate and the highly specialised doctor. Unfortunately, in 1984 it transpired that the government was not prepared to assume more than a token responsibility for the Second Phase. It was not prepared to finance any courses, limiting itself to offering a number of graduates the opportunity to train for further specialisation in a particular technical field.

An outline will now be given of the present status of the Two-Phase system. In changing the five-year curriculum into the four-year First Phase, no attempt has been made to compress the material into the confines of a shorter course. Instead, the opportunity has been taken to carry out a thorough revision of the curriculum. The graduation phase, which under the old system often took a year or more, has, in particular, been severely curtailed. During this phase the student participates in a research project, usually under the supervision of a PhD student. This work is rounded off with a thesis. In the new curriculum a maximum of six months is allowed for this undertaking. Furthermore, the many hours previously allocated to practical training in industry will be reduced. However, the experiments have become more relevant; for instance, at the technological universities more attention, is paid at a fairly early stage to process technology and cost aspects.

At the universities the basic curriculum for the First Phase covers two years, whereas almost three years are devoted to this in chemical engineering curricula. Information technology has been introduced into university curricula (already an existing option at the technological universities) and the art of verbal communication is receiving more attention. The shorter basic curriculum leaves the university chemistry student with a reasonable freedom of choice in his last two years, when specialisation takes place, and he has to choose a subject in which to graduate and also a subsidiary subject. On the other hand, the choice of chemical engineering students is limited to a few subjects, although they are allowed a certain degree of freedom as to the direction to be taken in their compulsory period of practical training in industry (a minimum of six weeks), their thesis and their preliminary plant or product design work.

From June 1986 onwards the First-Phase graduates will be entering the job market. They will have to compete with a large number of people who started their studies under the old system. The advantages and disadvantages of the new system will not, therefore, be clearly distinguishable for a number of years yet, although it is already evident that there has been a marked reduction in the percentage of drop-outs. This is due to a more intensive supervision of students and a better distribution of examinations over the academic year. Moreover, the limitation of the duration of courses has had the effect of making students study harder.

Although university authorities have been up in arms against the introduction of the two-phase system for a great number of years, the First Phase has been quickly implemented. Neither staff nor students are particularly unhappy about the First Phase. As already indicated, the introduction of the Second Phase is fraught with more problems. The teacher's training course has certainly been launched successfully but the two-years researcher's and designer's courses are not taking shape in the way which universities and industry would have wished. On the other hand, the introduction of a scheme for *two-year research assistants* (AIOs) is proving to be a viable proposition. These AIOs are expected to receive about six months' training, to be engaged for at least a year in research and to give three months of teaching themselves. The disadvantage of AIOs is that they can be given only very little training, which means that they have hardly any opportunity to broaden their expertise. On the other hand, they will be able to specialise in a particular technical field and accumulate a certain amount of independent research experience.

However, the low salary is a great problem. It is true that the AIO is paid for the teaching work which he does but this is not very much, certainly for the first two years. This means that the salary cannot compete in any way with starting salaries currently paid in the chemical industry. It is feared, therefore, that only those unable to find employment elsewhere will want to become an AIO, whereas it is precisely the more gifted students who are needed in research. Consultations are taking place between universities and industry with a view to finding a solution to this problem, since industry too will be at a great disadvantage on the long term if not enough good-quality people present themselves for post-graduate training.

Similar problems arise in connection with the four-year PhD course. The PhD student also is accorded AIO status under the new system. As far as can be seen at present, 15-20% of graduates will become eligible for a place on this course. According to the calculations of the Second-Phase Subcommittee of the *Koninklijke Nederlandse Akademie van Wetenschappen* (the Royal Dutch Academy of Science), an average of at least 30% of graduates are at present gaining their PhD: 44% at the universities proper and 25% at the technological universities and the chemical departments of the University of Agriculture in Wageningen. According to this committee, the PhD student should be devoting about two-thirds of his time to research and the balance to teaching. In the opinion of Prof. K. Vrieze (University of Amsterdam), about 30 out of every 100 First-Phase graduates should gain their PhD and another 30 should go on to complete the Second Phase if society's needs are to be satisfactorily served.

For both academic research and teaching it is a matter of the utmost importance that an adequate number of gifted graduates should go on to take a PhD. Studying for a PhD has always tended traditionally to be the labour of a lifetime in the Netherlands to which the student is asked to sacrifice more than four of five of his or her youthful years. This deters technologists, in particular, from taking this degree. In an effort to increase the numbers of engineers, admitted to dissertations on technical designs are accepted. A number of factors, nevertheless, still make it difficult to induce more students to stay on at the university, the foremost of these being the difference between *postgraduate remuneration and starting salaries in industry*. There is no immediate prospect of adapting AIO remuneration to comparative salary levels on the labour market. However, this would still not constitute much of a problem if this were compensated by a greater degree of academic freedom. Unfortunately, in recent years this freedom has been seriously impaired because of cutbacks in the purchase of apparatus and the amount of red tape involved in financing research projects.

Since 1984 the technological universities and industry have been making desperate efforts to introduce two-year courses for engineers at a limited number of interdisciplinary areas of research. These courses would concentrate upon the broadening of both technological and methodological skills. They have not been able to persuade the government to finance these courses but the Ministers of Education and Economic Affairs have both declared themselves prepared to accord initial subsidies to a number of vocational courses for a periode of five years. The conditions attached to these subsidies are that the courses must answer a clearly identifiable social need, that they will be able to finance themselves after five years and that the universities ensure that there is no duplication of effort.

The Delft-Leiden co-ordinating body for biotechnological studies has, without awaiting the outcome of the above discussions, already devised a post graduate course in biotechnology for graduate (micro)biologists, biochemists and chemical engineers. The course lasts for $1^1/_2$ years and has places for 25 students. The course costs amount to 30,000 guilders, of which the student himself must pay 4000 guilders. The course is composed of a series of separate units, some of which have been taken over from the First Phase, so that, for instance, a biologist will be able to take engineering classes. In addition, a number of advanced courses have been introduced which can also serve as postgraduate courses. The application of this system of multi-purpose units helps to keep the course costs down. To round off the course, the student undertakes an 11-month multi-disciplinary research project. The course can also be used to retrain unemployed chemists and biologists.

University refresher courses

Refresher courses for graduates are the exclusive province of the universities, who have discovered such courses to be *lucrative sources of income*. The demand for postgraduate (technical) courses is expected to increase, not only as a result of the rapid changes in science and technology, but also because of the reduction of university curricula. The requirements of these specially commissioned courses are discussed and agreed with the client (usually a company) and the course participant himself. Amongst industrial chemists there clearly exists a great demand for toxicology and safety knowhow. Courses in reactor technology, physical transfer processes and particulate behaviour are also very much in vogue.

MRS. N. GINJAAR-MAAS, State Secretary of Education and a chemist herself, is advocating making the study of mathematics and one of the natural sciences compulsory in secondary education. She hopes that this will raise the number of girls going into natural sciences after leaving secondary education.

In the province of Higher Professional Education there have been no developments at all in the direction of a Second Phase. Nor does J.B.M. Laauwen expect many recently graduated in this sector to go straight on to a continuation course, as the course which they have just completed is an end in itself. He believes that it would be more effective first to accumulate a few years of industrial experience and then to follow a detailed course specialising in a particular field. For this purpose they could take advantage of the new system by availing themselves of the university Second-Phase or postgraduate vocational courses.

As a result of the introduction of the new *Conditions of Employment Act* the chemical industry has to devote more attention to accident prevention in addition to its traditional concern with accident protection. This calls for expertise in the fields of risk analysis, breakdown analysis and reliability analysis. Since this entails the employment of experienced technologists, the HTSs have set up a continuation course in safety and industrial hygiene. There are many similarly motivated courses which have arisen in response to a call for a knowledge of modern analytical techniques, information technology and automation, bioprocess technology and measurement and control techniques. These courses, which are not government-subsidised, are provided by the Higher Professional Education Establishments and the universities, course costs varying from a few hundred to some thousands of guilders.

The Open University (OU)

The Open University started up in the Netherlands in 1984, the British version serving as a model in many respects. The graduate courses in the natural sciences deviate from the traditional university courses in that they cover the themes of nutrition and toxicology, ecology and business administration. The first of these offers the best opportunity for a scientific study in depth, whereas ecology is dealt with in more general terms. The object of the business administration part is to channel more people with a scientific background into higher management. In this way, side by side with an interest in the sciences, an interest is also generated in the humanities, law, economics and commerce. The curriculum consists of a mixture of specialised courses and courses whose principal objective is the integration of knowledge.

The OU's method of teaching by '*remote control*' has entailed interesting innovations in teaching techniques. For instance, in the Chemistry 1 course two computer-aided teaching modules have been incorporated which were developed under the supervision of Prof. H. Schenk (University of Amsterdam). The first one teaches the student to build an exact replica of an organic molecule on the basis of literature data. The second module is an aid to the planning of a multi-stage organic synthesis.

In the introductory course on natural sciences Dr. M.C.E. van Dam-Mieras and Prof. A.P. Zuur (State University of Leiden) have introduced an experimental form of '*Practical Work by Video*'. Practical work performed by first-year students at Leiden University was recorded as accurately and in as much detail as possible on series of video-discs and was used as a model for the OU approach. According to this approach, the student is first supplied with written documentation on the theoretical preparation and planning of experiments and then sees them being carried out by Laser Vision. The advantage of using video discs instead of video is that any one of a series of acts can be held in view as long as required and the tempo of the lesson adjusted accordingly. On the basis of the answers to a questionnaire it will be ascertained what the OU students who followed the experiments by Laser Vision learnt as compared with what was learnt by the Leiden students who themselves performed them.

Women in chemistry

In 1983 82% of the boys and 57% of the girls enjoying pre-university education chose mathematics as one of their examination subjects. However, only 25% of the girls were interested in the natural sciences. This has made it impossible for large groups of women to study the exact or applied sciences. In 1975 the number of girls attending technological universities reached a low of 1.9%. In 1983 this figure had risen to 3.5%. For chemical engineering this figure is somewhat higher (around 10%). It is nevertheless clear that an enormous potential of female talent is being lost to chemistry. This problem is being attacked on many fronts. One line of attack is being championed by *Mrs. N. Ginjaar-Maas,* a State Secretary of Education and herself a chemist. She is advocating making the study of mathematics and one of the natural sciences compulsory in secondary education. Before this can happen, the curriculum will, of course, have to be changed so as to make these subjects more attractive. She would also like to experiment with the idea of teaching this type of subject to girls in their own separate groups. Finally, she feels that teachers should make more of an effort to tune into the girls' own distinctive intellectual wavelengths.

Prof. A.P. Zuur (State University of Leiden) completely disagrees with Mrs. Ginjaar. In his view the time is now ripe for an extensive revision of chemistry teaching at the senior secondary level. To make mathematics, physics and chemistry compulsory subjects in the form in which they are currently being taught at this level he considers to be totally pointless. Instead, he suggests making 'General Science' (together with Dutch and English) compulsory. 'General Science' would comprise chemistry, physics, biology and geography and related subjects which would all be treated as an integrated whole, with the emphasis heavily placed on developments in the community and the way in which these affect the day-to-day world of the pupil. Chemistry, physics etc. would, of course, remain available as optional subjects to anyone interested in studying them, but the approach to such subjects would be strongly focussed on the technical content.

Zuur further urges that this type of education should not be geared to the needs of further education of a vocational or university type. In principle, it should be possible to include chemistry in any course syllabus as long as an effort is made to remove any deficiencies which might arise. This would entail supplying further training at a later stage to a large number of pupils, which Zuur considers to be an appropriate task for the universities. According to him, this can be done excellently and economically by means of computer-aided education. This would, for instance, enable more girls (and boys) who had initially chosen the 'wrong' set of subjects to study chemistry after all.

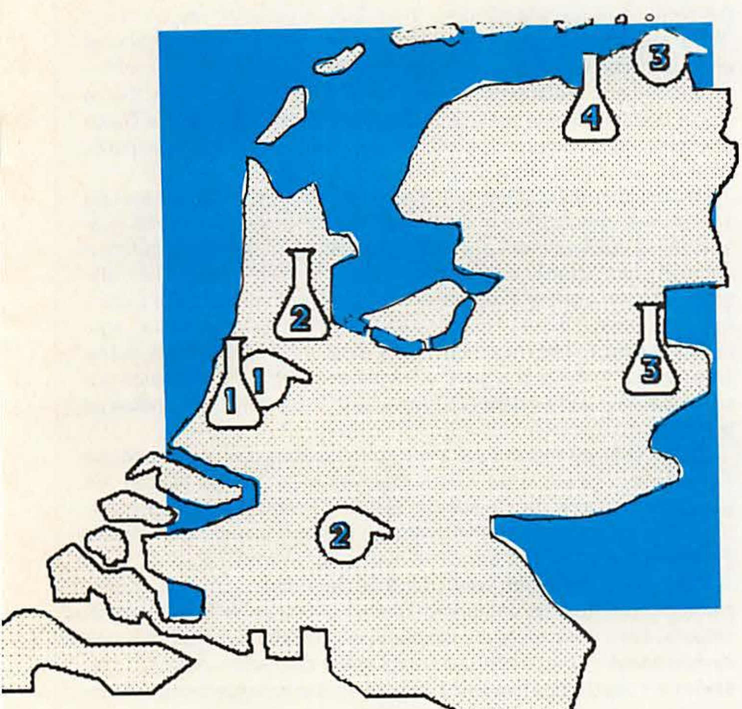
Conclusion

Changes in both public attitudes and didactic approaches to the subject over the last twenty years have drastically altered the face of chemistry teaching in the Netherlands. The search for a type of education that will give every citizen a reasonable picture of the chemical processes taking place around him still continues. What is more, many more young people have to be inspired with an enthusiasm for chemistry as a profession. There have been considerable budget cutbacks and huge changes to the structure of education in recent years, especially at university level. Although this situation does not make the work of teachers any easier, it does afford an opportunity for achieving various improvements to the educational system. The latest slogan of the Ministry of Education '*Higher Education, Autonomy and Quality*' gives us the hope of a future where there is less government interference and a greater appreciation of top quality.

LAUNCHING A BUSINESS IN A HIGH-TECH COUNTRY

By emphasing the Netherlands' strong points as a distribution centre, the Ministry of Economic Affairs has since 1978 succeeded in 110 foreign companies operating in the distribution field to establish a business in the Netherlands. This is all part of a new campaign to present the Netherlands to the world as a high-tech country.

Jos van den Broek



RECENTLY ESTABLISHED FOREIGN COMPANIES (Kjelldall flasks nr. 1 Centocor and Promega in Leiden, 2 Fuji in Tilburg and 3 Katalistiks in Delfzijl) and Science Parks (erlenmeyer flasks nr. 1 in Leiden, nr. 2 in Amsterdam, 3 in Twente and 4 in Groningen) Choosing the most suitable area is of big importance. Fuji, for instance needed clear water, while Katalistiks profited from relatively high investment premiums and cheap land. Other motives are the vicinity of universities (Science Parks) or good transport routes.

This campaign, which was specially planned by the *Commission for Foreign Investment in the Netherlands* (a department of the Ministry of Economic Affairs), has been a success. The number of new companies operating in the *distribution sector* has increased spectacularly since 1978. In the period 1982-1985 investments amounted to 250 million guilders. Of this total the USA invested 100 million guilders and Japan 120 million guilders.

The Commission has three key tasks: 1 *to recruit potential investors;* 2 *to arrange for their reception;* 3 *to prepare canvassing campaigns.*

The first task is in the field; a number of industrial commissioners recruit new investors on the spot, their activities being principally focussed on the USA, Japan and Western Europe.

About half of the foreign investors are from the American market. Five commissioners operate in the United States: three in New York and two in San Francisco. This is not really enough for such a large area. The Ministry of Economic Affairs is seriously considering the possibility of increasing its activities in the USA.

A quarter of the investors come from Japan, the market in that country being covered by a commissioner in Tokyo. There is as yet no representative in Osaka, Japan's second largest industrial region. This situation may change in the near future.

A quarter of the foreign companies which invest in the Netherlands also come from Western Europe. The two commissioners for Europe focus their attention mainly on Great Britain, Switzerland, Scandinavia and Western Germany. A third commissioner will join them this year whose task will be to recruit companies from France, Spain and Italy.

Korea

The head of the Commission, T.J. van Heesch, recently said in an interview with the *Financieele Dagblad* (the Dutch equivalent of the Financial Times) that he wanted to change the boundaries of the area covered by the Commission. To quote his words: 'Outside the USA, Japan and Western Europe there are still many other interesting areas worth investigating such as Korea, for example. The time has now come to consider whether we should not also have a representative there'. In van Heesch's opinion, other parts of the world will

FUJI: CLEAR WATER AND A CLEAR MIND

Clear water is just as essential for the production of photographic paper as it is for the preparation of Scotch Whisky. It is logical, therefore, that Fuji should go to Scotland to seek a location for its European base. However, in the final analysis this Japanese company selected neither the water from the Scottish Highlands nor even the mountain water from the Swiss Jura but the groundwater underlying North Brabant, one of the Netherlands' southern provinces.

At the end of the seventies the Japanese Fuji Photo Film Co. Ltd. made plans to build a large plant in Europe. By having a European production base, Fuji hoped to enlarge its share of the European film and photographic market considerably. The site finally selected would, however, have to meet a number of important conditions.

At the beginning of 1980 Kenzo Tatsuuma was commissioned to collect data as to suitable locations. He had had plenty of experience in this sort of work, having previously been responsible for building three smaller Fuji plants in Brazil, Korea and Indonesia.

Tatsuuma finally chose Tilburg, a town in the south of the Netherlands. In 1983 the first pile was driven for the construction of a plant for the manufacture of photographic paper. When the last of the three construction phases has been completed, about three hundred people will be working in a fully automated plant. A plant for the manufacture of film is also being planned. When we asked Kenzo Tatsuuma, who is now the director of Fuji's European plant, why he had selected Tilburg, he replied as follows: 'Ninety percent of what we produce here is exported to other European countries. We prefer to concentrate production and distribution in the same place. Moreover, we have very favourable road connections here. This was one of our main reasons for coming.'

A factor of no less importance than those mentioned above is Fuji's need for *clean air and clear water*, a self-explanatory requirement for a plant manufacturing photographic film and photographic paper. The plants in Ashigara in Japan draw their water from Mount Fuji, which made it very likely that the European choice would have fallen on the Scottish Highlands or the Swiss Jura. Nevertheles, the Japanese finally decided to select the Netherlands' southern province of North Barbant because the groundwater at that location more satisfactorily met their stringent quality requirements.

Tatsuuma, with remarkable frankness, cited a number of other reasons why he had selected this area as the location for his plant. 'I find the quality of the work in Tilburg and the surrounding area to be very good. This town used to be a centre of the textile industry and is, therefore, very industry-minded.' With obvious pleasure he continued: 'We are struck by the great enthusiasm for work and the *excellent work ethic*, qualities which completely satisfy our expectations.'

Furthermore, Tatsuuma considered it a great advantage that a stable political climate prevails in the Netherlands and that the Dutch are prepared to compromise. 'An unbiased attitude facilitates exports. After all, we export our products all over Europe.'

He considered the *stable and strong guilder* another advantage. He was no less appreciative of the helpful attitude of the central and local authorities. 'Government authorities are usually very friendly before a company has actually established itself but quickly change their attitude once the plant is in operation. Here, on the contrary, my experience has been different.' In Tatsuuma's opinion, environmental regulations like the Public Nuisance Act are strict in the Netherlands, but he emphasised that this is a great advantage for Fuji. 'Our operation is a very clean one and we cannot afford to be in the vicinity of and industrial pollution.'

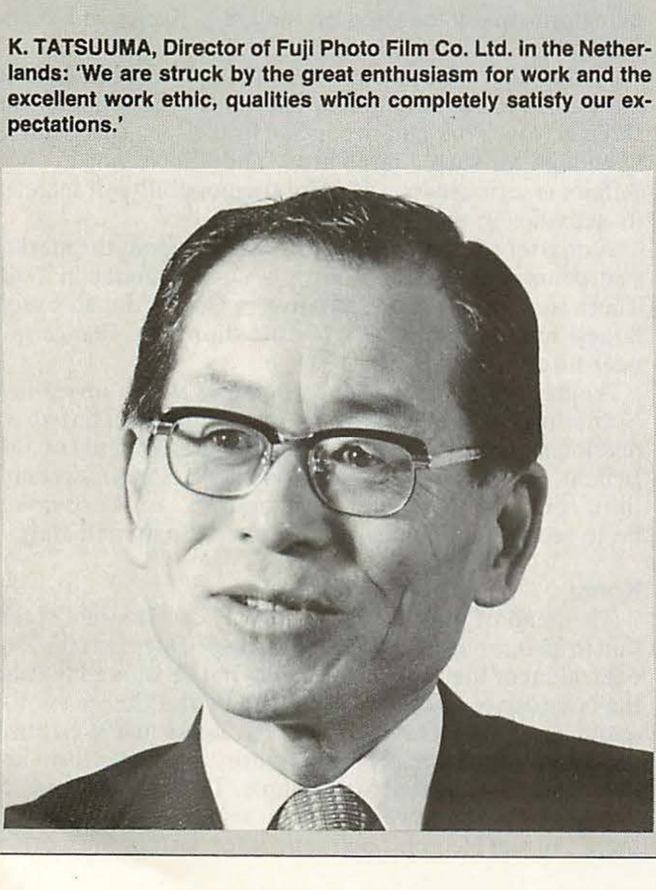
'Dutch subsidy regulations are also reasonably fair' continued the Fuji director. 'Unexploited labour reserves are relatively high in this area and, therefore, the Regional Investment Premium is also relatively high. The combination of this premium with the Investment Account Premium makes this an attractive market for foreign investors.'

Kenzo Tatsuuma was very complimentary about *the high level of training* given here as compared to other countries. In Tilburg and in close-by Eindhoven there are various institutions for training high-quality personnel. 'To operate our complicated computer-controlled machines we need operators who have reached at least Secondary Technological School Level. Chief operators must, in fact, be at least of Higher Technological School standard. We are well supplied with personnel of this calibre in this area.'

Another advantage of the good-quality education given in the Netherlands is the widespread knowledge of English. This is most important for a Japan-based company. A disadvantage, however, is the fact that Tatsuuma himself speaks hardly any Dutch.

One of those closely involved in the establishment of Fuji in the Netherlands was Frans L.C. Kok, the project manager for Japan in the Commission for Foreign Investment in the Netherlands at the Ministry of Economic Affairs. To quote Kok: 'We spent weeks travelling all over the place with Mr. Tatsuuma, visiting schools, suppliers, building contractors, architects and engineering design bureaux. In addition, we furnished him with data on, for example, salaries and levels of training. Last but not least, we sent many large water samples to Japan for analysis.' Kok is still in almost weekly contract with Fuji because it is continuously expanding. *'After-sales service'* is his name for it.

K. TATSUUMA, Director of Fuji Photo Film Co. Ltd. in the Netherlands: 'We are struck by the great enthusiasm for work and the excellent work ethic, qualities which completely satisfy our expectations.'



on the long term also be drawn into the canvassing net. To the areas which have meanwhile come under the purview of the Commission the South American countries can be added, particularly Brazil.

The industrial commissioners make initial contact by means of seminars, trade fairs or a network of consultancy bureaux. In addition, there are firms operating in the Netherlands like Peat Marwick and Price Waterhouse which contact investors and, hence, act in a way like estate agents. Regional development associations and cities such as Amsterdam and Rotterdam and other smaller towns also make contact with interested companies.

The commission's second task is to arrange for the reception of potential investors. Once a potential investor has shown some interest in the Dutch market, he then comes under the aegis of the Commission's *Project Management Department.* These project managers follow the project through all their stages, even after the company has been launched (see Fuji). Together with the interested parties, they visit the sites already selected by the potential investors for the establishment of a new company. In addition, they make contact with regional development associations, management trusts and foundations such as the Industrial Project Foundation. The provision of information about the various subsidy regulations is, of course, an important task of the Project Management Department.

Canvassing Campaigns

The third task of the Commission for Foreign Investment in the Netherlands is to prepare *canvassing campaigns.* Joris J.J. Vogelaar, the head of the department concerned, explained the work as follows: 'We develop new canvassing campaigns highlighting the respects in which the Netherlands is an interesting place for investors to launch a new business'.

Mr. Vogelaar's department also plays a co-ordinating role between the commissioners abroad and those operating on the home scene. Although there is obviously no point in organising incidental campaigns to cover separate regions of the Netherlands, these regions can, nevertheless, profit from the Commission's expertise.

Incidental campaigns have in any case little point. To quote Vogelaar: 'The organisation of separate campaigns by local municipalities, regions and development bodies generally has little point. Such campaigns will have little chance of success if we have not first told potential investors where the Netherlands is on the map. The Netherlands must be 'sold' abroad'.

Luckily, co-ordinated campaigns have led to more attention being focussed on the Netherlands. *Katalistiks* have built a plant for the manufacture of catalysts as a result of one such campaign. Gary H. Danner, the project manager of the Commission for Foreign Investment, explained this as follows: 'Some regions, such as the North Netherlands', are experiencing a relatively high degree of unemployment and, therefore, award high premiums to any company wishing to invest there. Such premiums are very attractive to such types of industrial enterprises as chemical companies, for whom every cent saved per kilo is important. What is more, land is cheaper out in the regions'.

Gateway to Europe

As already mentioned, until recently the emphasis has been on the Netherlands as the *distribution centre* for the Western European market. To quote Vogelaar: 'We advertised ourselves as Holland, the Gateway to Europe.' This strategy proved very successful; recently, the 110th company was ushered into the distribution sector, which represents one third of alle foreign companies which have established themselves in the Netherlands since the beginning of the campaign.

Meanwhile, two eminently eligible candidates have now joined the campaign: HIDC and Distriport. HIDC (Holland International Distribution Center) functions as a co-ordinating link between the KLM, the city of Amsterdam, the international airport at Schiphol and the air charterers. In Distriport the city of Rotterdam (the world's largest seaport) and the local shipping and distribution companies work together. Both the above organisations are jointly focussing their recruiting efforts on the United States and the Far East.

The joint activities of Distriport and HIDC allow the Commission for Foreign Investment more scope for the development of new activities focussed on the *Netherlands as a high-tech centre.*

T.J. VAN HEESCH, Head of the Commission for Foreign Investment in the Netherlands of the Ministry of Economic Affairs, wants to enlarge the boudaries of the area covered by the Commission. It is now active in the USA, Japan and Western Europe.

Biotechnology

According to Vogelaar: 'The Netherlands is one of the oldest high-tech countries in the world. We are now allowing foreign investors to see what we are achieving, for example, in the field of biotechnology'. Moreover, the Ministry of Economic Affairs has described the Dutch biotechnological scene in two brochures. These explain what industrial companies and universities are doing in this field and what forms of co-operation exist between the two sides.

Vogelaar's department is currently preparing a brochure on the market for medical technology in the Netherlands, a market in which the Netherlands occupies a very important place. This brochure will appear later this year. The same applies to the market for computer-aided design/computer-aided manufacturing (CAD/CAM). What is more, at some time in the future, Vogelaar will be turning his attention to other fields in which the Netherlands play a prominent role such as in ecology and membranology.

To quote Vogelaar: 'It is interesting to highlight a radical change in government policy over the last two or three years. A few years ago it was the policy to give aid to the weaker sectors of industry. Under the current *'Target Area'* policy, aid is given to companies with growth potential. Although not a hard and fast rule, it is often the custom of our canvassing planning department to co-operate with this policy. In this way we have attracted three biotechnological companies to the Netherlands: Centocor, Mogen and Promega.'

Science Parks

All three companies have premises in the Bioscience Park in Leiden in the Western Netherlands. This park is the result of the initiative of the Leiden City Council and the University of Leiden and is situated at a stone's throw from the modern headquarters of the university's science departments.

Centocor is well advanced in building a plant for the manufacture of monoclonal antibodies. The director of Centocor, Dr. Hubert J.P. Schoemaker, expects to be able to start production some time this year. Meanwhile, the first excavation work has begun on the proposed site for the Mogen company. Promega, on the other hand, is still temporarily housed in the university laboratories.

The project manager, Gary H. Danner, has been closely involved in the establishment of Mogen and Centocor at Leiden. To quote Danner: 'The Netherlands is a very attractive location for companies of this kind on account of the biotechnological infrastructure of the country. In addition, the University of Leiden has at its disposal a number of

J.J.J. VOGELAAR, active in the preparation of the canvassing campaigns of the Ministry of Economic Affairs: 'Incidental campaigns by local municipalities, regions and development bodies generally have little point. First of all, you must tell a potential investor where the Netherlands is on the map.'

G.J. DANNER, a project manager of the Ministry of Economic Affairs: 'The idea of biotechnological Science Parks greatly appeals to the Americans because of their similarity with the campuses where they themselves were raised.'

world-famous researchers in the field of biotechnology. According to Danner, the idea of a Science Park greatly appeals to the Americans: 'They like beautiful buildings in green surroundings. These are, as it were, reconstructions of the campuses where they themselves were raised.' Danner definitely expects this first batch of businesses to act as an inducement to others to follow.

Recently a university industrial centre was established in the same Science Park. Here any enterprises wishing to establish themselves can rent laboratory facilities for a small fee and at the same time, because of the close proximity of the university science departments, can also have recourse to the knowhow, skills and equipment available there.

Business

It is clear the the word 'business' has now been at last accepted into the terminology of the Dutch academic world. 'Commerce is no longer a dirty word' is the slogan which Cees van Puffelen is ventilating in the academic upper reaches of the State University of Groningen. Van Puffelen is a director of the Science Park in the Netherlands' northernmost university city. He is trying to commercialise the University of Groningen's research work.

J. BLAAK, director of the MIP: 'For companies wishing to invest in the Netherlands it is attractive to work with a government body which is also interested in making a profit.'

For the first five years the Ministries both of Education and Economic Affairs will be granting a total subsidy of 7.8 million guilders and the University of Groningen will be adding 1.5 million guilders to this amount. Finally, the participating industrialists will also be contributing. It is estimated that the total amount for the first five years will be 16.8 million guilders.

Van Puffelen is looking for manufacturers for each of the University of Groningen's commercially feasible projects. The Noordelijke Ontwikkelings Maatschappij (Northern Development Foundation) is, of course, closely involved in this. Candidate companies are being sought not only from the north but also from other parts of the country and abroad. For instance, an American company manufacturing sensors will be coming to Groningen.

The fact that academic knowledge can be turned into money has been proved by Syncom B.V., a small company engaged in the small-scale production of fine chemicals. Syncom originated within the Department of Organic Chemistry at the initiative of Prof. Hans Wijnberg, in whose department many chemical materials are synthesised. This company was set up in order to exploit the knowhow available and to supply the special chemicals needed in certain syntheses and research projects. Océ-Andeno, a manufacturer of fine chemicals, associated with the activities of this small company.

Plans are also being drawn up at other universities besides Leiden and Groningen for the establishment of Science Parks. The Technological University of Twente, the only university in the Netherlands with a real campus, which is situated in a woodland area in the east of the country, is on the point of putting such a plan into operation.

MIP

The MIP (Industrial Project Development Foundation) has played an important role in the establishment of high-tech industries in the Netherlands, including, for example, the Centocor and Mogen companies located in the Bioscience Park in Leiden. This foundation was set up to channel investments coming into new industrial activities as an integral part of the re-industrialisation policy. Another stimulus was provided by the shortage of *risk-bearing capital* in the Netherlands business world.

'The MIP is a classical case of a venture-capital company, its aim being to participate in new investments', states Jaap Blaak, one of MIP's directors. The MIP participates not only in companies being newly launched but also in existing companies, in order to promote the expansion of business. The Ministry of Economic Affairs is with its 27% the largest shareholder, the remaining 43% of the shares being in the hands of 86 private investors, such as pension funds, insurance companies and banks.

The MIP has adopted a number of interesting principles. For instance, it is never responsible for more than 49.9% of the risk-bearing capital. If there are several partners, the MIP will not generally wish to be much larger then the largest shareholder. Furthermore, it is, in principle, only a temporary partner. Usually, after 7-10 years it will sell off its shares in order to create funds for new activities.

According to Blaak, the MIP prefers to invest in the risk-

bearing sector rather than banks, pension funds and insurance companies, which prefer to look for a constant source of income and risk free investments.

To quote Blaak: 'For companies wishing to invest in the Netherlands it is attractive to work with a government body which is also interested in making a profit. After all, a body that confines itself just to granting subsidies has quite different criteria.'

According to Blaak, the MIP is mainly interested in sectors in the Netherlands where growth can be expected because they are as yet underdeveloped. It is actively canvassing in the United States for companies operating in such sectors. This is, of course, being done in close consultation with the Ministry of Economic Affairs and the industrial commissioners.

The MIP even has a resident contact man in the United States, Daniel J. Piliero, who lived in the Netherlands for 15 years, was President of the Dutch branch of Chevron and was Chairman of the American Chamber Of Commerce (AmCham) for many years. In short, a man who is not afraid to crack the whip. Piliero has established numerous contacts with the American venture capital world, with investment bankers and with firms of accountants. This is, for instance, how Centocor found its way to the MIP.

Monoclonal Antibodies

The MIP has an interest in the growing market for *monoclonal antibodies*, a field in which important research is being carried out in the Netherlands but whose commercial potential has not been exploited. Centocor, a biotechnological company from Philadelphia, are developing a variety of products in this field for use, firstly, in the diagnosis of heart and vascular diseases and cancer and, secondly, in the treatment of such diseases. There is expected to be a large market for such products. Centocor have invested $ 30 million in the Netherlands in order to commercialise the knowhow now available in this country and the MIP is contributing $ 2.5 million towards this project.

THE LEIDEN SCIENCE PARK. Near the State University of Leiden, a Bio-Science park is under construction. Three foreign biotechnological companies have launched a business there.

Mogen (Molecular Genetics) from Minnetonka, Minnesota, came to the Netherlands mainly on account of their interest in the *Dutch seed industry*. This is a well developed industry enjoying a substantial share of the world market. There are, however, technical developments taking place in the perfecting of seed cultivation techniques in which modern biotechnology is playing an important role.

It is impossible for smaller seed companies to acquire these techniques but, as Mogen possess an expert knowledge of them, such companies in the Netherlands are invited to conclude research contracts with Mogen and also to participate in the research. The MIP has a $ 2 million share in Mogen. To quote Blaak: 'The MIP are trying to look for suitable American companies willing to adapt themselves to Dutch business structures and activities.'

Entry into Europe

Blaak made the following concluding comment: 'In the case of many small and middlesized companies from the United States and Japan who do not know their way around Europe it is good to have a pilot on board like the MIP who knows Europe well and can take us safely through the harbour entrance.' This conclusion received unsolicited endorsement a few days later from Centocor's director, Mr. Schoemaker, in the following words: 'The entry obtained through the food offices of the MIP was probably more important to us than the money!'

TECHNICAL ADVICE

Research is an expensive necessity in a world where to stay put is to stay behind. Because many chemical companies lack the knowhow, time or equipment to carry out research themselves, this work is often farmed out to research establishments. Those playing an important role in the Netherlands world of chemistry will be reviewed in this article.

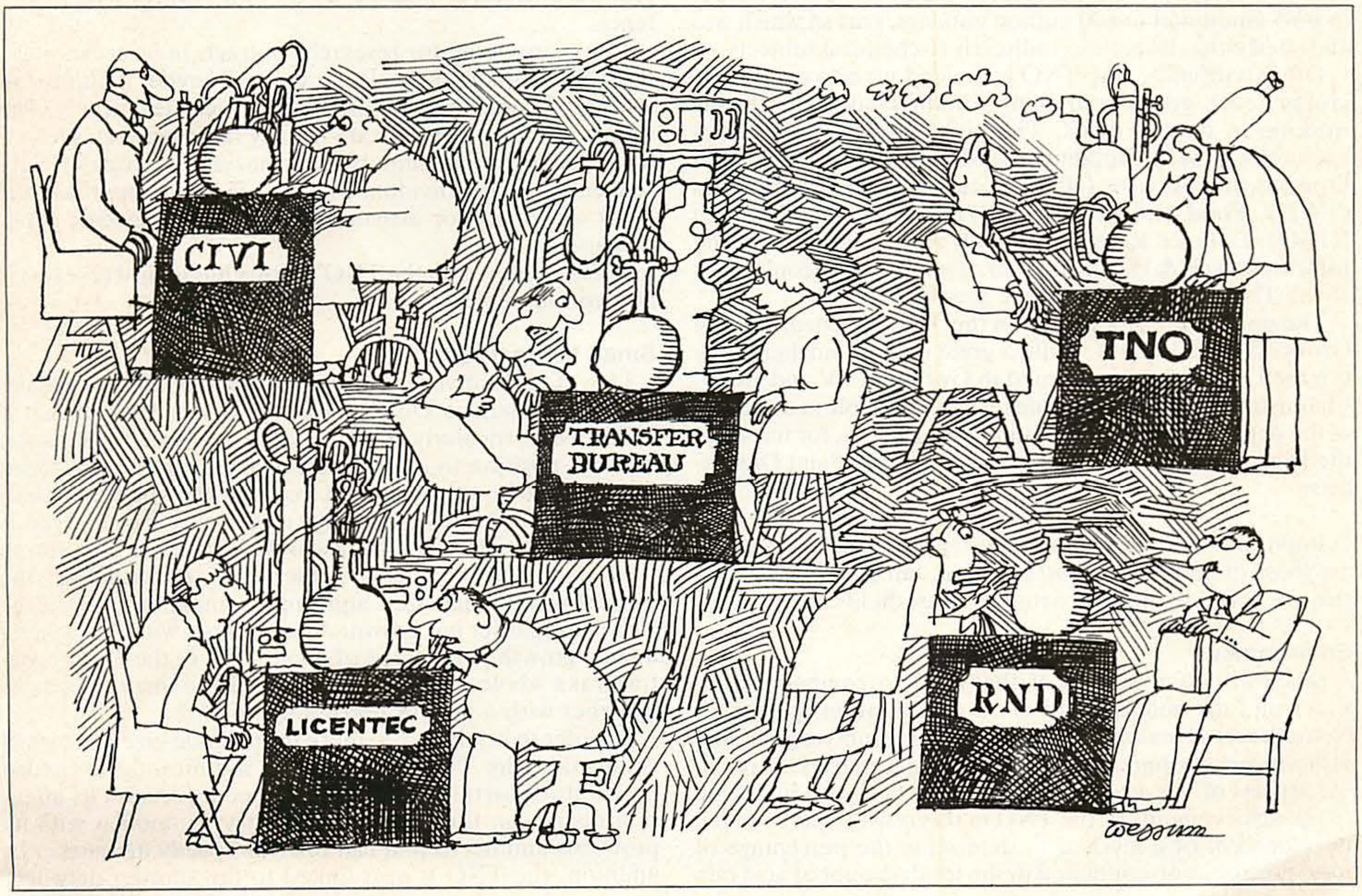
Nico Berendsen

'Scientists are just like racing cyclists with the one in front having to keep an eye on his nearest rivals,' once said by Prof. H. Bloemendal, a renowned biochemist at the Roman Catholic University of Nijmegen. No front runner can be first past the post without the indispensable support of his team mates. Technical advice bureaux bear a close resemblance to these team mates. It is almost impossible for a company to carry out on its own all the research that is needed to keep it in the forefront.

By far the largest establishment performing contract research and development work in the Netherlands is the *Netherlands Organization for Applied Scientific Research* (TNO), which has a staff of approximately 5000. Contract research, which in the united States is usually carried out by the universities, is performed in the Netherlands by the TNO.

Traditionally, Netherlands universities have focussed their efforts almost exclusively on fundamental research. This left a gap, which was filled in the thirties by the establishment of the TNO. Two other advice bureaux, *RND and CIVI,* which operate more in the fields of business economics, technical economics and management, also date from this time. In this critical period it was necessary to give industry a greater innovative impetus. Fundamental research data had to be adapted for practical application in profitable industrial processes.

The *transfer units* located at the traditional universities, the technical universities and *the Licentec foundation* are of



a much more recent date, being only about five years old. These units can be viewed as a practical manifestation of the positive attitude of the academic world towards industry. On the one hand, these units are endeavouring to accord a cash value to the research data generated at research establishments and, on the other hand, they wish to give medium-sized and small companies an opportunity to profit from available expertise. One of the most important activities of the independent foundation, Licentec, is also the commercialization of innovative university research data.

It is a remarkable fact that Licentec and the transfer units were, just like the TNO, CIVI and RND, set up at a time when the economy was at a fairly low ebb and innovatory activities were being sought in industry.

TNO

The Netherlands Organization for Applied Scientific Research (TNO) was set up in 1932 on the initiative of the Netherlands Government with the legally defined objective of ensuring that the results of technological and scientific research served the public interest.

The TNO is an independent establishment that derives a large percentage of its income from contract research. In the case of the industrially oriented departments within the TNO, this varies from 70 to 90%. The TNO receives the rest of its income from the Government. The TNO's total budget in 1985 amounted to 600 million guilders, part of which was allocated either directly or indirectly to chemical subjects.

Organisationally, the TNO is divided up into eight main groups, each group containing a number of departments working in related fields. The eight groups cover Social Technology (MT), Building and Metal (B & M), Industrial Products and Services (IPD), Technical Scientific Services (TWD), Food and Foodstuffs (HVV), Health Research (HGO), Defence Research (HDO) and Policy Studies and Information (B & I). A total staff of about 5000 people work at the TNO, 25% of whom are graduates.

The most important groups in the TNO for chemistry are Groups MT and HDO, while a great deal of biochemically oriented research is performed in Groups HVV and HGO. Chemistry also plays a far from insignificant role in a number of the departments within Group IPD, such as, for instance, the Plastics and Rubber Department and the Paint Department.

Important fields in which chemistry plays a significant role are those of the *environment* and *food*, but the TNO's activities are certainly not restricted to these fields.

Environment

Much attention is paid at the TNO to combating soil, water and air pollution. In close co-operation with other Netherlands research establishments and universities and also with establishments in neighbouring countries, all possible aspects of the *acid rain problem* are being studied. One of the achievements of the TNO in this respect has been the development of a method to determine the percentage of 'dry' precipitation contained in the total amount of acid rain which the Netherlands soil has to absorb annually. Another research project concerned the prevention of organic pollution in the Netherlands atmosphere. From this, the daily amount of pollution breathed in and deposited on the soil was calculated.

This soil pollution also receives plenty of attention at the TNO, where a soil decontamination method has been developed which employs micro-organisms to remove decomposable hydrocarbons.

The TNO usually performs this type of research under contract to the Government, but industry also often requests advice on the disposal of solid and liquid waste.

The TNO also develops *processes* for reducing pollution. For instance, it has studied the effect of anti-emission measures on the incidence of photochemical air pollution over Rijnmond, the area around the port of Rotterdam. Another example is the recovery of heavy metals from waste. The TNO, under contract to a tannery, has, for example, developed a procedure for recovering chromium.

Key areas

The TNO selects from its research programme certain key areas which can serve as good bases from which to initiate new developments. At the TNO much attention is being focussed on *biotechnology* and *information technology* at present. Biotechnological research is spread over three main groups: Social Technology, Food and Foodstuffs and Defence.

In its canvassing for research contracts in biotechnology, the TNO employs a special strategy. It invites a number of interested companies to take part in a cluster project. The subjects of such a project are usually fairly general, such as, for example, how to immobilise an enzyme on a carrier. Subsequently, each individual company is free to approach the TNO separately for assistance with its own specific applications.

Foreign interest in the TNO's biotechnological research is also considerable.

Small companies

One of the motives for setting up the TNO in 1932 was the need to modernise Dutch industry. It was thought that it would be particularly medium-sized and small companies not in a position to afford their own research laboratories which would be able to benefit from the knowhow and facilities of the TNO. However, large companies also emerged as major users of the TNO's research facilities in addition to their own. During the last few years, nevertheless, the interest of medium-sized and small companies in what the TNO has to offer has grown. As compared with the average annual growth percentage of about 10% in the TNO's contracts as a whole, that of medium-sized and small companies is higher with a growth percentage of 15%.

In order to be able to do more for medium-sized and small companies, the TNO has recently significantly expanded one of its departments. This department focusses its attention mainly on this corner of industry, is familiar with its problems and needs and can provide speedy assistance. In addition, the TNO is also linked to the transfer network, which means that all incoming questions are passed as quickly and as efficiently as possible to the particular research establishment in the Netherlands most capable of dealing with them.

An example of a small chemical company of this type that has requested the TNO's assistance is *Denka Chemie,* a specialist in pesticides. This small company, which has 40 employees and an annual turnover of about 13 million guilders, is paying the TNO 2,5 million guilders for a five-year research project into the application of *pheromones in insecticides.* The TNO is isolating and synthesising a set of five pheromones, while Denka is responsible for the formulation of the insecticides. The combined use of insecticides and pheromones means that much smaller quantities are needed, which is more economical in the long run and also much more environmentfriendly. The TNO has been performing research in the field of pheromones for approximately fifteen years now.

Abroad

The TNO is turning its attention increasingly to other countries in its quest for research contracts, being particularly attracted to those countries which are important potential customers for Dutch exports. In this respect, it hopes to be able to collaborate especially with those research establishments which are located in neighbouring countries such as West Germany and Belgium. In 1984, the TNO earned 35 million guilders from foreign contracts and in 1985 this amount is estimated to have grown by about 20%.

Transfer units

Transfer units were introduced in 1976, first at the technological universities, but very soon afterwards also at the more traditional universities. These units serve to transfer knowhow from university to industry and to pass back any resultant queries. The object of the exercise is to promote co-operation between universities and industry.

Most of the large-scale companies already had contacts with relevant people at these academic establishments but the medium-sized and small companies were reluctant to make such contacts.

The first transfer units were initially set up at the instigation of both the traditional and the technological universities themselves but they are now subsidised by the Government. Currently and until 1988, money is being placed at their disposal in order to ensure that particularly the medium-sized and small companies can benefit from the technological knowhow available at these academic establishments. Recently, therefore, RND representatives (referred to later) have been located at the various transfer units.

Each transfer unit is, therefore, staffed not only by those who know their way about the academic world but also by those who are acquainted with the problems and needs of medium-sized and small companies. These RND appointments were made at the joint initiative of the Ministeries of Education and Economic Affairs.

Transfer units are located not only in university establishments but also at the TNO, the Government Industrial Consulting Service (RND), at the Orde van Nederlandse Raadgevende Ingenieurs (Association of Netherlands Advising Engineers), to which many engineering bureaux belong, and at the Higher Vocational Schools. All these transfer units are linked via the *transfer network.* The purpose of this network, which is still expanding, is to pass queries as quickly as possible to the particular establishment most capable of dealing with them.

Mediation

The transfer unit acts as an intermediary between industry and the research establishments. Its tasks include the following:

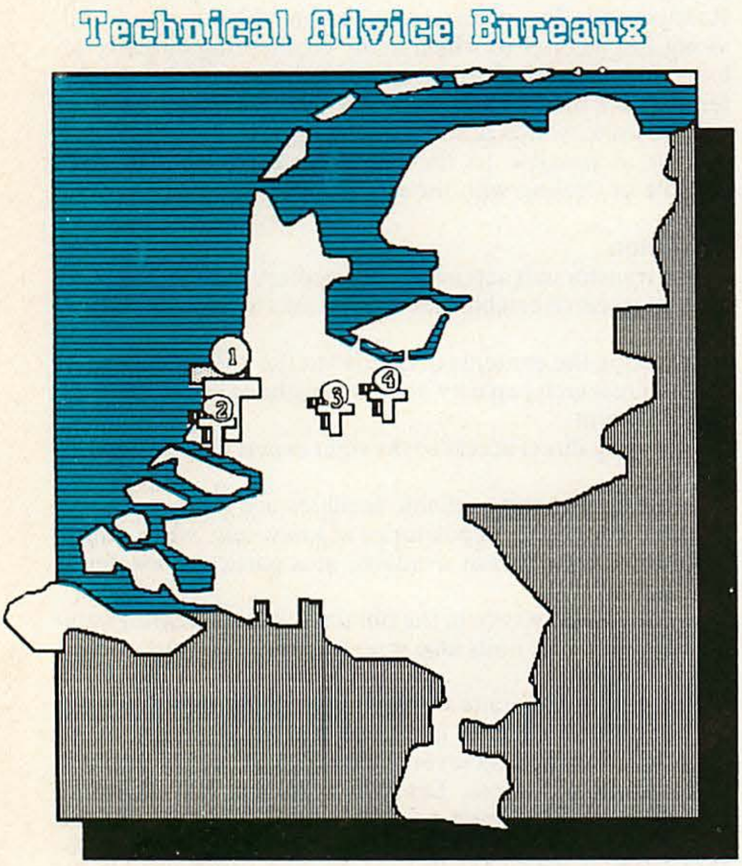
□ matching the contents of queries to the knowhow, expertise and research capacity actually available at the research establishment;
□ providing direct access to the right expert at the establishment;
□ ensuring that the available facilities are used;
□ looking for other depositories of knowhow, when the required knowhow is not available at a particular establishment;
□ rendering assistance in the obtaining of risk-bearing capital. Some transfer units also support companies just starting up in business.

The transfer bureaux were not set up exclusively for the benefit of medium-sized and small companies. In the Netherlands in recent years severe cutbacks have had to be made in university resources. Direct government subsidies (the first source) and indirect government subsidies (the second source) for academic research have, therefore, been somewhat reduced. For this reason, these establishments have more than before been forced to look for other sources of income (i.e. the third source, which is derived from research paid for by industrial companies). In this way the Technological University of Twente, where one of the most active transfer units is located, earned 30% of its income in 1984 from contract research for the Government and industry. The Agricultural University, which, among other things, has a great deal to offer in the field of biotechnology, also earns about 20 million guilders annually from contract research. Some of these assignments are obtained through transfer units.

The number of applications received by both technological and general universities varies considerably. In the case of the former, this figure fluctuates around the 700 level each year, whereas the university transfer units deal with between 200 and 300 applications per annum.

One of the most pleasant current phenomena, in which the transfer units are also playing a part, is the rise of a respectable number of *small high-tech companies* which often have strong links with a university establishment. A few examples are given below:

MTC (Membrane Technology Consultants) is a small, high-tech company of only five years' standing which is located at a stone's throw from the University of Leiden's laboratories. This company specialises in waste water treatment and the recovery of raw materials with the aid of membranes which they have synthesised themselves. MTC uses the university as an intermediary to keep itself up to date



TECHNICAL ADVICE BUREAUX are an important factor in the continuous innovation process of the Dutch chemical industry. A national transfer network is being set up to pass queries as quickly as possible to the most suitable research establishment. RND and CIVI (1) in The Hague, TNO in Delft and zeist (2 en 4) and Licentec in Utrecht (3). Transfer Units are omitted.

with the current 'state of the art' but an important advantage is also the availability of university equipment. This company is housed in the ABC (Academic Companies Centre) where small companies can hire research premises at a favourable rent.

A Netherlands company specialising in **dental technical materials** has provided work for as many as five university establishments, three Dutch and two American. In co-operation with the university of Amsterdam, the company has now developed an artificial tooth root, in which a ceramic coating is fitted on to the metal root. In this way, the implant is fixed to the jaw bone and a bridge or crown can be fitted to it. This result has recently led to the establishment of a new company, Delphi Dental Industries.

The Technological University of Twente has successfully assisted in the **launching of new businesses** and has set up a Company Technological Centre offering office accommodation, knowhow facilities and management support. The transfer unit has directed the feet of various young businessmen to this centre, which has given scores of little companies their start in life.

Licentec

The Licentec foundation is a private body acting as a link between the research and business. Licentec does not carry out any research itself but functions purely as a *mediator and advisor*.

Licentec was set up in 1978. It is financed by Berenschot and the Amro Bank. The foundation has a number of participants: regional development companies, engineering bureaux, a number of patent bureaux. Hence, the foundation works independently of any government agency.

Licentec matches demand and supply by finding a suitable manufacturer for a newly designed product, finding a suitable design or product for a manufacturer or mediates in the conclusion of licensing agreements. Licentec gives advice on patent applications and the evaluation of knowhow. It also assists in market research and negotiations concerning the commercialization of new products. It negotiates on behalf of the client in drawing up co-operation agreements.

It mediates on behalf of the potential supplier of a new product or a new technology in the search for commercial partners at home or abroad. For example, a designer has applied for patent coverage for a product in a number of countries but lacks the opportunities for developing and commercialising his product. Licentec looks for suitable partners at home and abroad and negotiates a suitable contract on behalf of his designer client. A large number of the advisory contracts carried out by Licentec concern the evaluation of commercial value of knowhow or patents. This may be work done on the instructions of, for example, banks or research establishments. In view of the confidential character of the majority of the contracts, it is not generally possible to mention projects by name. Some characteristic exceptions in the licensing field are illustrated by the two examples given below:

□ On the instructions of the University of Groningen, a licensing contract was drawn up covering a revolutionary form of artificial blood vessel. The licensee was the American company Medtronic.

□ On the instructions of the Veeteeltkundig Instituut (Cattle-breeding Institute) at Zeist, a co-operation agreement with a small American company was signed. The latter invention is based on a method for determining the sex of cattle embryos before their implantation.

Licentec can also mediate on behalf of a manufacturer in the search for and acquisition of new products or technologies. For example, a company is looking for new possibilities, such as a new product. Licentec then assists in mapping out the area within which the search has to be made.

Licentec advises whether it is desirable to apply for a patent for an invention. It also estimates the commercial possibilities. For example, some researchers at a university have made a discovery. Before they publish the results of their research (and, hence, lose their proprietary rights) Licentec investigates whether the invention can be patented and whether the product can be marketed. If it is decided to postpone publication and a patent application is filed, Licentec can provide patent protection. They also provide advice on protecting products, processes, and knowhow.

Licentec advises on the commercial value of knowhow, inventions and patents. For example, a bank is requested to finance a project entailing a new product which the applicant wishes to put on the market. In the bank's assessment, the value of the applicant's assets is generally the deciding factor. Licentec gauges the feasibility of a new project. Its financing can, therefore, be based on the profit expectations.

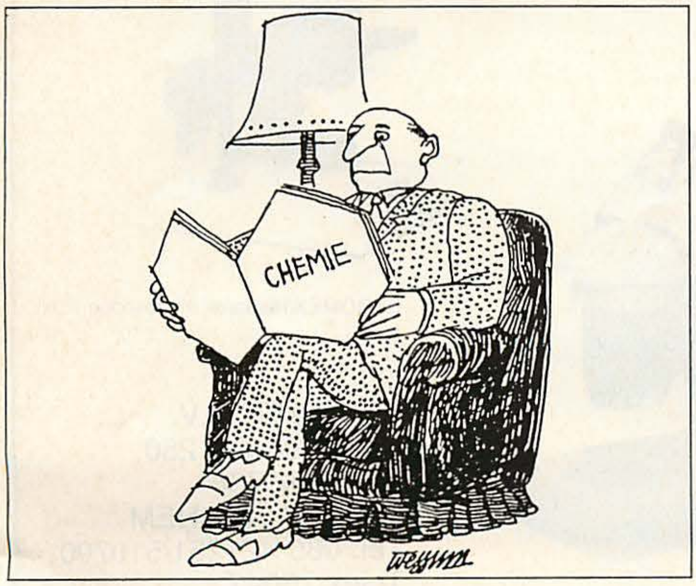
Licentec's function is that of a *knowhow 'matchmaker'*. In seeking licensees, it directs its attentions to both large and small companies, internationally and nationally. Moreover, it also works in an advisory capacity for the EEC, the Government, the universities and investment companies.

CIVI

The *Central Institute for Industrial Development* (CIVI) was, like the TNO, set up in the thirties in a period of economic recession. Both government and local authorities realised at that time that they had themselves to become actively engaged in the development of industry. This resulted in the establishment of local ETIs (Economic Technological Institutes) in the provinces, which were controlled centrally by the CIVI. Not long after that, the ETIs became independent of the CIVI and the latter, which had originally been attached to the Ministry of Economic Affairs, developed into an independent advice bureau.

The CIVI carries out *technological*-economical studies for public authorities and industry. Any resultant report usually provides the client with a basis for management decisions. This report is based on the technical, administrative and commercial aspects.

The CIVI carries out feasibility studies, profitability studies, in-depth business investigations, comparative data evaluations and market research but confines its studies to the industrial sphere. It prefers not to embark on research into the marketing of typical consumer products and matters which fall solely within the province of engineering bureaux and organization advisors.



In addition to studies commissioned by industry, in which CIVI plays a confidential role, it is active in the area of some of the Innovation-Oriented Research Programmes (IOPs) started by the Ministry of Economic Affairs. This Ministry makes funds available for the exploration of research fields with innovatory potential for industry.

(For more information on IOPs, see elsewhere in this issue). The CIVI is actively involved with IOPs in the areas of polymer composites and special polymers, biotechnology and carbohydrates. It indicates, for example, the key areas in the various programmes on which the proposed research should be focussed.

For instance, it advised the Government to support any new biotechnological companies being launched, following the approach already adopted in America since 1982 by the Small Business Innovation Research Program (SBIR). This program supports promising ventures from the start instead of helping those that have failed to recoup their losses after the event. CIVI houses the planning commissions for the biotechnology and carbohydrate IOPs. These commissions are responsible for the organizational and administrative aspects of an IOP.

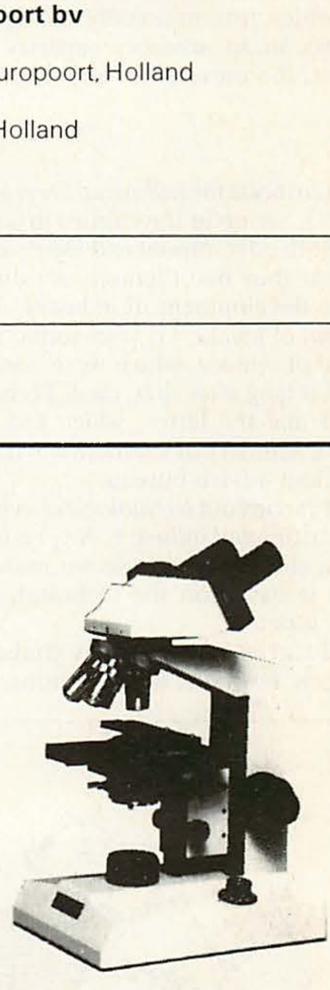
RND

The Rijksnijverheidsdienst, RND, the Governmental Industrial Consulting Service, is a mobile Directorate of the Ministry of Economic Affairs and has a staff of 120 men and women (10% of whom are graduate scientists). This service was founded in 1910 to fulfil the task, briefly stated of *promoting the development of small and medium-sized industrial enterprises* with up to 200 employees. The RND performs no research itself, but can help an enterpreneur to evaluate future prospects and to formulate a plan of action.

RND advises on technological, economic and organisational problems. Normally no charge is made for information and shortterm advice given bij RND. Only when a longer investigation or counselling is necessary is payment required. This service, for example can find a way through the labyrinth of subsidy possibilities for small and medium-sized enterprises.

RND also has many contacts with the large research establishments. With his working knowledge of these organisations the RND advisor can contribute to this communication link, especially by clearly formulating the problem. This task of the RND is sometimes labelled *'transfer of knowledge'*. It is carried out by three transfer units. These being the departments for 'technological advice' in the office at Amsterdam, Tilburg and Zwolle. Their task is to disseminate and to translate scientific knowledge for practical use. They maintain close contacts with colleagues of the transfer units in many research and educational establishments.

Another aim of RND's activities is the *protection of knowledge.* Its Patent Advice Bureau investigates whether a certain invention accords with the rules of Patent Law.



ENGINEERING BUREAUX IN THE NETHERLANDS

The Netherlands is an attractive location for engineering bureaux and the Port of Rotterdam is a focal point for the European (petro)chemical industry, an industry constantly undergoing innovation. The Netherlands is centrally situated between potential customers in the other countries of Western Europe and, in addition, in the last few years has been a central point from which many commissions for projects in the Middle East have been launched.

Nico Berendsen

THE ROTTERDAM AREA. The concentration of chemical industries in this area ensures a continuous number of projects for the engineering bureaux although there is fierce competition between them.

Many chemical companies such as AKZO, Dow, DSM and Shell have their own design offices but the majority of the new designs for chemical plants have been carried out by independent engineering bureaux. Thirteen of such bureaux operating in the chemical field were asked to furnish details of their expertise, projects recently completed, projects in hand, turnover and size of staff.

Of these thirteen four did not reply, namely Coast Engineering, Esmil, Matthew Hall Keynes and DHV. Of those who did reply, some were either originally foreign companies which had established themselves in the Netherlands (for example, Badger, Lummus Crest, Fluor and John Brown) or local Dutch engineering bureaux (for example, Comprimo, KTI and Tebodin). The activities of these Dutch-based companies are focussed mainly on the construction of oil recovery facilities for use in the North Sea, the construction of chemical plants in and around Rotterdam and the development of projects for the Middle East.

Such projects are certainly not there just for the asking, as was the case in the sixties. On the contrary, there is severe competition between these companies and some have had to make cutbacks in recent years. Kellogg Continental BV, for example, had to cease operating in the Spring of 1985 because of a shortage of projects. This contractor, employing a staff of 175 people, was an offshoot of Kellogg in America and the large industrial concern of VMF-Stork in the Netherlands. In spite of the expected difficulties involved, 40 ex-employees announced in the Autumn of 1985 that they were launching a new engineering bureau called 'Continental Engineering BV'. This company, whose staff are experienced in the gas, oil, petrochemical, fertiliser and biotechnology fields, still see many openings on the market. 'Chemical manufacturers are farming an increasing amount of work out and are keeping fewer and fewer people in their own service.'

THE TURNOVER AND EMPLOYEES OF ENGINEERING BUREAUX IN THE NETHERLANDS (n.a. = not available)

	turnover in mln Dutch guilders			employees		
	1983	1984	1985	1983	1984	1985
Comprimo	146	221	220	1394	1453	1450
Tebodin		not available		?	864	1032
Lummus Crest	265	185	295	982	1043	1000
Fluor	153	454	n.a.	851	835	700
Badger	650	400	170	680	710	600
John Brown	102	254	n.a.	395	401	550
Protech	32	36	40	280	300	320
KTI	85	100	120	187	202	250
Alpha Engineering	22	25	30	200	210	220

ALPHA ENGINEERING

Alpha Engineering started to design machines and instruments in 1956. In 1964 food processing and the handling, storage and use of bulk materials were included in the range of industries for which they produced designs. This engineering bureau of about two hundred employees is a subsidiary of VMF-Stork of Amsterdam, one of the largest industrial concerns in the Netherlands.

Alpha Engineering has experience in designing for the food industry (dairy processing plant, plant for the production of starch and its derivatives), the iron and steel industry (coal pulverisation units, blast furnaces) and various other branches of industry such as rubber and plastics processing, glue manufacture and aluminium oxide sintering.

Alpha takes on complete turnkey projects or the entire management of a project. In addition, it also performs part projects for its clients such as consultancy assignments, feasibility studies, project planning and cost control, design and construction, procurement, despatch, and service and equipment inspection.

Projects

Pulverised coal injection system (1983) for Hoogovens IJmuiden BV For the production of iron from iron ore in a blast furnace, coke is essential. However, because coke is expensive, processes have been developed for the addition of up to 50% oil or pulverised coal as fuel. Hoogovens chose pulverised coal injection and engaged Alpha Engineering to construct the facilities required. The latter opted for a process developed by ARMCO in conjection with Babcock and Wilcox (USA). The total investment costs were 85 million guilders, 45 million of which were spent on a coal pulverisation unit. This coal injection system gives savings of 500 000 to 700,000 guilders per week.

Aluminium oxide sintering plant for Alcoa in Ludwigshaven, Western Germany Alpha Engineering were commissioned to build this aluminium oxide sintering plant. Sintered Al_2O_3 is a high-density compound and is not very porous. It is also extremely hard, coming directly after a diamond on the Mohr Scale. This material is often used, therefore, for applications in which sudden changes of temperature and wear occur. The sintering plant too has to meet a number of special requirements because sintering takes place at about 2000°C.

BADGER

The Badger Company was formed in 1841 and through a number of changes of ownership, the company has been known successively as E.B. Badger and Sons Company, Inc., The Badger Manufacturing Company, and, finally, The Badger Company, Inc., now a wholly owned subsidiary of the Raytheon Company.

Badger was among the first engineering bureaux to apply continuous distillation to petroleum processing. Its development work in the 1920's on the cracking, distillation and decomposition of lubricating oils led to, among other achievements, the installation of the earliest continuous vacuum units in the United States for the production of lubricating oils. Early Badger process development work in mass transfer was not limited to distillation, but also included pioneering work in solvent dewaxing and solvent extraction.

Among the achievements which have helped to establish Badger in a position of eminence among process contractors are the application of superfractionation techniques to present-day separation demands and the mastery of fluid catalyst knowhow, which has had many applications in chemical oxidation reactions. Badger has pioneered the development of processes to make styrene from ethylene and benzene, acrylonitrile from ammonia and propylene, and vinyl chloride via an all-ethylene route.

The corporate headquarters of Badger's worldwide organisation and the management of its USA operations are located in Cambridge, Massachusetts. Badger B.V., located in The Hague, the Netherlands, is the headquarters of Badger's European operations.

The Badger organization currently employs about 1400 people. The distribution of employees between the North American and the overseas offices is approximately equal.

Although operating as an independent entity, each major office enjoys a broad exchange of information, experience and services with each of the other offices. Job requirements are often met by the transfer of personnel from one office to another.

Badger is a fully integrated company offering the complete services required to initiate projects of any type and carry them through to completion. The range of services available includes but is not limited to the following: licensing, project financing, project management, engineering and construction.

Badger has earned a reputation for competence in the engineering, procurement and construction of process plants and is fully capable of providing a complete range of service in any geographical area. The combined services of the entire Badger family of companies are available to clients. Often it is advantageous to make use of imported technology and equipment and foreign export credit in the execution of a major project. As a result of Badger's extensive worldwide experience, a knowledge of foreign codes and standards and the ability to work with several codes simultaneously are inherent within the organisation.

Badger is experienced in construction in almost all parts of the world and has available an international pool of construction supervisory personnel. The coordination of the various offices, through corporate management, assures the best utilisation of the construction staff as required geographically.

Badger in The Hague (Binckhorstlaan 117) currently employs 600 people of whom approximately 20% have a university degree. It is the company's largest office on the European continent providing the full scope of Badger's services. This office consolidates all the European activities.Badger has been active in the Netherlands since its establishment in 1956 and ranks among the largest international contractors in the area.

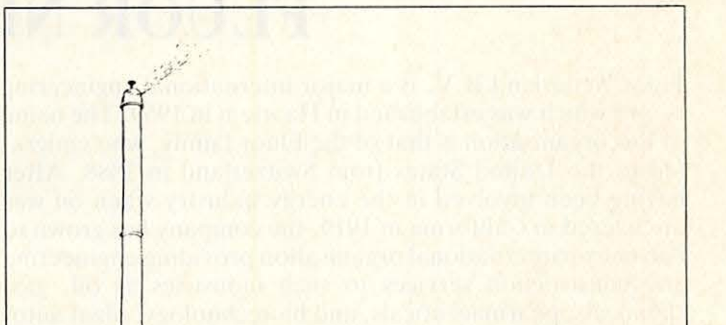
The office in Milan is equipped to deal with local projects and to support worldwide procurement and technical liaison programs.

Major Projects

In 1980 the New Zealand Refining Company awarded a lump sum contract for engineering, procurement and construction to Badger and Chiyoda Chemical Engineering and Construction Company of Japan for their *Whangarei Refinery expansion*. The total value is in excess of one billion US dollars utilising more than two million home office manhours. Completion is scheduled for mid-1986.

During the same year Mitsui Engineering and Shipbuilding Company awarded a contract to Badger for the complete engineering of *a grass roots refinery* in Oman.

Within the last two years Badger has been awarded a number of projects by the Nederlandse Aardolie Maatschappij (NAM) culminating in a *natural gas desulphurisation project* at Emmen in 1984 for the complete engineering, procurement and construction management execution. The project is expected to be on stream in mid-1987.



COMPRIMO

Comprimo B.V. is a Dutch independent engineering and contracting organisation which handles international assignments.

Comprimo's aim still corresponds to the original object of the 'Articles of Association' drawn up for at Comprimo's foundation in 1924: 'to supply and install plant for the chemical industry'. Additionally, Comprimo's activities are concentrated on the revamping and retrofitting of existing installations and on environmental engineering and energy optimization projects.

With a staff of approximately 1450 Comprimo is engaged in the design and supply of installations for oil/gas production (on-/offshore), oil refineries, chemical plants, gas treating plants, energy and utility systems and waste treatment facilities. Engineering and sales offices are located in Amsterdam, Antwerp, Hannover, London, Stavanger, Oman and Singapore.

The overall staff of the Comprimogroup in the Netherlands numbers approximately 1000, 700 of which are employed in the Amsterdam office. Another 450 staff members are employed in the sales and engineering offices abroad. About 50 percent of the staff have a university degree.

The Amsterdam headoffice has a large process department of some 70 engineers for the development and application of process technology. Comprimo has its own – in many countries patented – sulphur recovery technology based on the Claus process with an integral incineration system. Other Comprimo developments include, for instance, a process for producing epichlorohydrin from propylene and chlorine (developed jointly with Spolek pro Chemickou, Czechoslovakia).

Comprimo is in a position to license technologies and to provide processes from licensing companies such as Allied Chemical, Asahi Chemical, BASF, Elf Acquitaine, Houdry, IFP, Norton, Stauffer, Union Carbide and UOP. In 1981 Comprimo became the authorized licensor for a number of Shell processes: ADIP, SULFINOL, SCOT tail gas treating and a process for the degasification of liquid sulphur.

Comprimo has extensive experience in the basic design, project management, process engineering, detailed engineering, procurement and construction of petrochemical and chemical process plants.

Comprimo has special expertise in the production of chlorine/caustic soda, polypropylene and other polymers (polystyrene, MBS, isoprene), epichloorhydrin, carbon tetrachloride, perchlorethylene and vinylchloride monomers.

Other executed special projects include quinine extraction, benzene recovery, aromatics and various pharmaceutical facilities.

Projects

Recent projects include a 10 million Nm^3/d natural gas treating plant (turnkey), a 250 000 mt/a membrane electrolysis chlorine-alkali plant (engineering), a 1.3 million Nm^3/h flue gas desulpharisation (Bisschof process) (engineering, procurement, construction management), a revamp of a 100 000 t/a polypropylene plant (engineering), a modification of natural gas dehydration plants (glycol absorption) with a total capacity of 5.8 million Nm^3/d (basic and detailed design), several sulphur units and various environmental studies concerning SO_2 and NO_x emission, soil and water pollution.

FLUOR NEDERLAND

Fluor Nederland B.V. is a major international engineering centre which was established in Haarlem in 1959. The name of this organisation is that of the Fluor family, who emigrated to the United States from Switzerland in 1888. After having been involved in the energy industry when oil was discovered in California in 1919, the company has grown to become an international organisation providing engineering and construction services to such industries as oil, gas, chemicals, pharmaceuticals, and biotechnology, plant automation, and hazardous waste disposal. Fluor Nederland is housed in a building purpose designed for client engineering needs. The company's staff of 700 are predominantly qualified engineers.

Fluor Nederland's operation, skills and experience are backed by Fluor Daniel World Wide resources. Fluor, being experienced in petrochemical and chemical, industries combined in 1977 with Daniel, a company of equal standing and special experience in industries such as food and pharmaceutical manafacture, the electronics and the nuclear industries. The management and resources of these organizations are integrated, allowing full and constant exchange of information and experience. These resources are constantly available to Fluor Nederland and its clients, and provide an extra dimension to the wide range of services that the company provides in The Netherlands.

The work the company undertakes for its clients ranges from studies to help validate options for a potential investment – location, environmental impact, cost, choice of process etc. – through engineering, design and procurement to construction, start-up and maintenance. A major strength of Fluor Nederland is that a choice of client services is available from a single source. This ensures efficiency and good communications in undertaking the project. Fluor Nederland brings together specialists for a client's project on an as-needed basis, drawing on the project management, engineering, design, project controls, procurement and construction groups within the company.

For design Fluor Nederland offers manual draughting, 2D CAD and 3D CAD. Again, the choice rests on considerations of project scale and cost. Three-dimensional draughting has demonstrated its ability to shorten schedule and control costs and is being used by Fluor Nederland for chemical industry work.

Small Projects Group

Many of Fluor Nederland's projects are small and are handled by a small projects group. The head of this group, the point of contact for clients, ensures that things are kept simple. His job is to ensure that neither the client's staff nor budget is overloaded with unnecessary manhours or techniques. In the initial phase a job may require a single specialist – an instrument engineer, process engineer or quality control inspector. Fluor Nederland provides such individuals. Medium to large scale projects require a more sophisticated, complex response, and Fluor Nederland is geared to place the right resources at the client's disposal to fit the scale of need.

Projects

Current work being undertaken by the company in the Netherlands includes overall project execution responsibility or the largest investment made by an international oil company in the Netherlands, the Esso Nederland *flexicoker* at Rotterdam, *offshore work* for NAM in the Dutch sector of the North Sea, and a *sophisticated plastics raw materials facility* for General Electric at Bergen op Zoom.

Fluor Nederland has also a long successful record of operating outside Europe in such areas as the Middle East, Africa and the Far East. The company, therefore, has comprehensive knowledge of conditions, including the legal, labour and logistics considerations that affect plant design, erection and operation, not only in Europe but also worldwide. The company's recent and current projects include work for Essochem, SIPM, Hercules, BP, GE Plastics, Billiton, Akzo, ACF and DSM.

THE DESIGN OF CHEMICAL PLANTS using 2D CAD and 3D CAD techniques, such as are here being used by Fluor Nederland is almost daily practice for engineering bureaux.

JOHN BROWN ENGINEERS & CONSTRUCTORS

The Netherlands office was established in 1964 as a subsidiary of Crawford & Russell, a company with an international reputation in the design and construction of chemical and process plants and with a special expertise in polymer technology. In 1979 Crawford & Russell was acquired by John Brown PLC, and integrated into the Engineering and Construction Sector. The name of the Netherlands office was changed to John Brown Engineers & Constructors B.V. in July 1982.

John Brown provides full-range contracting services to the plastics and polymers, chemicals, petrochemicals, pharmaceuticals and biochemical process industries throughout the world. Over the last decade, the office has expanded its activities into oil and gas and Integrated Control Systems, and is now a major contractor in these fields.

John Brown has the experience and capability to manage projects worth up to $ 3 billion and is currently engaged in major projects throughout Europe, the Middle and Far East.

The worldwide experience in the engineering and construction of chemical plants encompasses a wide range of products and the application of many types of equipment and unit operations. In many cases, the projects undertaken have involved the use of new technologies requiring the scale-up of client data from both a pilot-plant and a laboratory scale.

The specific services which have been carried out to assist in the evaluation and planning of new projects include:

- Site surveys for new plant locations, to help a client assess present and future requirements.
- Feasibility studies, to help determine the most practical and economic basis of design for new facilities.
- Assistance in technology licensing to and from third parties; licence evaluation to aid clients in selecting the process that best fits their requirements.
- Engineering studies and definitive cost estimates for obtaining final project approval and capital appropriations.
- Process safety studies (MCA and HAZOP).
- Environmental studies.
- Preparation of documents for submission to Authorities and obtaining the required approvals.
- Lump-sum turnkey bids.

The office is a full-services organisation; it currently employs some 550 direct personnel in a complete range of engineering, procurement and construction management services.

The majority of the permanent staff are Dutch nationals, a significant number of whom hold engineering degrees. The procedures and methods used in the Netherlands office are compatible with those used in company offices in the UK and the USA, thus permitting the ready transfer of the 4000 employees within the Corporate Engineering and Construction Sector.

Projects Recently Completed

– Petrochim, *Thermoplastic Elastomer Finishing Plant;* Belgium
– SIBP, *MTBE Unit Expansion,* Belgium
– Du Pont, *Energy Conservation Study,* Germany
– General Electric Plastics, *PPO Plant,* the Netherlands
– General Electric Plastics, *Control System Modernization,* the Netherlands
– General Electric Plastics, *Polycarbonate Plant Expansion,* the Netherlands
– Conoco, *Engineering for Kotter and Logger Field Offshore Platforms,* the Netherlands
– Aramco Overseas Company, *Refinery Tank Modernization,* Saudi Arabia

Projects in Progress

– Confidential client, *Polymer Sheet Plant,* Luxembourg
– CPC, *Wheat Processing Plant,* the Netherlands
– ARCO, *Polybutadiene Liquids Plant,* the Netherlands
– Confidential client, *Polymer Compounding Plant,* the Netherlands
– Aramco Overseas Company, *Renovation of Products Handling Facilities,* Saudi Arabia

KTI

KTI (Kinetics Technology International) is an engineering bureau completely geared to the (petro)chemical industry. The company was launched in 1963 under the leadership of Jacob Voogd, who is still its head. The company went public in 1971 and now employs a thousand people distributed over 18 branches throughout the world. The office in the Netherlands has a staff of 250, two-thirds of whom are graduates or engineers.

KTI takes responsibility for the process design, the engineering, the purchasing of equipment, the construction and/or the supervision of the construction of hydrogen, ethylene, vinyl, chloride, ammonia, methanol, oxo-alcohol, carbon monoxide and other units. Energy conservation, recycling processes and oil/water separation are further items falling within KTI's field of activities.

This engineering bureau both develops its own new processes and also acts as licensee for many other processes. KTI's research and development activities currently include a process for manufacturing *'low-cost aromatics'* (benzene, toluene) *from LPG* (Pyroforming), a new process for *manufacturing methanol constituting a 20 to 30% energy saving* (Methanox) and a process for manufacturing *ethylene from methane.*

KTI supplies computer programs mainly applicable in the chemical processing industry and sells them via two associate companies, Pyrotec and Cascade Graphics Development (CGD). The programs available include *simulation programs for cracking naphtha* into all its possible derivatives, for making *process flow sheets* and for the *optimisation of a chemical process.* In addition, CGD has developed a whole series of Cascade programs for CADD (Computer-Aided Design and Drawing).

LUMMUS CREST BV

Lummus Crest BV was first launched by Walter E. Lummus, a self-educated man, who in 1907 founded Walter E. Lummus Co. During the First World War this company succeeded in gaining a firm foothold for itself in the petrochemical industry by developing a process for the extraction from oil of the toluene required in the manufacture of explosives. In the thirties Combustion Engineering Inc. obtained a majority interest in Lummus and the first offices overseas were opened. During the Second World War also, Lummus was engaged in projects such as the construction of three plants for the production of kerosine (with a capacity equal to 30% of total American production), three butadiene plants for the production of strategically important synthetic rubber and a penicillin plant.

In 1954 Lummus opened an office in the Hague, where currently about 1000 people work. This office's field of operation covers the Netherlands, Europe including Scandinavia, the Middle East and the Far East. Lummus Crest has its head office in Bloomfield in New Jersey, USA, and the Netherlands company, Lummus Crest BV, is one of the largest engineering bureaux in the processing industry, concentrating its efforts on the oil, chemical, petrochemical, metallurgical, nuclear, pharmaceutical and other processing fields. This company takes on complete projects and also part projects covering such aspects as project management, engineering, procurement, construction, start-up, maintenance and training for oil and gas recovery.

Projects

The following large projects were carried out by the Hague office:

A *refinery,* including a vacuum unit for crude a catalytic re-

former and a kerosine treater, for ARAMCO in Saudi Arabia in 1984.
A *grass roots NGL plant* at Yanbu on the Red Sea, also for ARAMCO, in 1978.
A *onshore gas terminal* for BP in the Netherlands in 1985.
Butane storage for ARCO in the Netherlands in 1985.
Energy conservation facilities in a cyclonexane plant for Esso in the Netherlands in 1984.
A *vacuum unit,* a mild *hydrocracker* and a *visbreaker* for BRC in Belgium in 1984.
Ethylene cracking furnaces for Shell in the Netherlands in 1984.

One ambitious project in which Lummus Crest is closely involved is the modernisation of the Shell refinery at Pernis near Rotterdam. One of the most technologically interesting innovations included in this project is the *Hycon process,* a process developed by Shell to convert into valuable products the heaviest residues remaning after vacuum distillation. The complete modernisation of the refinery is going to cost $ 700 million, of which the Hycon unit will account for half. This unit will have a capacity of 4000 metric tons per day.

PROTECH INTERNATIONAL

Protech International started operations in 1964 under the name 'Aardgas Service', an engineering company established in The Netherlands and equally owned by Bechtel Inc. of the USA and Wilton Feijenoord, a Dutch shipbuilding and industrial company. The initial engineering work of the company was concentrated on large natural gas compressor stations, cryogenic facilities and refinery offsites.

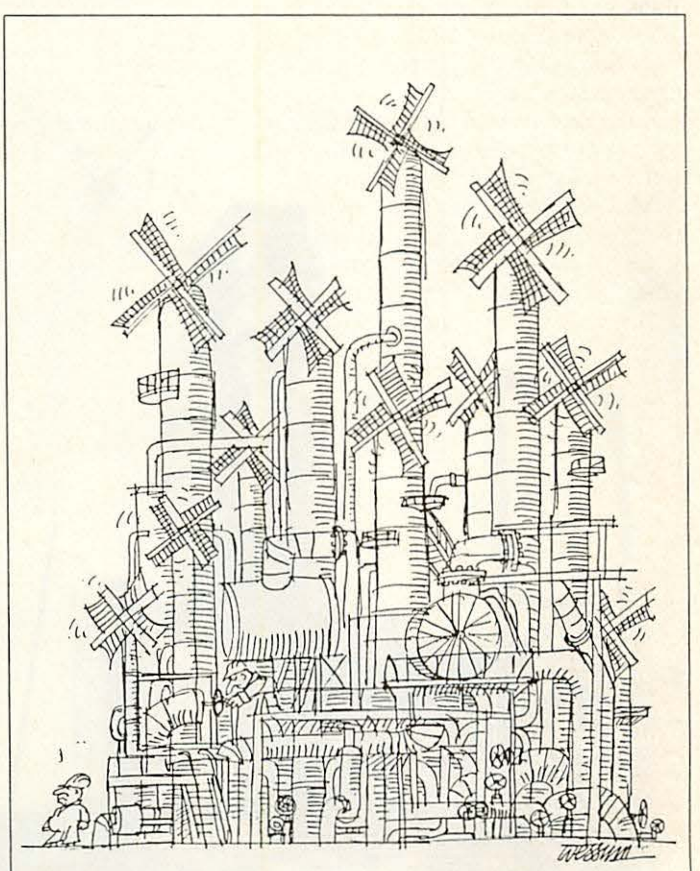
In 1969 the company name was changed to 'Protech International', while ownership passed equally to Williams Brothers, USA and VMF-Stork, one of the largest industrial groups in The Netherlands. Since 1973 the Protech International Group of Companies has been a wholly owned subsidiary of VMF-Stork, who also owns the previously discussed Alpha Engineering Company. The group has engineering offices in the following locations: Schiedam and Beverwijk in the Netherlands, in London, in Houston, in Kuala Lumpur in Malaysia and in Kuala Belait in Brunei.

Protech International's field of activities comprises transportation and storage facilities as well as the original activities of building LPG, LNG and other cryogenic facilities. Within this field, they provide engineering design, procurement and construction management services on a worldwide basis.

The permanent staff of Protech International in Schiedam numbers 320 personnel. Of the engineering staff, 50% have a university degree. The order backlog per the end of 1985 amounted to Dfl 33 million.

Major projects recently completed, include:
AWG-1 self elevating gas production facilities offshore Ameland, the Netherlands, with a capacity of 12 million Nm^3/day;
P15 oil production platform in the Dutch sector of the North Sea with a capacity of 25,000 barrels/day oil and injection facilities for 35,000 barrels/day water;
TBA/methanol loading, blending and metering facility, Europoort, the Netherlands;
LPG handling and storage facilities, Pernis, the Netherlands;
Oil field development in urban Rotterdam, with a capacity of 2500 barrels/day of oil and 30,000 Nm^3/day of gas;
Gas production and dehydration facilities with a capacity of 41,000 Nm^3/day at Norg, the Netherlands.

Major projects in progress include:
K12-B gas production facilities in the Dutch sector of the North Sea, including CO_2 removal, with a capacity of 5.4 million Nm^3/day, in cooperation with KTI, the Netherlands;
A 930 km-long 46-inch crude oil transportation pipeline, including pumping stations and storage facilities, from Baiji in Iraq to Ceyhan in Turkey. The capacity is 5000 Nm^3/hour;
Project specification for the renovation of four sour gas production facilities in the Schoonebeek area of the Netherlands.



TEBODIN

The Tebodin Advice and Construction Bureau, which was originally a Dutch Engineering Bureau, first started up forty years ago. It is now one of the largest in the Netherlands with almost 900 employees, 120 of whom have been academically trained. Tebodin is an engineering bureau covering a wide range of fields. It is not, therefore, specifically geared to chemical processing technology but also has knowhow in the fields of, for example, mechanical engineering, systems engineering, civil and construction engineering, electrical engineering and environmental and safety engineering. Tebodin also suplies legal advice, performs economic studies and can be called in for procurement work.

Tebodin currently has six branches in the Netherlands, three in the Middle East and one in Curaçao in the Caribbean.

As a result of its involvement in the reconstruction of the Netherlands industry immediately following the War and the subsequent industrial developments in the sixties and seventies, Tebodin is closely involved with the national industrial scene. Many clients, in both the private and the public sectors, repeatedly call upon Tebodin not only to carry out new construction work but also to modify, renovate, adapt or extend existing facilities or plants. Tebodin also plays a role in various technological developments in close collaboration with its clients.

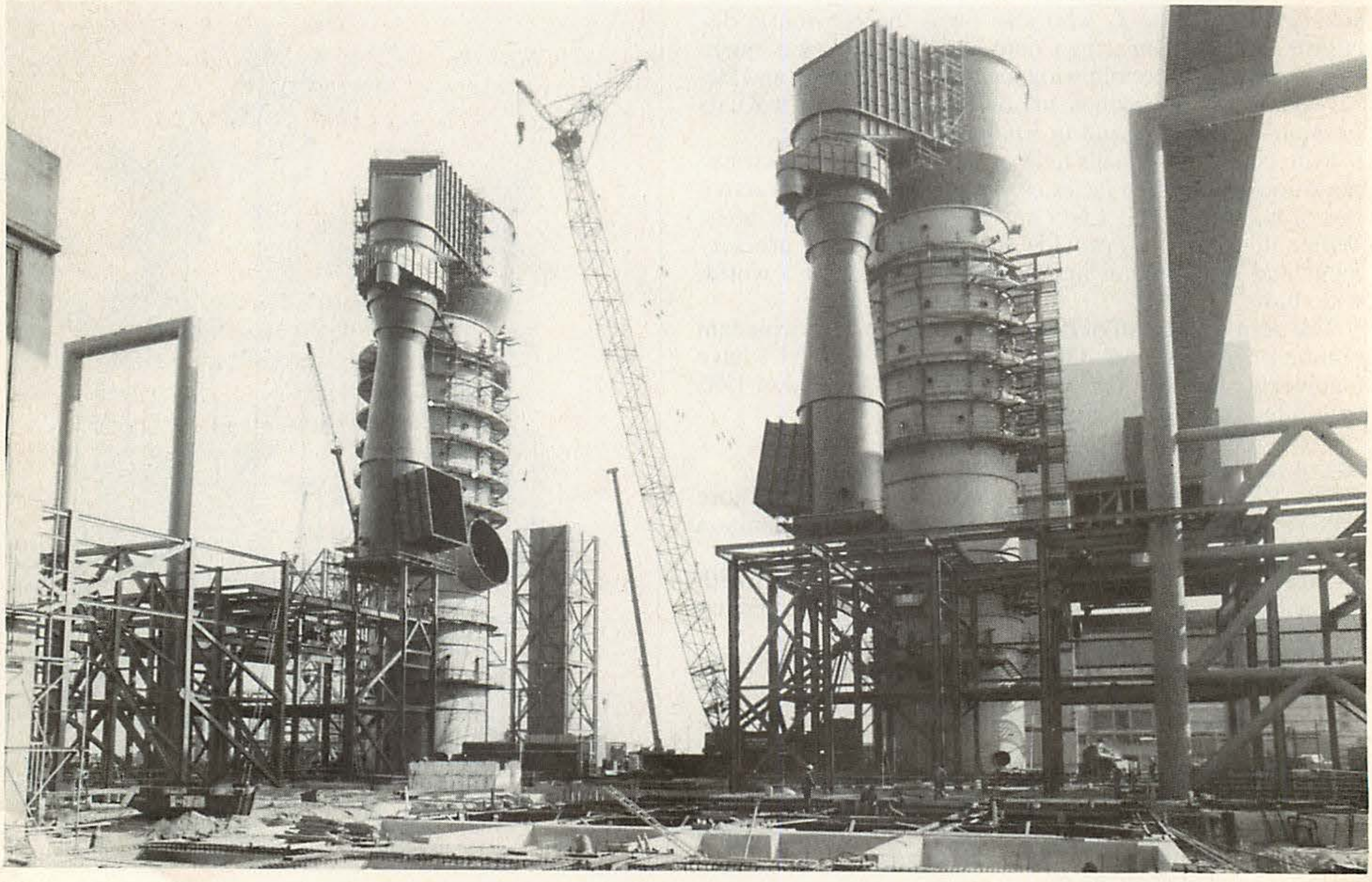
Recently Completed Projects

Tebodin has lent its name to a respectable number of projects in both fine and bulk chemicals. These include:
Fuji, Tilburg, *photographic materials,* 1982 - 1986.
DSM resins, Hook of Holland, *synthetic resin plant,* 1984.
Cynamid, Rotterdam, *solvent recovery and methanol stripping unit,* 1985.
Océ Andeno, Venlo, *solvent and bromine recovery,* 1985.
CIR, Rotterdam, *phenol plant revamp,* 1986.
Shell, Rotterdam, *sour water treating facilities,* 1980.

Projects in Hand

Tanker cleaning facilities, Amsterdam.
Supervision of the construction of a *flue gas desulphurisation* unit for the public energy utility in Rotterdam.
Extension of the newly constructed *carboxyl-methyl-cellulose* plant for AKZO in Arnhem in co-operation with AKZO Engineering.

FLUE GAS DESULPHURISATION. Tebodin has been charged with the construction of, in co-operation with the German company Bischoff, the responsibility for a flue gas desulphurisation unit for the public energy utility in Rotterdam.



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The Dow Chemical Company

The Dow Chemical Company is one of the world's largest chemical companies. Employing 50,000 people with 120 production plants and over 150 sales offices throughout the world. Dow specialises in the production and sale of bulk and specialty chemicals such as synthetics, agricultural chemicals and pharmaceutical products. Turnover for 1985 was $11,5 billion.

Dow Chemical Benelux Region

There are a number of subsidiaries operating under Dow Chemical Management International:
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  This company has three establishments: Botlek, Rotterdam and Terneuzen.
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Dow promotes an open, results-oriented type of organisation with a horizontal structure. A "pay for performance" principle is combined with a company philosophy in which creativity and initiative are the main concepts.
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Dow Chemical (Nederland) B.V., P.O. box 48, 4530 AA Terneuzen, Holland.
Telephone: 01150-7 12 34. Telex: 55061.

DOW CHEMICAL BENELUX REGION

Maarten de Hoog *(29) graduated at the Amsterdam Free University. Since the end of 1984 he is employed by the Royal Netherlands Chemical Society, acting as assistant Secretary.*

Gerard Kleywegt *(24) graduated at the University of Leiden. His main interests are computers in chemistry, university-industry relations and various meta-scientific subjects.*

Ernst Homburg *(34) graduated at both the Amsterdam universities Since 1979 he is employed by the University of Nijmegen, first working on a research project on the history of the dyes industry and from 1984 on as a teacher of Chemistry and Society.*

Nico Berendsen *(27) is studying chemistry at the University of Nijmegen. He is now graduating on a research project concerning strong fibres. He also works for the 'Chemisch Weekblad' and has been editor of the former science magazine 'Technovisie'.*

Jos van den Broek *(35) graduated at the University of Leiden in 1977 and gained his PhD on a pharmacological subject at the same university in 1981. He has been a senior editor of the 'Chemisch Weekblad/Magazine' since 1983 and is since January 1986 also editor of the magazine 'Biotechnologie in Nederland'.*

Wouter Jongepier *(23) is a student of Chemical Engineering at Delft University of Technology. He has been involved in the discussions about the new 'Two-Phase' structure of university education as a member of Delft University Council and as a representative of a national student organization.*

Ed de Jong *(34) graduated at the University of Utrecht. He gained his PhD in 1980 on a research project on Masspectrometry. From 1980 until 1986 he was employed by Janssen Pharmaceutica in Beerse and Techmation in Utrecht. He is Senior Editor of Chemisch Magazine and Instrumental Analysis.*

Fridus Valkema *(39) is senior editor of Chemisch Weekblad/Chemisch Magazine. He holds a masterdegree in Physical Chemistry. He covers chemical industry, chemical research and technology policy.*

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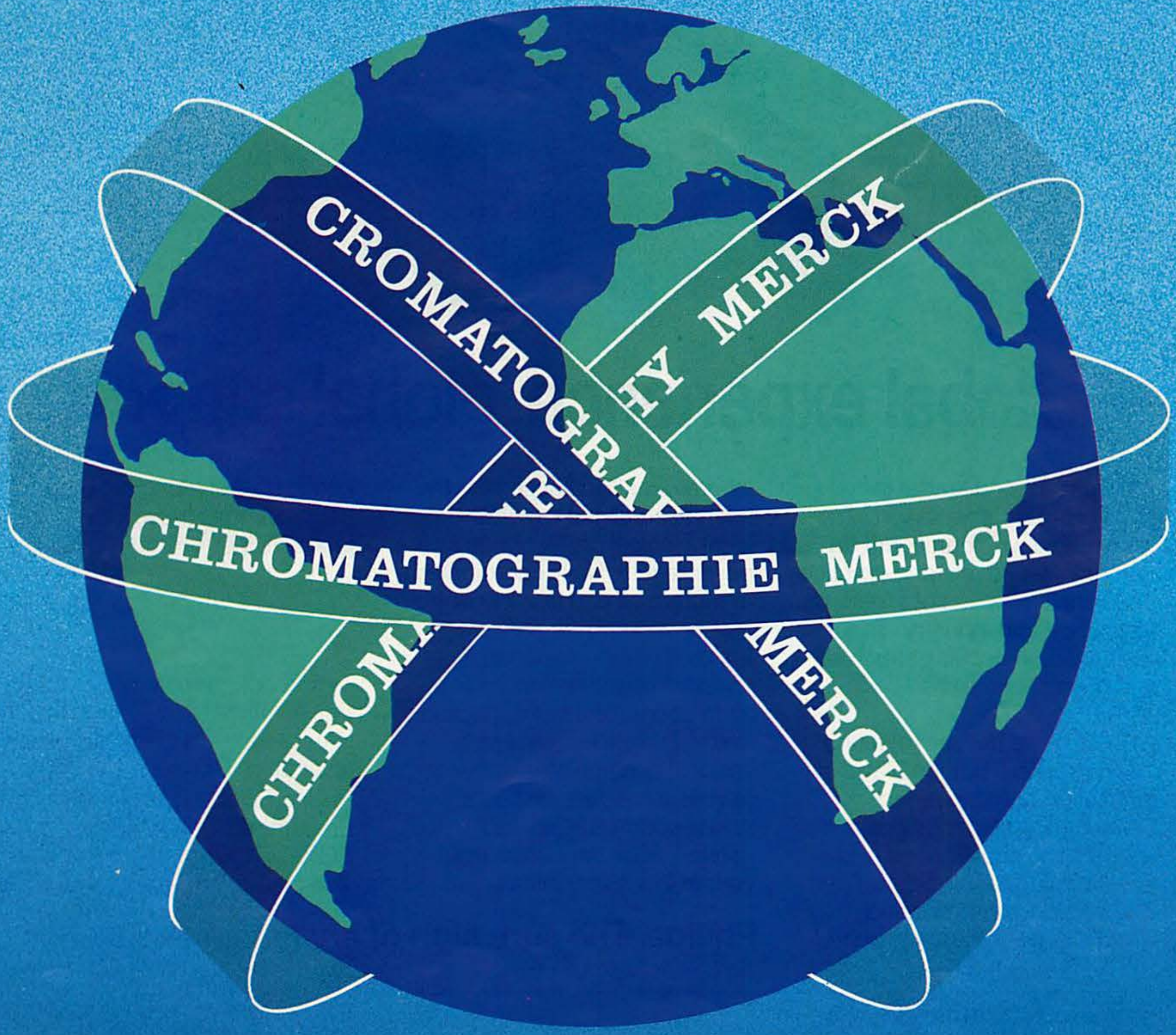

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