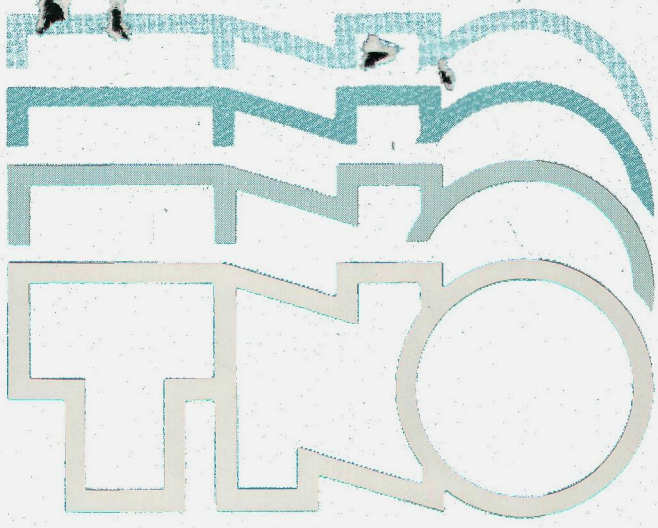
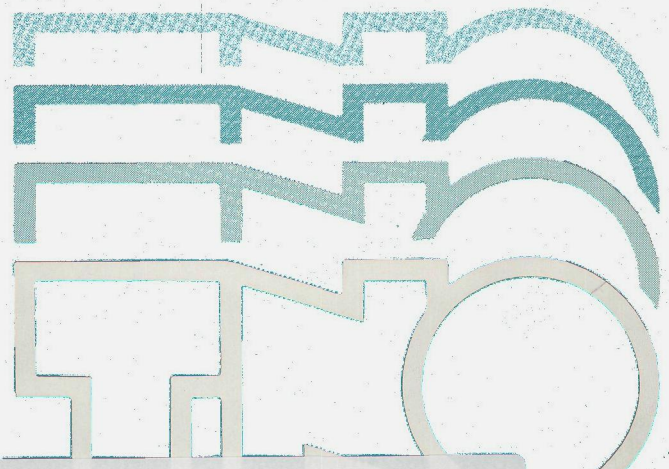


ORGANISATION FOR APPLIED SCIENTIFIC RESEARCH TNO

# its background and activities



*February 1977*

TNO, Juliana van Stolberglaan 148, P.O. Box 297
The Hague, The Netherlands

# TNO - its background and activities

Applied scientific research has become one of the strongest innovative forces in modern industrial society. But rather than research into the latest theoretical insight, it is the steady application of older and more widely known scientific principles that has provided mankind with an unprecedented range of material goods – as well as quite a number of problems. No government can afford to ignore applied scientific research; government must stimulate, control, and often pay outright for, certain types of research.

Governments have evolved various organisational structures for satisfying their research needs. Some prefer government-owned laboratories, where scientists are civil servants, others turn more easily to independent foundations and private research institutions. Still others rely mostly on the universities for their research.

The solution adopted by the Netherlands is unique in Western Europe. The Dutch establishment for applied scientific research was created by an Act of Parliament, as a complement to existing facilities for R & D. It is subsidised by the government, but it is formally independent of the government. It works for and closely with the government, but serves industry as well with equal ease. This establishment is called the 'Netherlands Central Organisation for Applied Scientific Research', or by its popular Dutch name TNO.

## The birth of an idea

TNO came into being as a result of the unrelenting pressure of the Dutch scientific community. Its origin goes back to the sorry state of the economy in the First World War, when the Dutch discovered that they were highly dependent on foreign countries for industrial products and even for the needs of life. The Nobel laureate Prof. Dr. H. A. Lorentz, then one of the presidents of the Royal Academy of Sciences, asked in public whether the high state of scientific knowledge in the Netherlands should not be applied to the pressing problems of contemporary society.

After the death of Lorentz other members of the scientific community kept up the pressure, and in 1930 Parliament passed an Act, now called the 'TNO Act', providing for the creation of a 'Central Organisation for Applied Scientific Research'. Two years later, the government implemented the Act by establishing TNO. The Great Depression was then at its height.

## The early years

The first years were very difficult. High unemployment, industry working far below capacity, and the fact that TNO still had to prove its worth and establish its place in the Dutch community combined to keep the Organisation small. During the Second World War there was some growth, mostly in the food and nutrition sector, but at the end of 1945 TNO employed only 313 people, of whom no less than 167 had an academic degree. The Organisation was unknown to the general public, and only a few industries – largely in food and nutrition – had any idea of its research potential.

The period of reconstruction after 1945 and the official policy of rapid industrialisation gave TNO the chance it had been waiting for. More and more, government and industry turned to TNO for the answers to often quite difficult problems, and the Organisation started to grow rapidly. At the end of 1976 total employment was around 4850.

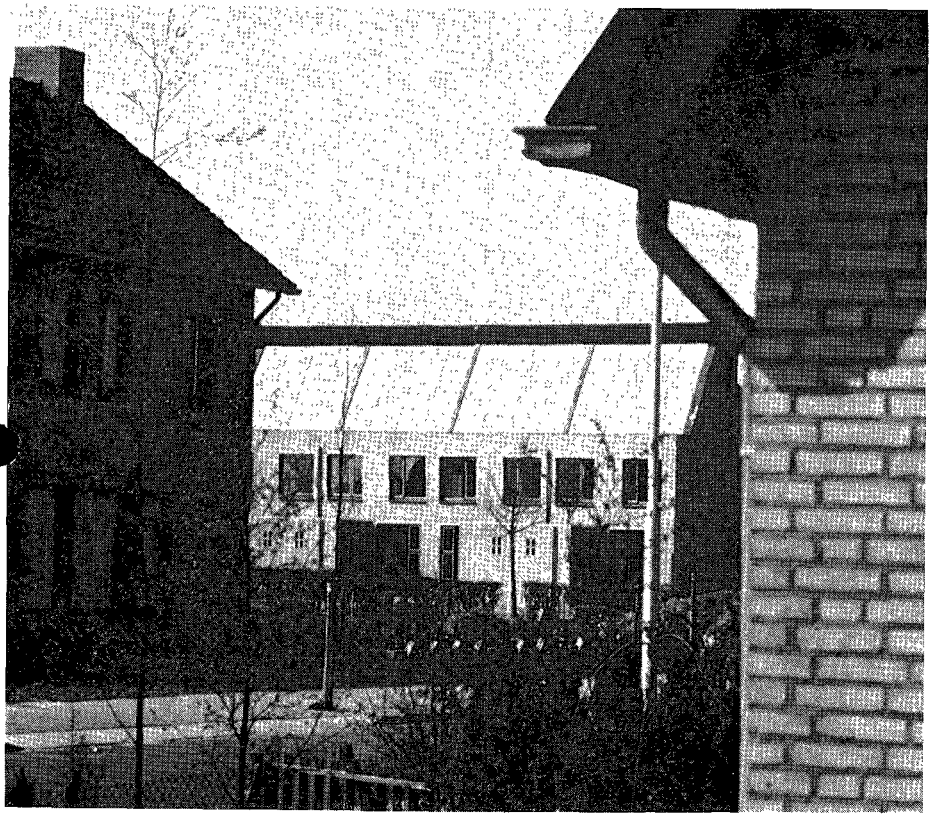
TNO is an organisation for applied scientific research, and this fact is reflected in the employment statistics. Nearly 1000 employees have an academic degree, and another 1200 hold a degree of the Dutch Advanced Colleges of Technology.

## Tasks and structure

Those who drafted the text of the TNO Act at the end of the nineteentwenties had to interprete the term 'applied scientific research'. Clearly, the humanities had to be excluded in favour of the precise sciences. The position of the behavioural sciences and applied mathematics was unclear. It was therefore decided to keep some parts of the Act quite general, so as not to exclude future developments in applied scientific research. As a result the TNO Act is very flexible, and has until now accommodated the growing field of activities without any stretching.

The first article of the Act says that the aims of the Central Organisation TNO will be 'to ensure that applied scientific research is put at the service of the community in the most efficient manner possible'.

But is was never intended that the Central Organisation would try to cover the enormous field of applied scientific research as defined in the Act. There were fears that this wide



*Experimental solar houses, built to test a new type of solar panel*

scope would lead easily to a loss of identity, so the Act provides for the possibility of establishing 'special Organisations' of TNO. Each special Organisation is established by ministerial decree, and serves one or at the most a few sectors of the community. As a result, each Organisation has its own distinct identity.

At the moment TNO has four special Organisations, given below with their founding dates:

- The Organisation for Industrial Research TNO (1934)
- The Organisation for Nutrition and Food Research TNO (1940)
- The National Defence Research Organisation TNO (1946)
- The Organisation for Health Research TNO (1949)

The TNO Act lays down that the Central Organisation and each special Organisation are corporate bodies.

**The boards and the Executive Committee**

The Central Organisation is governed by a board whose members are appointed by the Crown, being drawn from among experts in the natural sciences and economic affairs.

Each of the special Organisations also has a board with members appointed by the Crown. Their qualifications for appointment are appropriate to the field of applied scientific research of the special Organisation. The interests of the government are safeguarded by a number of provisions. The chairman and the vice-chairman of the Central Organisation and the chairmen of the special Organisations together form the Executive Committee of TNO.

The Executive Committee is assisted by the general secretary and the general treasurer with their respective staffs, and by a number of staff departments.

**Financial matters**

The TNO Act specifies that the government will grant TNO an annual subsidy, which is based on a budget presented by the Central Organisation. Another important part of revenues is payments for R & D work carried out for the government, provincial and local authorities, and Dutch and non-Dutch firms and sponsors. A relatively small part stems from payments for the stimulation of certain types of research and from collective research associations, maintained by a number of branches of industry. In 1977 the total budget of TNO will be 400 million Guilders.

The costs of research carried out for sponsors are calculated on the basis of the number of man-hours spent on the project.

**The research section**

R & D is carried out in 35 well equipped laboratories, called the 'Institutes' of TNO. The accompanying list of names and addresses gives a survey of all the TNO Institutes and Research Units.

The majority of Institutes were established for assisting one, or at the most a few, branches of industry. There are, however, a number of Institutes of a more general character, such as the Central Laboratory TNO, the Institute TNO for Mathematics, Information Processing and Statistics and the Institute of Applied Physics TNO-TH. The division of Institutes was essentially complete in 1955 – more than 20 years ago.

The Industrial Research Organisation manages the largest number of Institutes and employs 35% of all personnel. Together with the other Organisations, the Industrial Research Organisation serves not only industry, but government agencies as well.

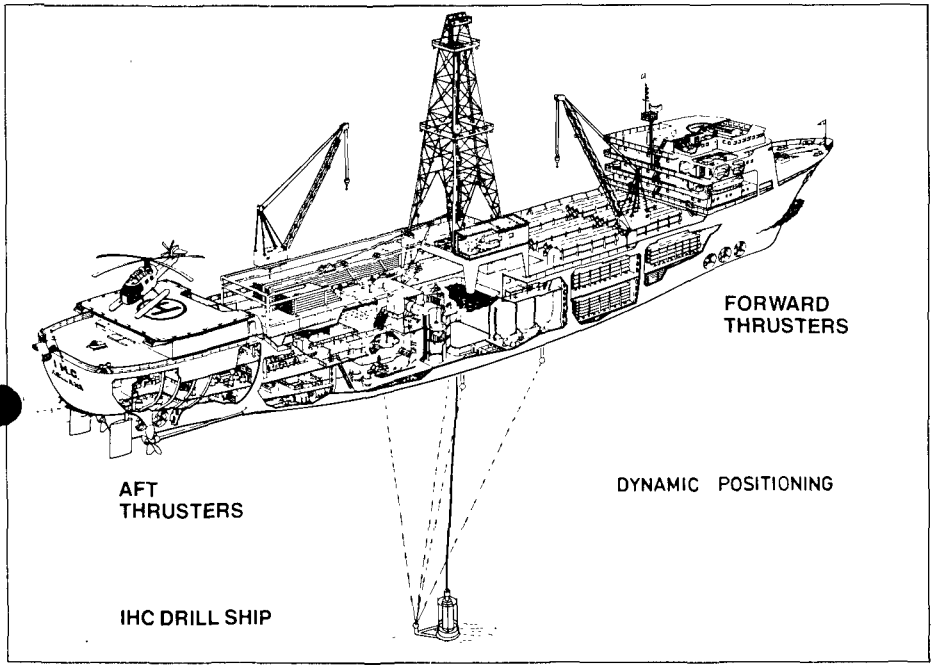
The Central Organisation comes next, with 21 % of all employees. It maintains a few Institutes of a more general nature and has under its wings most of the Councils and Committees of TNO. It is the financial and administrative centre of the Organisation and is responsible for the major part of the advisory tasks of TNO (see next section).

The National Defence Research Organisation TNO and the Health Research Organisation TNO are about equally strong with, respectively, 15 % and 18 % of all personnel. The former has five discipline-oriented research Institutes.

The Health Research Organisation not only maintains research and service Institutes, but also quite a number of Research Units that carry out most of their activities in institutions not belonging to TNO.

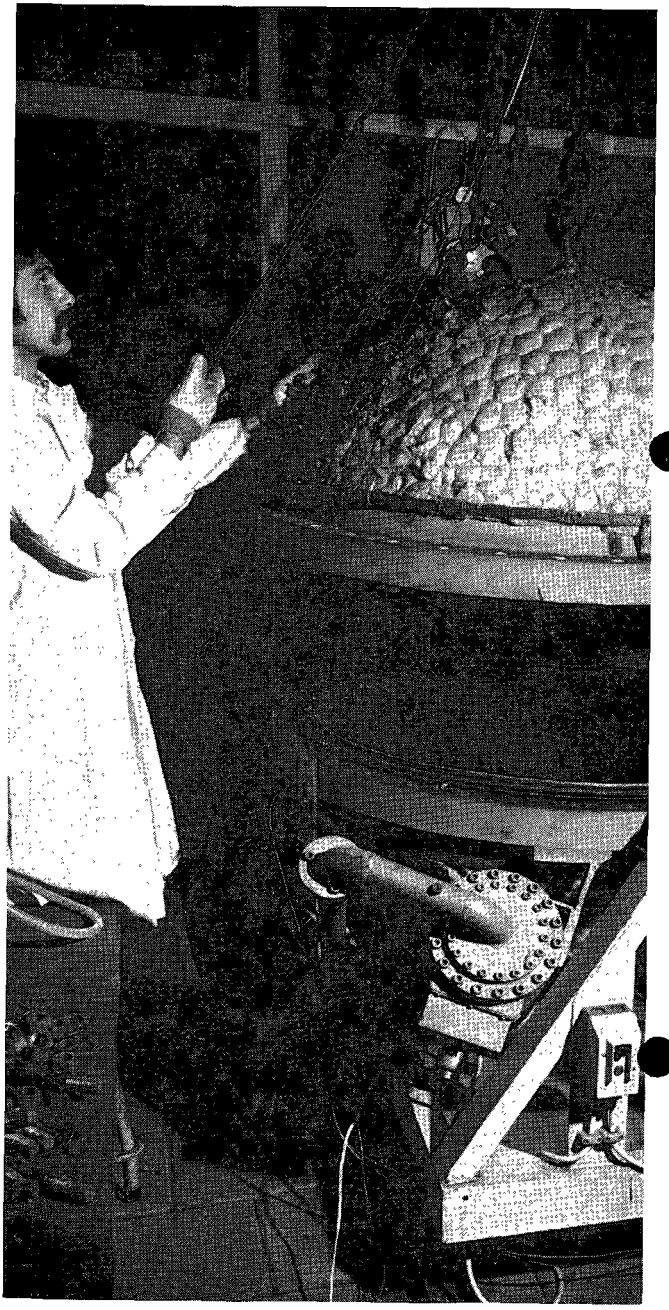
The Nutrition and Food Research Organisation is the smallest of the TNO family, with 10 % of all personnel. It consists of one large, general Institute and two that are smaller and more branch-oriented.

Finally, there are a number of Affiliated Foundations that are wholly independent but prefer to work closely with TNO, and receive a small part of their income from TNO.




*Dynamic positioning of a drill ship using thrusters*

*Spherical gas vessel of 0.5 cubic metres, used for the determination of the explosive properties of mixtures of gases and vapours with air*



Quite early in its existence, TNO had to determine which fields of applied scientific research it could and should enter. It was decided to leave alone those parts where industrial R & D was already strong, as in chemistry and electronics, nor to compete with research establishments of, for example, the Post Office or the public utilities. Here, TNO aims at acting as a complement to existing bodies by providing special and sophisticated research facilities for which one institution or large firm will not have enough work. Firms with a more modest research effort turn to TNO with problems calling for either special knowledge or specialised equipment, whereas firms without facilities for R & D, or with only small facilities, often farm out a large part of their research to TNO. In this respect collective research should also be mentioned, which is carried out for example for the potato-starch industry, the paint industry, the bakery and biscuit industry and the Association of Butchers.

In its R & D activities for national defence and the Services, TNO aimed at internationally high standards of results from the start. This policy was partly dictated by the relatively modest amount of funds a small country can earmark for this type of research.

In health research, TNO had to adjust to the fact that a large amount of medical research is done at universities and hospitals. The solution was to concentrate not on individual patients or particular diseases, but on groups of the Dutch population. To name a few examples, research in medical physics benefits groups of people with certain disabilities; the results of gerontological research are of importance to the large group of the aged forming more than 10% of the population; the work of the TNO Radiological Service protects a fairly large group in industry, hospitals and laboratories against overdoses of ionising radiation. By concentrating on groups, TNO has established its own place in the whole of health research in the Netherlands.

**Advice and co-ordination**

The TNO Acts states that the Organisation may give unsolicited advice to the government, and in some instances TNO has voiced its opinion without being asked. But the government observed at an early stage that a more regular flow of advice about matters of applied scientific research would be helpful, and that some co-ordination of the activities of various institutions would be necessary. In a number of fields this advisory and co-ordinating function has been entrusted to TNO.

To carry out this part of its task, TNO has founded a number

*Measuring ground-water levels*

of Councils and Committees, which differ somewhat in their aims and in the scope of their activities.

The National Council for Agricultural Research TNO co-ordinates and steers all agricultural research funded by the government, including that of the agricultural research establishment which comes under the control of the Ministry of Agriculture and Fisheries.

The Committee for Hydrological Research TNO, on the other hand, also has a steering and co-ordinating function, but here the mere provision of information is also very important. In the Netherlands, there are so many institutions involved in different aspects of hydrology that it is of prime importance to keep everyone informed about the activities of others.

The Council for Health Research TNO, to take the third and final example, advises the government on matters of policy in public health and on the best ways to reach the goals that have been specified. This Council gave important advice about the measures to be taken to diminish the incidence of heart disease, and actively influenced the reconstruction of the system of cancer research in the Netherlands.

The external advising and co-ordinating activities of TNO

have expanded considerably in the last ten years, a clear sign that Dutch society has become more complex.

Although TNO practised multi-disciplinary research long before the word was coined, this approach to the successful management of complex R & D projects became established practice less then ten years ago. At the moment over half of all sponsored R & D is of a multi-disciplinary character, and this proportion is expected to rise in the near future.

The multi-disciplinary approach cuts across the vertical organisational structure of TNO, with its special Organisations and Institutes, by connecting the acivities of a number of Institutes. Examples are: Explosion Safety, Buildings and dwellings, Industrial Innovation and Offshore and Oceanology. In some cases managerial structures have been developed to control the multi-disciplinary research activities of TNO. This led to the creation of some institutionalised bodies, that do not carry out any R & D, but act only as co-ordinators, sometimes in co-operation with institutions outside TNO.

**Recent changes in emphasis**

In the 45 years since TNO was founded, Dutch society has changed out of all recognition. The Netherlands is no longer primarily an agricultural and trading country, but a highly industrialised nation with one of the highest population densities in the world. Industrialisation has ended poverty and has even brought affluence to many sectors of society, but it has also caused a host of serious problems: destruction of the natural environment, pollution and a growing dissatisfaction with conditions of life in many strata of society. These phenomena occur in most other industrialised countries, but in Holland they are aggravated by the high population density. The primacy of technology as the generator of wealth and progress is increasingly being questioned, and this fact is reflected in the nature of the projects carried out by TNO – a growing proportion relate to the containment of the consequences of present technology.

At the same time, the traditional role of the government in funding applied scientific research is also being questioned. New ideas are under discussion such as the 'customer – contractor principle', launched by Lord Rothschild in Great Britain a few years ago.

All these changes have had their effect on TNO. The Organisation is reconsidering its position in society – especially as the country is a member of the EEC – and is discussing new ways in which its large pool of knowledge and experience can be used to solve pressing social problems.

# Examples of current activities

Every year TNO has in hand many thousands of research projects. This great volume of work makes it impossible to give a fair and representative picture of the experience and research potential of TNO in only a few examples. However, the research projects mentioned below show the wide range of work carried out.

**Nationwide registration of emissions into the environment**

The government has asked TNO to carry out a complete registration of all materials, whether natural or man-made, that are emitted into the environment. For this purpose, TNO has brought together a permanent team of 60 highly qualified employees, with another 40 part-time participants. The registration is done province by province, and will take several years to complete.

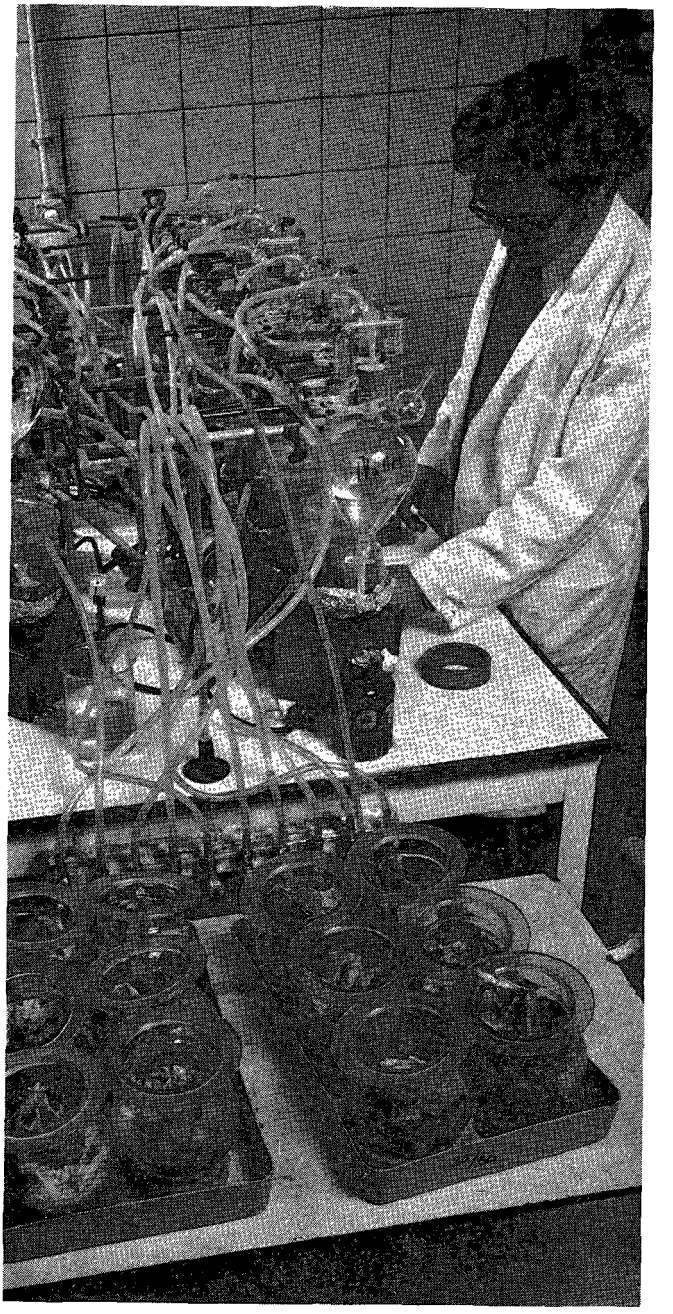
In practice, the emissions are calculated from known facts whenever possible. Measurements are taken when no data are available, or when there is good reason to suspect that an industry or institution emits heavy pollution or less easily degradable substances. Voluntary participation of industry has been achieved by stipulating that all information will be regarded as confidential, and will only be put at the disposal of certain government officials.

**Biological toxicology**

In modern society man is exposed to substances that do not occur naturally, such as powders, sprays or components of air pollution. Whether these substances are harmful must be investigated.

TNO has a large and highly qualified multi-disciplinary research team, consisting of veterinary surgeons, biologists and biochemists who can carry out the necessary biological toxicological tests. Experimental animals – mostly rodents – are exposed to the substances under investigation in various ways. In a complete test, the substances are administered orally and dermally. Additionally, there are inhalation studies and a

*Checking a sample of lettuce for pesticides*

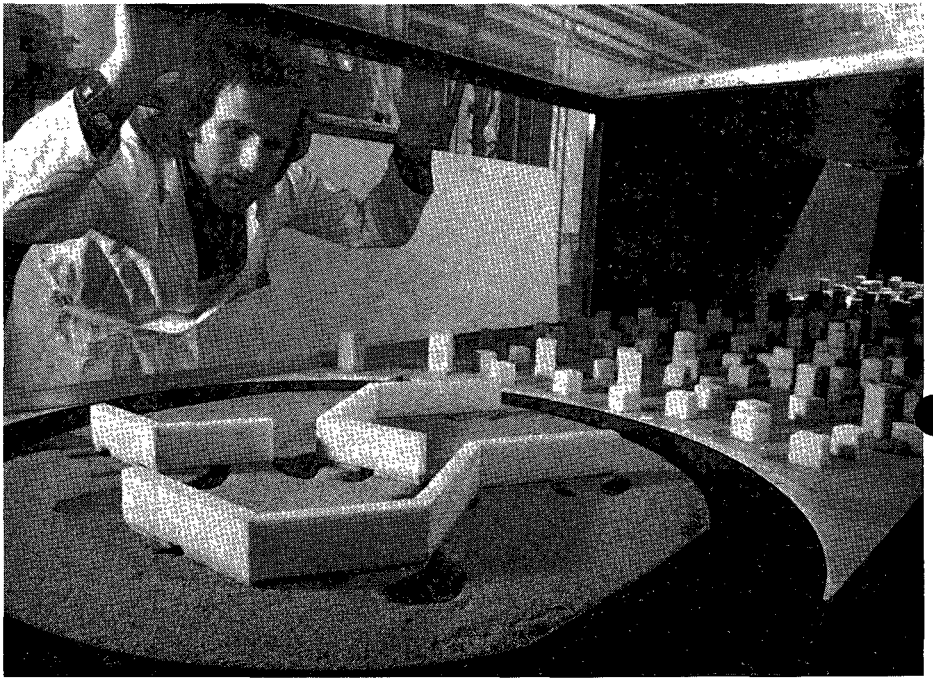


test for possible eye irritation. A recent project was the participation of the biological toxicological group of TNO in the international investigation of the carcinogenic properties of vinyl chloride.

**Exposure to radiation**

Ionising radiation is a known health hazard, and a growing number of people may be exposed to it, for example nurses, employees of laboratories using radioactive materials, or employees of nuclear generating stations. The Radiological Service Unit TNO has been given the task of monitoring people in the Netherlands who may be exposed to ionising radiation. In the past, exposures were measured with film badges that had to be assembled and read out manually. TNO is now switching to a new method of measurement based on the well known physical effect of thermoluminescence. For this purpose, a simple dosimeter has been designed that can be worn as a bracelet. Assembling the dosimeters is far easier than film badges, and readout can be fully automated.

At the same time, all data about persons who have been ex-



*The interaction between wind and buildings – testing a model in a wind tunnel*

posed to radiation are being fed into a computerised data base. This system will lead to better control of, for example, maximum permissible exposure levels. The computer can easily give a warning when a person is in danger of reaching his maximum permissible dose over a certain period, or even over his whole lifetime.

**Noise**

The study of noise, its abatement and its effect on humans is one of the larger fields of research. Internationally famous investigations have been carried out into noise levels at the place of work, the effects of working in a noisy environment, and the possibilities of arriving at standards for 'personal noise dosimetry'. A recent TNO study has shown that nearly half of the 1.1 million Dutch industrial workers are exposed to unacceptably high noise levels. A safe working noise level is considered to be less than 80 dB(A). However, noise levels below 80 dB(A) may still cause other problems, such as severe irritation.

Studies for the abatement of high levels of traffic noise have been part of the research programme of TNO for years. A design for a simple noise dosimeter of reasonable accuracy that gives an instant indication of noise levels was completed successfully a few years ago. The effects of strips of trees and shrubs alongside busy traffic lanes have been investigated carefully, and rather surprisingly it was shown that their effect on noise was less than thought.

A third example concerns the noisiness of compartments for the crew on ships and offshore constructions. When these compartments are not designed and constructed carefully with use of the right isolating materials, they can be exceptionally noisy. TNO has worked out the general principles that should be followed in the design of low-noise compartments, and has in addition large and specialised measuring facilities for checking these designs.

**Development co-operation – ground-water surveys**

The government and the majority of the population in The Netherlands believe that effective development co-operation is one of the important means to narrow the gap between the developed countries and those of the Third World. The amount of money earmarked for this purpose per head of the population is one of the highest in the Western World.

Most development projects are carried out at request of the Dutch government, but TNO has also accepted assignments from international agencies, such as the Food and Agricultural

*Opposite page:*

*The wheelhouse of a ship manoeuvring simulator containing all the usual instruments and navigational aids*

*On this continuously movable table models of harbours, coastlines or natural bays can be built. Projection is on a translucent screen and in colour. The images have correct perspective in any position on the table and contain all navigational marks present in reality.*

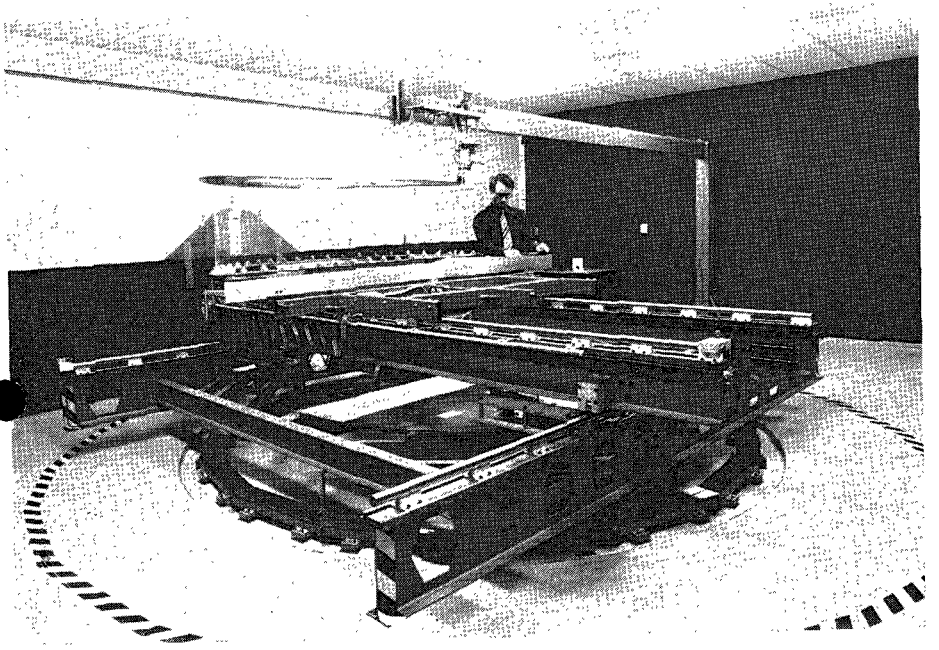
Organisation (FAO), the United Nations Development Programme (UNDP), UNESCO, the United Nations Industrial Development Organisation (UNIDO) and the International Bank for Reconstruction and Development. At the end of 1976 75 projects were under consideration or actually in progress in the Third World, and the countries in which TNO is most active include Colombia, Cuba, Bangladesh, India, Indonesia, Tanzania and Sudan.

Projects have differed considerably. The food situation and the protein deficiency received much attention, but technical assistance also figures largely in the records. Less spectacular, but certainly important, are the ground-water surveys carried out, and still continuing, in a number of countries. The results may indicate possibilities for irrigation, which in turn may end subsistence farming and so lead to a rise in living standards. TNO has been asked to carry out these surveys because of its experience of more than a quarter of a century in measuring and mapping ground-water levels in Holland.

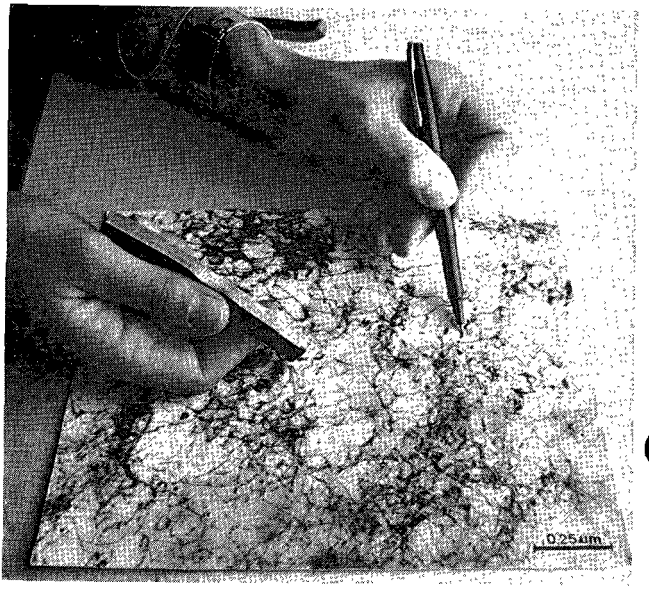
**Offshore**

TNO has been active in the offshore field almost from the start of the North Sea oil rush, and was in fact one of the first to advocate the use of reinforced concrete in offshore constructions. It was thought that this use of a composite material in a hostile environment would pose some new problems. TNO therefore carried out an investigation into the influence of composition on the resistance of concrete against attack by seawater, since it was known from previous research that some soils can have a devastating effect on certain types of concrete.

Another problem, especially with pylons of more than 100 metres high, was that the actual shape will deviate somewhat from that laid down by the designer. The deviations are small and may look unimportant, but under the severe operating conditions in the North Sea they may lead to unacceptably high stresses in the steel reinforcement, with the subsequent collapse of the platform. TNO has the necessary computer techniques to allow the calculation of a shape for the pylons and a layout for the reinforcement that will not cause these unacceptable stresses even under the most unfavourable combination of deviations from design. The facilities of TNO have been used by companies active in the construction of reinforces concrete platforms. A third problem was that, in heavy weather, waves cause tremendous variations of stress in the reinforcing steel bars, which may then fail through fatigue. TNO therefore carried out a careful analysis of the fatigue strengths of various reinforcing steels.



*Examination of the dislocation pattern of a broken steel test bar, as shown in a micrograph produced by a 1000 kV electron microscope*




**Renovation of dwellings and city areas**

Since his invention of cities nearly eighty centuries ago, man has demolished dwellings as soon as they became dilapidated, to build new ones in their places. Until quite recently, modern cities did exactly the same. Ageing parts of cities were often left to themselves, and when living conditions really became intolerable the inhabitants were moved to new houses or new towns, and everything was pulled down. Restoration of monuments was usual, while renovation of old city quarters was exceptional.

It slowly became clear that the social costs of this process might be very high. Older parts of cities often have a special social climate and flavour that will disappear with the inhabitants, never to return. Studies indicated that the move to a new house could be an upsetting experience for many, and that family ties might become weakened or even broken. Ties of kinship and friendship often snap, and useful social traditions, that may have taken generations to develop, disappear for ever. So now the tendency is to renovate whenever possible. This process is rather costly, as city councils in Holland and other countries have discovered, and architects and builders know by now that it can be full of unpleasant surprises.

Most houses to be renovated were built in times when only bricks and the dimensions of wooden beams were standardised,

and it may be discovered that in one row of houses different materials and even different types of foundations have been used without any obvious need.

To assist architects, the building trade and city councils, TNO joined forces with some government and private institutions to work out general solutions to these problems. This co-operation may even lead to the preparation of check-lists containing everything that should be investigated before a decision for renovation is taken. The initiative has been welcomed by many city councils, architects and the building trade.

**Industrial innovation**

The conditions for successful innovation have become better known in the last few years. It is now realised that technological competence alone is not enough and that marketing research and good marketing techniques are at least equally important. For in two out of every three introductions of new products it is the 'demand pull' of the market that decides between success or failure, and not the 'technology push' of the innovating firm.

As successful industrial innovation is extremely important for industries that want to maintain their position in international markets, the Dutch employers Organisations and TNO began to search for better ways to use TNO's large pool of knowledge and experience for innovation.

**Consumer research**

TNO has been protecting the consumer for many years. Quite a long time ago some government institutions asked the Organisation to carry out regular checks of the quality of certain foods and drinks, such as bread and bakery products, meat and meat products, as well as beer, fruit juices and soft drinks. More recently, TNO was asked regularly to determine pesticide residues in vegetables by the analysis of daily samples taken at greengrocers and markets. Analysis results are usually in the parts per million range, but may go down to parts per billion. Lastly, national and non-Dutch consumer organisations have come to TNO for testing quality and safety of many foods and drinks, products and appliances.

**Energy**

Energy research and energy conservation really are familiar subjects at TNO – 'heat economy', as it was formerly called, occurs quite early in the research annals of the Organisation. Although TNO is still concerned with the efficiency of steam boilers, its activities in energy research now cover a far wider field. When the Netherlands decided to participate in the

design and construction of the European Breeder Reactor, TNO was asked to manage a part of the Dutch contribution to the research and testing programme. This activity involved the testing, both on a model and a one-to-one scale, of the pumps, pipes and heat exchangers present in the sodium loops.

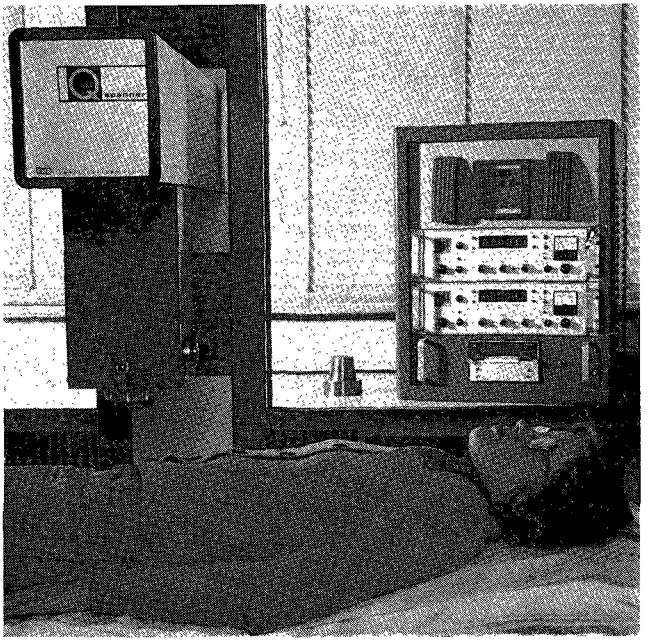
More recently, TNO started to investigate alternative sources of energy. Studies of the possibilities of extracting energy from wind have been pursued for some time, and a programme for solar houses is actually in the testing stage. In 1975, three solar houses were built in the south of the country to check the efficiency of a solar panel especially designed by TNO for use in the Dutch climate. The effectiveness of the panels has now been proven, and at the end of 1976 a second row of solar houses was under construction in a satellite town of The Hague, to test the efficiency of systems for the storage of energy.

**Monitor for heavy metals**

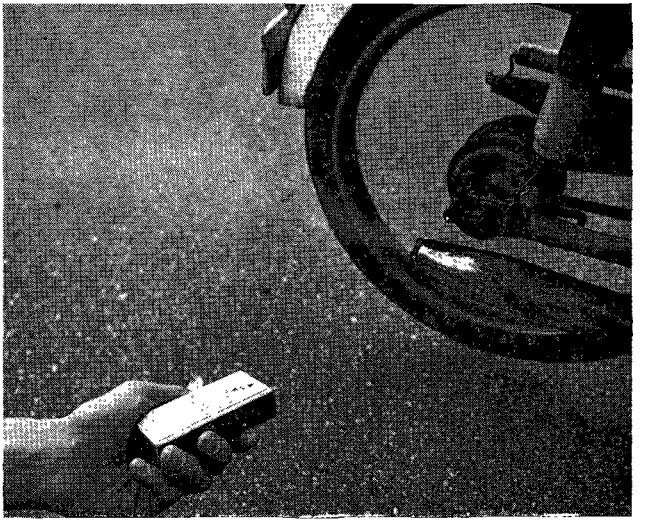
Anyone who wants to combat environmental pollution effectively must first measure the pollutants. With this requirement in mind, TNO designed and developed automated measuring instruments for serious air pollutants such as sulphur dioxide, nitrous oxides and fluorine. The most recent addition to this range is a monitor for heavy metals that continuously measures the concentration of copper, lead, zinc and cadmium in surface waters.

*Investigating driver behaviour on the road: a fully instrumented test subject*

*Quantitative scintillation scanner*



*A pocket-sized noise indicator, with a range of 40 to 120 dB(A) and an accuracy of 2 dB(A)*



**Industrial safety**

Modern industrial installations often are very large and as a result, the consequences of accidents can be serious. Nowadays it is extremely rare for accidents to be caused by design faults, most accidents are caused by so called 'unplanned events', which may lead to disaster. As the results of calamities may be very serious, the safety of industrial installations should be analysed carefully. Studies of industrial safety have become an important activity of TNO, and the Organisation can cover the whole field, from hazard analysis and operability studies to reliability analysis and risk analysis. In addition, TNO has a number of facilities for studying subjects related to industrial safety, such as: facilities for the study of the inflammability of materials and the explosive properties of substances and mixtures, and for the simulation of the effects of blast and explosions. Examples of recent activities are: prevention of dust explosions in the food industry, especially those industries handling flour, starch and powdered milk, and a large study on transport of dangerous materials by water, both by sea and on inland waterways.

*Opposite page:*

*Exposing a tiled roof with a window to simulated rain and wind*

# The Institutes of TNO

*The institutes of TNO are in roman types, other TNO bodies in italics*

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