Oil and Gas
in the
Netherlands.

NAM

ENERGY FROM THE DEPTHS

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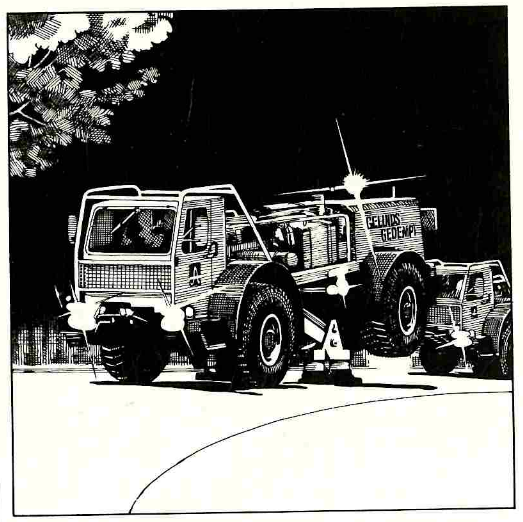
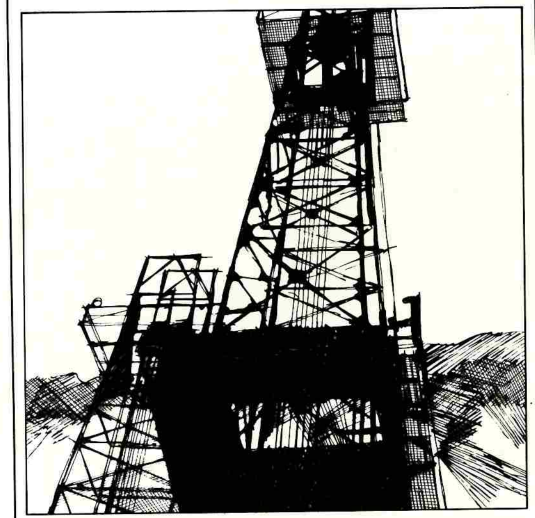
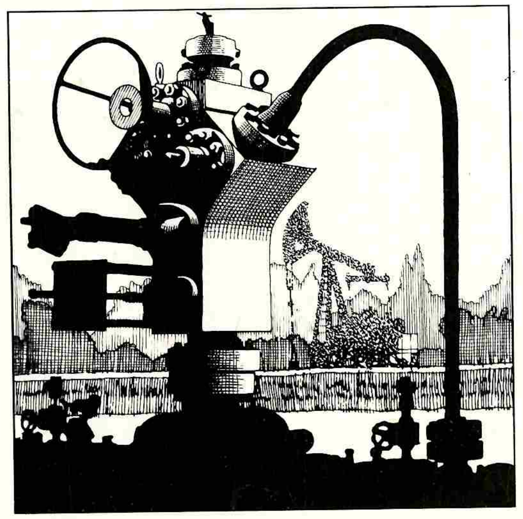
Illustration on front cover: Ammonite.
This is a fossil shell of certain species of molluscs that lived from the Lower Devonian Age (395 million years ago) to the Upper Cretaceous Age (65 million years ago).

Ammonites (Lat.) = rolled-up horn (horn of Ammon)

Oil and Gas in the Netherlands.







NAM

ENERGY FROM THE DEPTHS

Oil and Gas in the Netherlands.

Energy has come to play an indispensable part in our society. We cannot press a light switch, start a car or turn on a machine without using this precious commodity. Without energy virtually none of the things we use could be manufactured, without energy we would be unable to prepare our daily food.

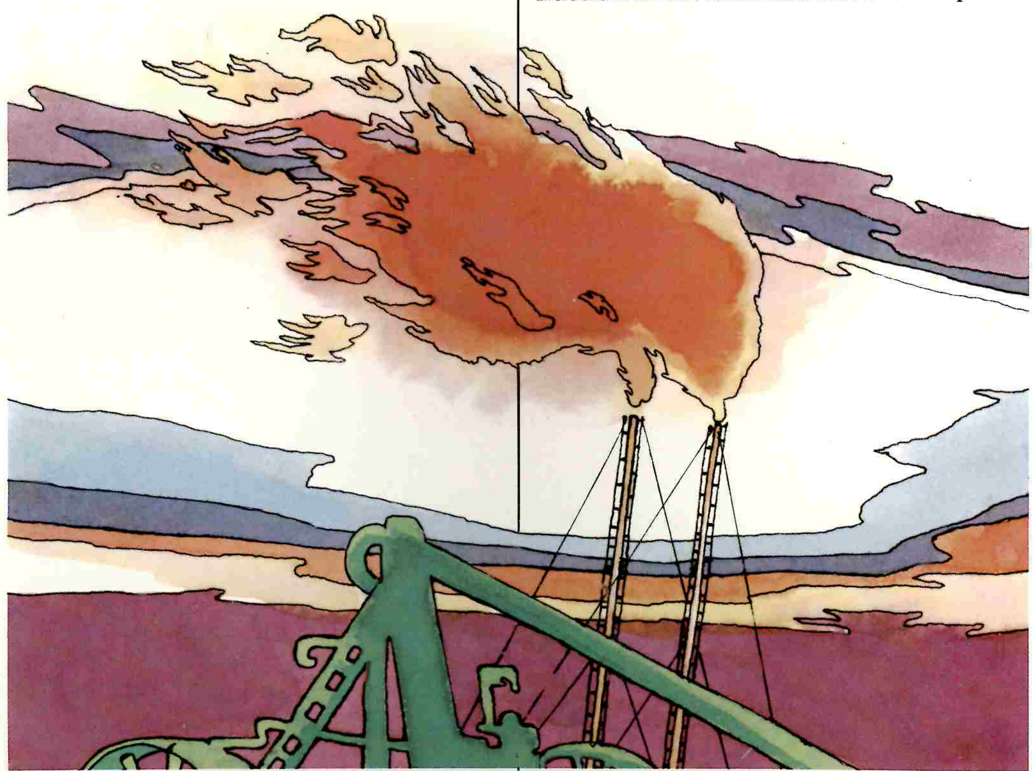
This booklet deals with energy wrested from the earth in the Netherlands.

The main energy sources are the fossil fuels oil and natural gas. Each covers about half of the Netherlands' total energy requirement.

The Netherlands is self-sufficient in natural gas and is even able to export it to a larger number of West European countries.

The fact that natural gas has come to play such an important part is due to the discovery of one of the world's largest gasfields in the Dutch Province of Groningen in 1959.

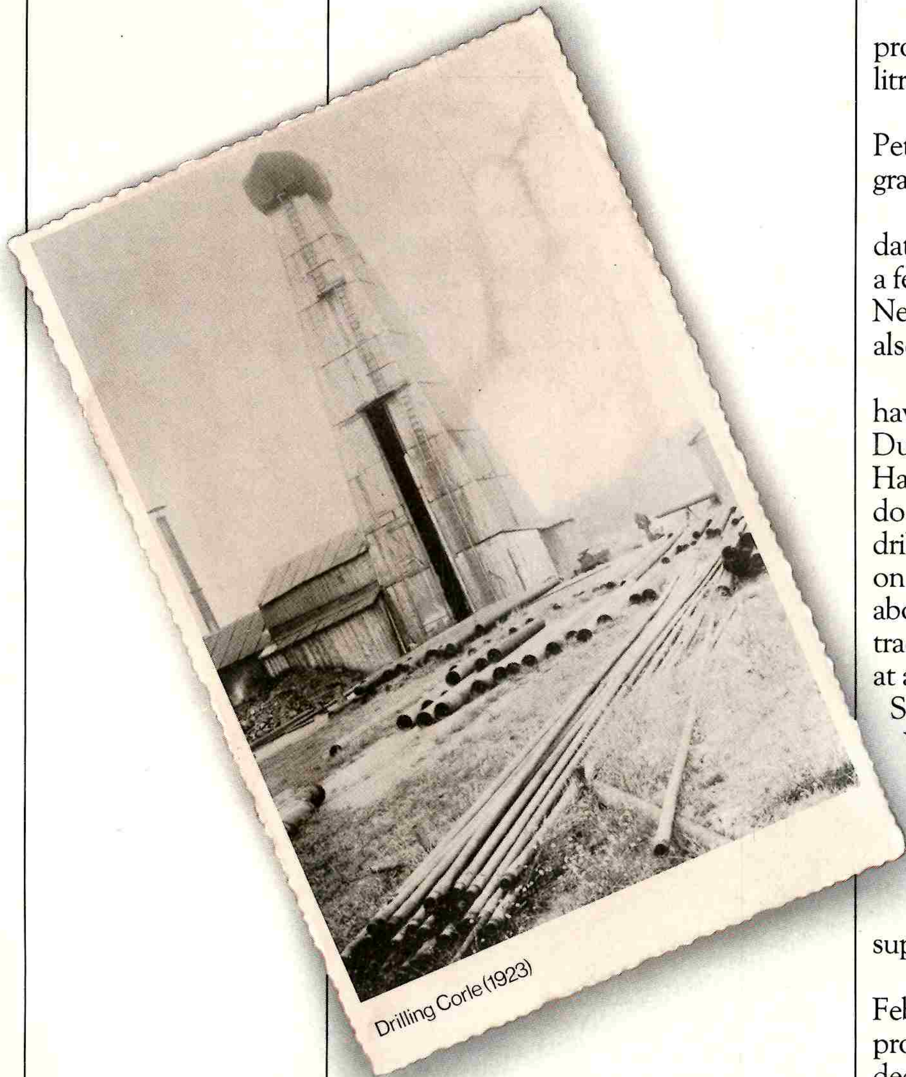
On the other hand, almost all the oil that the Netherlands needs must be imported. The Schoonebeek oilfield and the smaller fields in the west of the country together yield only a small fraction of the total amount of oil required.



The degree to which the Netherlands depends on oil from the Middle East was clearly demonstrated by the oil crisis in late 1973. The Dutch Government's 1974 Energy Memorandum consequently stated that the Netherlands must create a 'strategic' natural gas reserve. The need for such measures has since been confirmed by the continuous rise of oil prises.

◀ Sunday driving ban (late 1973).

The historical background.



Oil was first encountered in Dutch soil in 1923 when the National Prospecting Service struck oil in the hamlet of Corle near Winterswijk.

However, the amount involved proved to be very small: a total of 250 litres was raised.

In 1935 N.V. De Bataafsche Petroleum Maatschappij embarked on a gravimetric survey in the Netherlands.

In order to assess the worth of the data obtained, a dozen wells were drilled a few years later in the east of the Netherlands. A number of drillings were also made in order to survey deep strata.

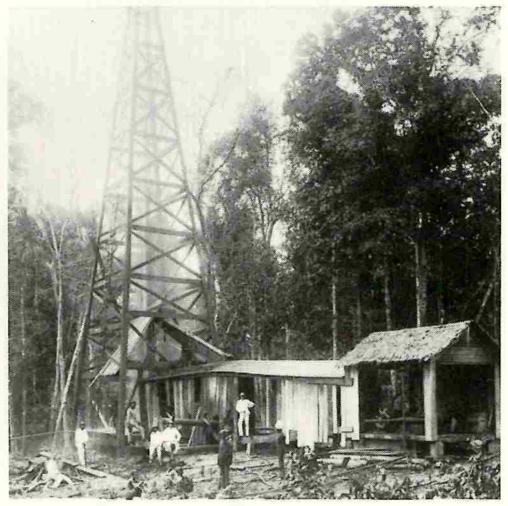
In the summer of 1938 an exhibition having as its theme oil production in the Dutch East Indies was organized in The Hague. But how could such an exhibition do without a drilling rig? An entire oil-drilling installation was therefore erected on the De Mient exhibition grounds. After about six weeks of drilling operations, traces of oil were struck quite by chance at a depth of about 450 metres one Saturday afternoon.

World War 2 broke out and German forces occupied the Netherlands. The Germans were naturally keen to get whatever oil they could, and so a first well was drilled in Coevorden in 1942 under their supervision.

This well was dry; a second well in February 1943 yielded some oil, but production was so modest that it was decided to drill a third one. This well was located near the town of Schoonebeek.

Surprise at De Mient (1938).

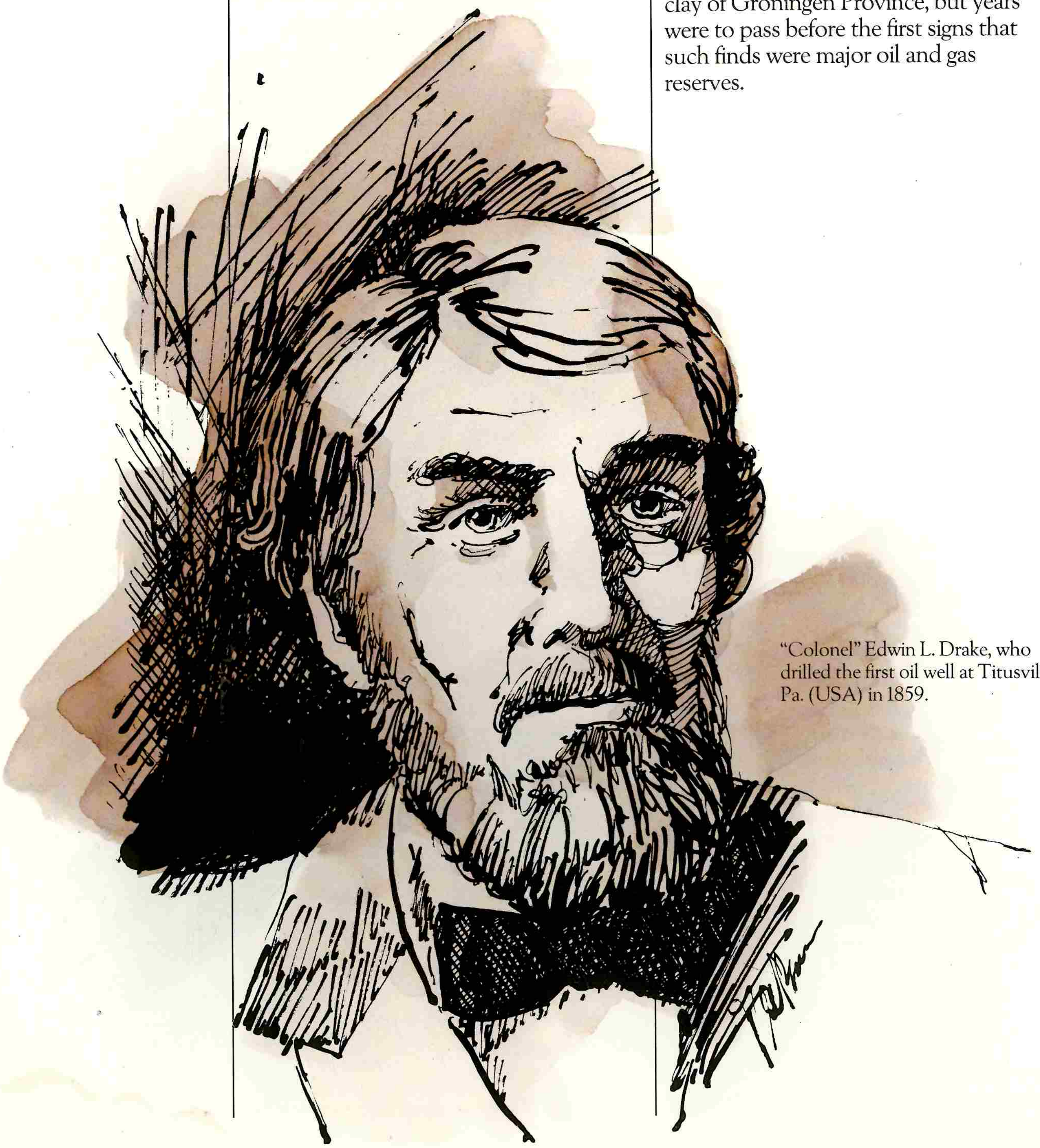
Oil extraction in the former Dutch East Indies.



The well was successful, but the Dutch drillers made sure that production remained at a minimum.

The discovery of the Schoonebeek oilfield and indications that oil might be found elsewhere in the Netherlands led in 1947 to N.V. De Bataafsche Petroleum Maatschappij (Royal Dutch/Shell Group) and the Standard Oil Company of New Yersey (Esso, subsequently Exxon Group) setting up a company to explore and develop the country's mineral resources. Shell and Esso each took a 50% interest in the new company, which was called Nederlandse Aardolie Maatschappij (NAM). A start was made on mapping the geology of the Netherlands with modern exploration techniques.

Oil was struck beneath the greenhouses of the Westland region between The Hague and Rotterdam, oil was struck in the south-east of the Province of Drenthe, gas was struck deep beneath the clay of Groningen Province, but years were to pass before the first signs that such finds were major oil and gas reserves.



"Colonel" Edwin L. Drake, who drilled the first oil well at Titusville, Pa. (USA) in 1859.

The petrified past.

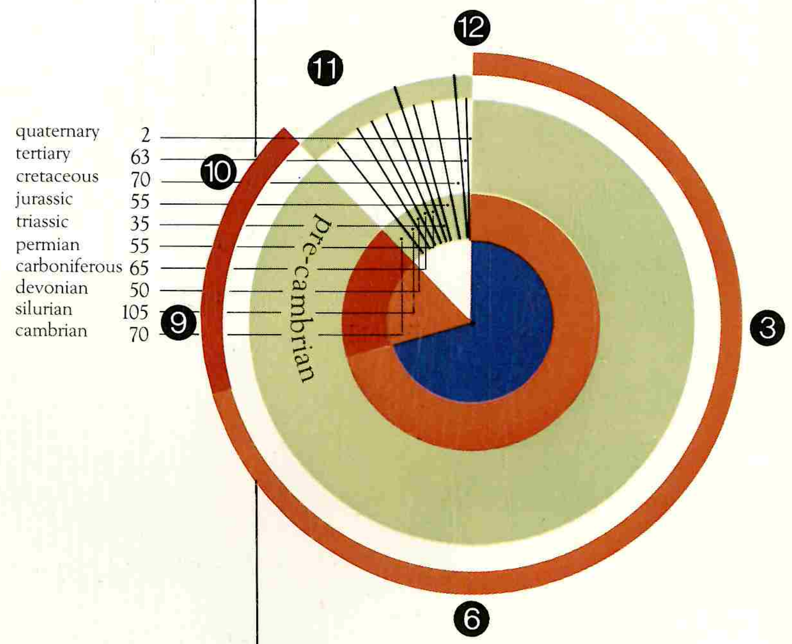
The only person who has ever been there, albeit on the wings of his imagination, is Jules Verne. By 'there' we mean the centre of the earth, some 6400 kilometres down.

Although man has succeeded in landing on the moon some 400,000 kilometres out in space, he has penetrated less than 10 kilometres into the earth's crust.

It is here that traces of life in ages long ago are concealed. The unknown past lies petrified in the earth's crust.

Formation of the earth's strata involved processes lasting millions of years. An example: in Limburg, the Netherlands' southernmost Province, there is a 100-metre thick layer of coal (petrified remains of dead trees and plants). For such a thick layer of coal to be formed, there must have been a mass of vegetation at least 1000 metres in height.

There are various ways of portraying the history of the earth's development. One of these is the 'geological clock'. If we assume the earth to be 4600 million years old, we can represent this period as 12 hours on the clock. One minute on the dial thus corresponds to 6.4 million years. If the earth comes into being at midnight, it takes until 3.08 a.m. – i.e. 1200 million years – for the liquid, red-hot mass to solidify. We know practically nothing of the period before that, representing many millions of years. No life appears on earth until 10.30 a.m.



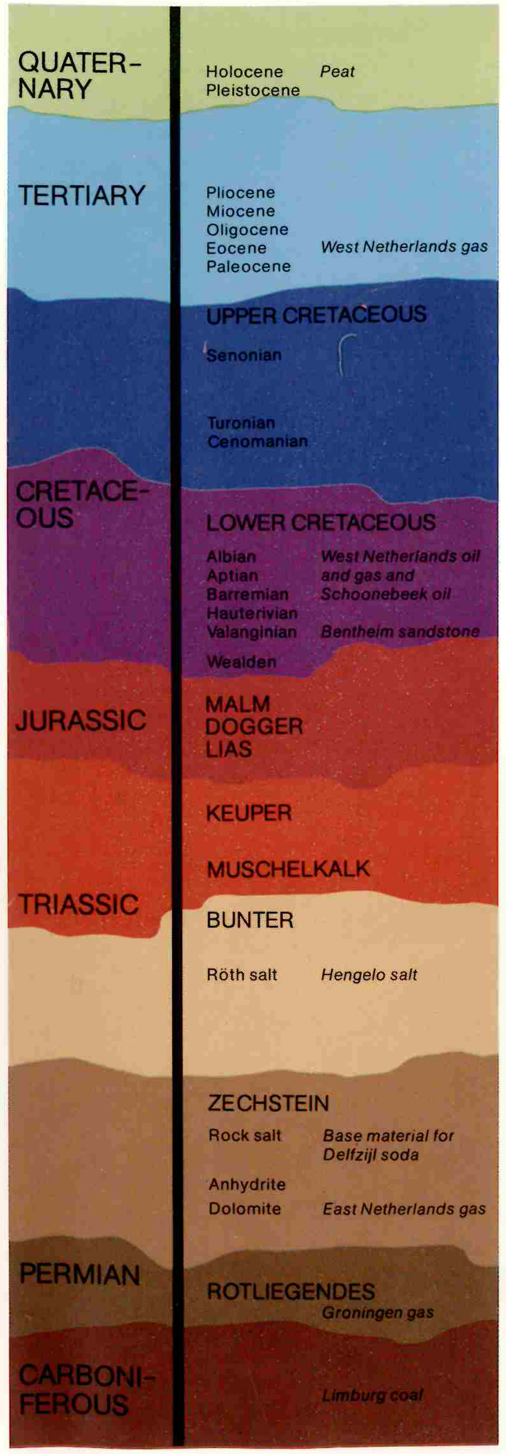
A geological clock: 4600 million years represented on a 12-hour dial. The period between 10.30 a.m. and 12.00 noon can be subdivided into Quaternary Age, Tertiary Age etc.
The names of the Ages are followed by their duration in millions of years.

Then things start developing – at least on the clock – very fast indeed. Within a few hours an observer would be able to watch a bewildering variety of life forms and earth movements. He would be able to see animals, both minute and colossal, come into being and die out within short spaces of time. He would see mountains rise and then disappear, seas engulfing the land and then receding to leave new land.

Between 11.18 a.m. and 11.21 a.m. the reservoir rock holding Groningen gas would be formed, and the Schoonebeek oil reservoir rock exactly 19 minutes later.

A geologist at work.

Man would not appear before 10 seconds to 12 o'clock, and a fraction of a second before midday would mark the start of the period we term human civilization.



Subdivision of the various Ages on the geological clock.

Formation of oil and gas.

Cross-section of a porous reservoir rock.

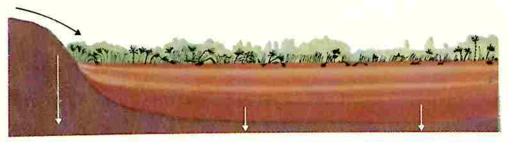
Subterranean oil lakes do not exist, nor do underground bubbles of natural gas. Oil and natural gas are encountered in porous rocks often lying deep beneath the earth's surface. The oil extracted in Schoonebeek lies at a depth of about 700 metres. Groningen's natural gas comes from a stratum lying at a depth of approx. 3000 metres.

The earth's crust, an approximately 35 kilometres thick shell, is built up of many overlying strata. Some strata were formed on the seabed, where plankton came to rest together with matter brought from the land by water and wind, such as sand, gravel and clay. Where once there were seas, enormous layers of salt were formed by evaporation. Processes leading to the formation of the geological strata took place on land as well. Coal strata, for example, were formed from the swamps of primeval forests. In fact, coal is the remains of vegetation and plants that died millions of years ago and have been preserved by being covered by the sea with sand and clay. Strata were formed one after the other and deeper-lying strata were increasingly compressed by the accumulation of strata above.

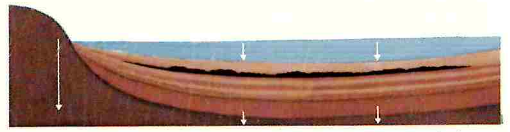
Porous and less porous rocks were formed under the influence of many factors. It is only in porous rocks that oil and/or natural gas can occur.

Oil was formed in strata that came into being on the seabed from the organic remnants of plankton and other marine flora and fauna.

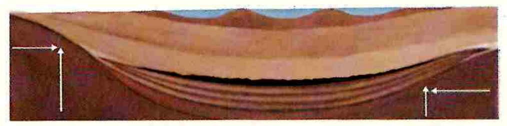
Tropical swamp



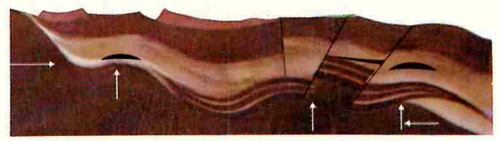
Basin formation and accumulation of peat in the Carboniferous age (tropical swamp). Severe subsidence of earth, causing vegetation to be flooded then covered with layers of clay, sand and lime, alternated with less marked movements of the basin, enabling vegetation to re-establish itself.



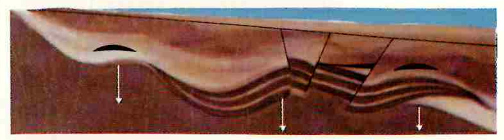
This period was followed by continuous subsidence of the basin, accompanied by sea encroachment. The seabed was covered by sediments forming an airtight seal over the remains of vegetation in the most recent layer of peat: coal measures were formed from the peat under the ever-increasing pressure caused by further sedimentation.



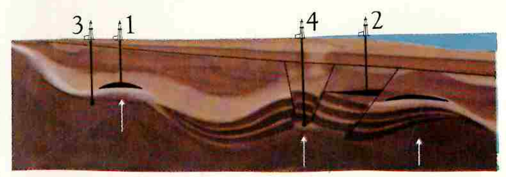
The basin is almost entirely filled up. The sea recedes. Start of folding due to uplift and lateral pressure. Formation of gas by coalification of coal measures. Migration of gas to a sand stratum.



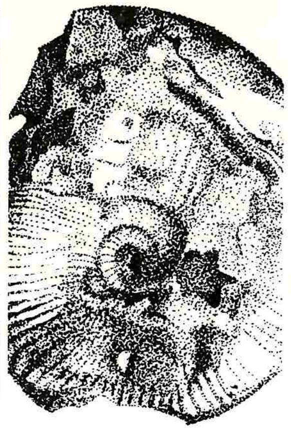
Continued uplift, followed by erosion. Folding and faulting. Accumulation of gas in a sand stratum.



Subsidence and slight tilting. Renewed encroachment by sea. Sedimentation.



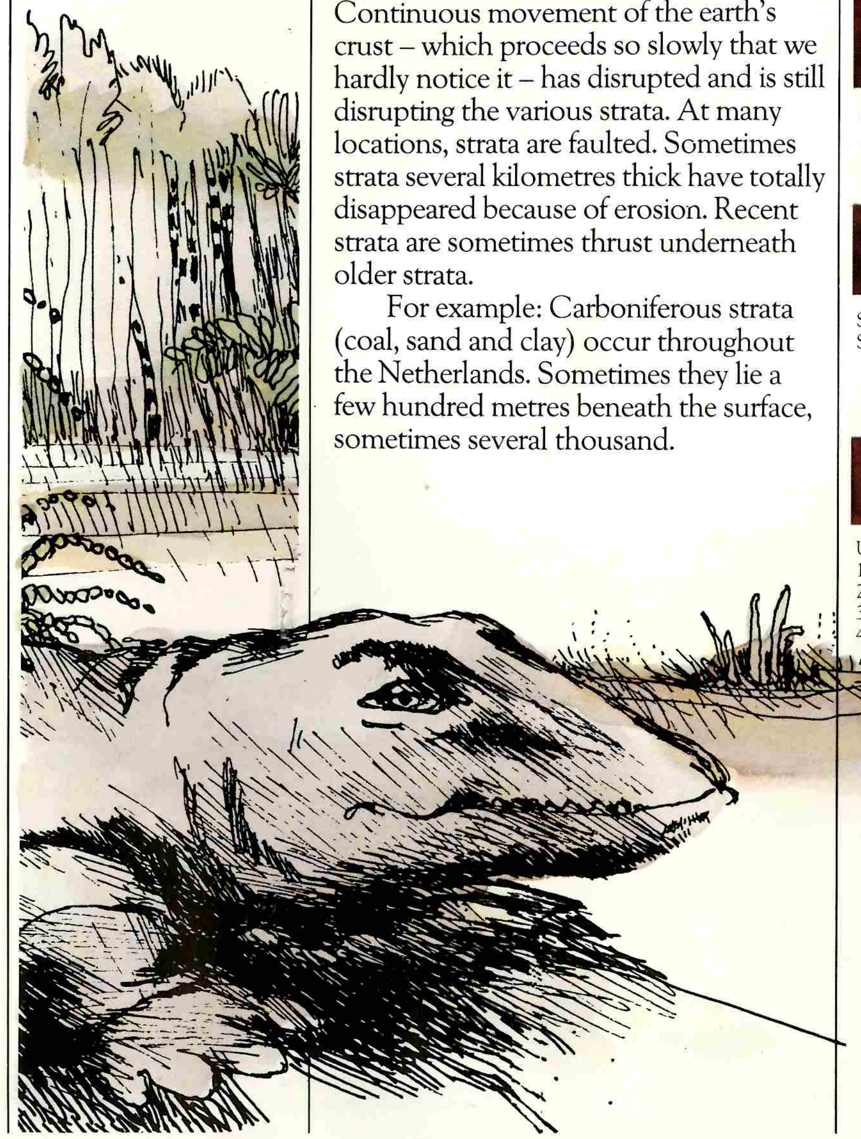
Uplift. Sea recedes.
1. Borehole in anticlinal accumulation of gas.
2. Borehole in gas accumulation against a fault.
3. Borehole too far down the flank. No gas struck.
4. Borehole encounters no reservoir rocks.



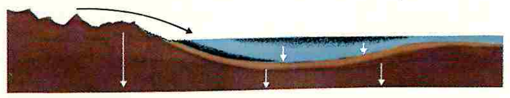
However, it is almost certain that the gas from Groningen, most other Dutch fields and the southern part of the North Sea was formed in quite a different way. The Dutch geologist Dr. R. J. H. Patijn came to the conclusion in 1963 that this is 'mine gas'. Dr. Patijn believes that Dutch natural gas was originally formed in coal measures. In a later stage of coalification, large quantities of natural gas were, he claims, released by 'post-coalification'. This gas must have migrated to higher-laying sand strata. The thick series of overlying salt strata prevented further upward migration of the natural gas. At present, this theory is regarded as the most likely explanation in geological circles.

Geological strata are not tidily stacked one on top of the other according to age. Continuous movement of the earth's crust – which proceeds so slowly that we hardly notice it – has disrupted and is still disrupting the various strata. At many locations, strata are faulted. Sometimes strata several kilometres thick have totally disappeared because of erosion. Recent strata are sometimes thrust underneath older strata.

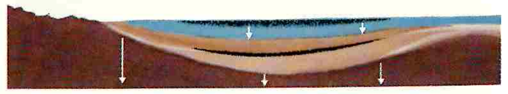
For example: Carboniferous strata (coal, sand and clay) occur throughout the Netherlands. Sometimes they lie a few hundred metres beneath the surface, sometimes several thousand.



Organisms

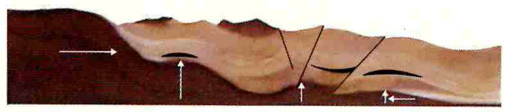


Erosion and transport into a subsiding basin. Deposition of dead organisms and erosion debris from highland (sediment).

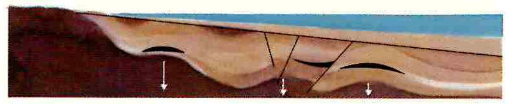


Further subsidence and filling up of basin.

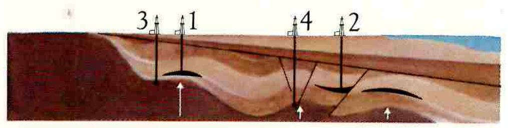
Basin practically filled. The sea recedes. Folding starts as a result of uplift and lateral pressure. Formation of oil and gas in layer of clay. Migration of oil and gas into a layer of sand.



Continued uplift, followed by erosion. Folding and faulting. Accumulation of oil and gas in a sand layer.



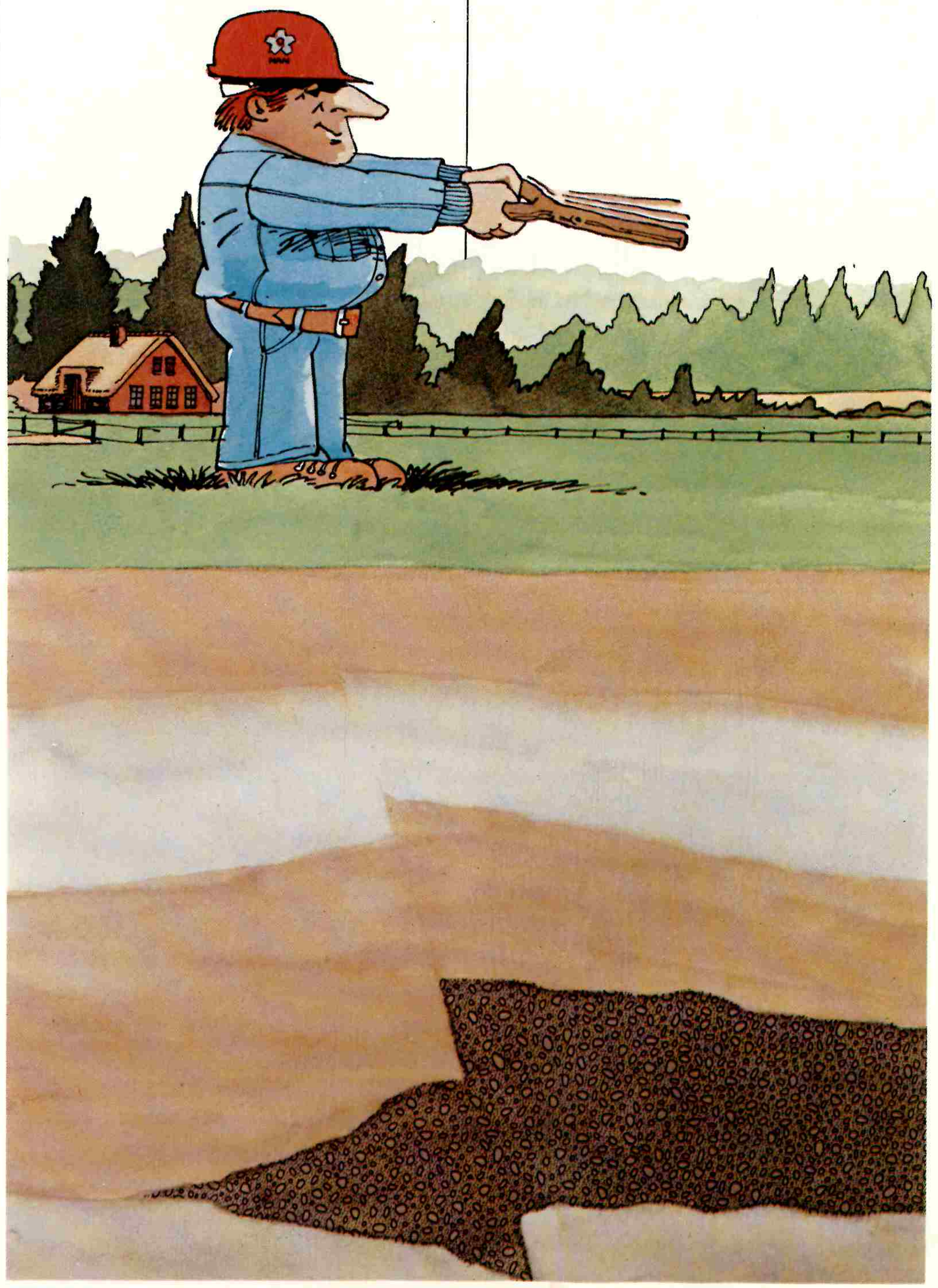
Subsidence and slight tilting. Renewed encroachment of sea. Sedimentation.

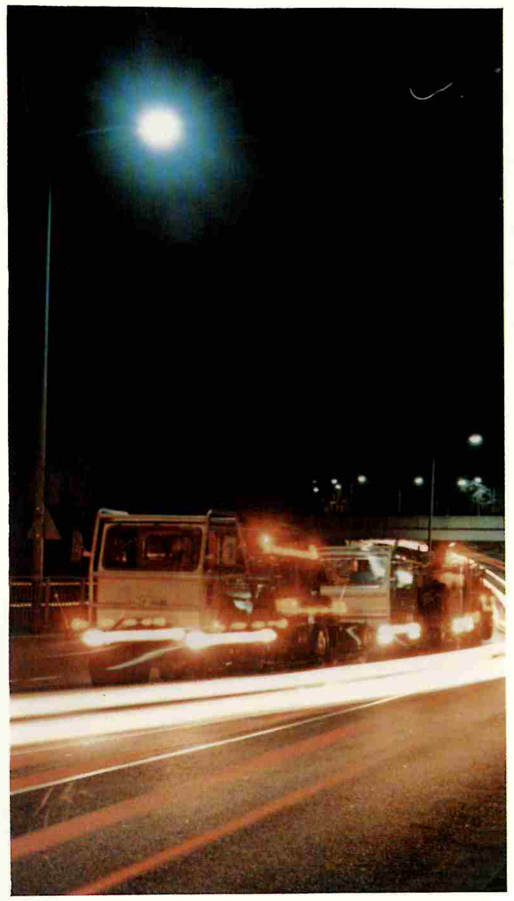


Uplift. Sea recedes. Present situation.
1. Borehole in anticlinal accumulation of oil.
2. Borehole in oil accumulation against a fault.
3. Borehole too far down the flank. No oil struck.
4. Borehole encounters no reservoir rocks.

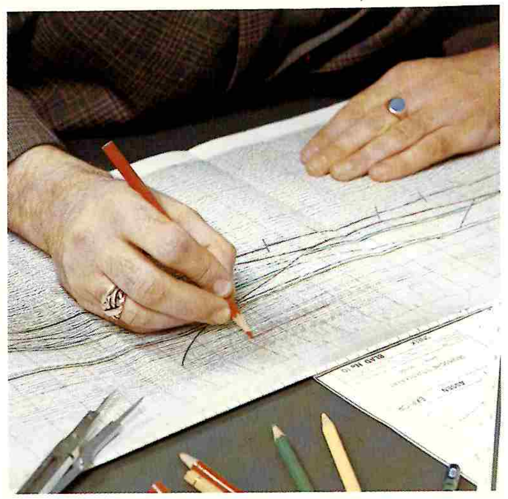
The jigsaw puzzle of the earth's crust.

The first step on the long road that may lead to the discovery of oil and gas is extensive investigation of the composition of the earth's crust. The people engaged in this investigation are called geologists. They attempt to answer questions such as how the strata are built up and from which geological age they originate.
At what depth do they lie, can they contain oil or natural gas. The answers to these questions must be sought and assembled like the tiny pieces of an enormous jigsaw puzzle.
On the basis of data acquired from geological surveys, the geologist prepares geological maps. There are a number of methods of mapping subsurface formations:
* Gravimetric: based on variations in gravity.

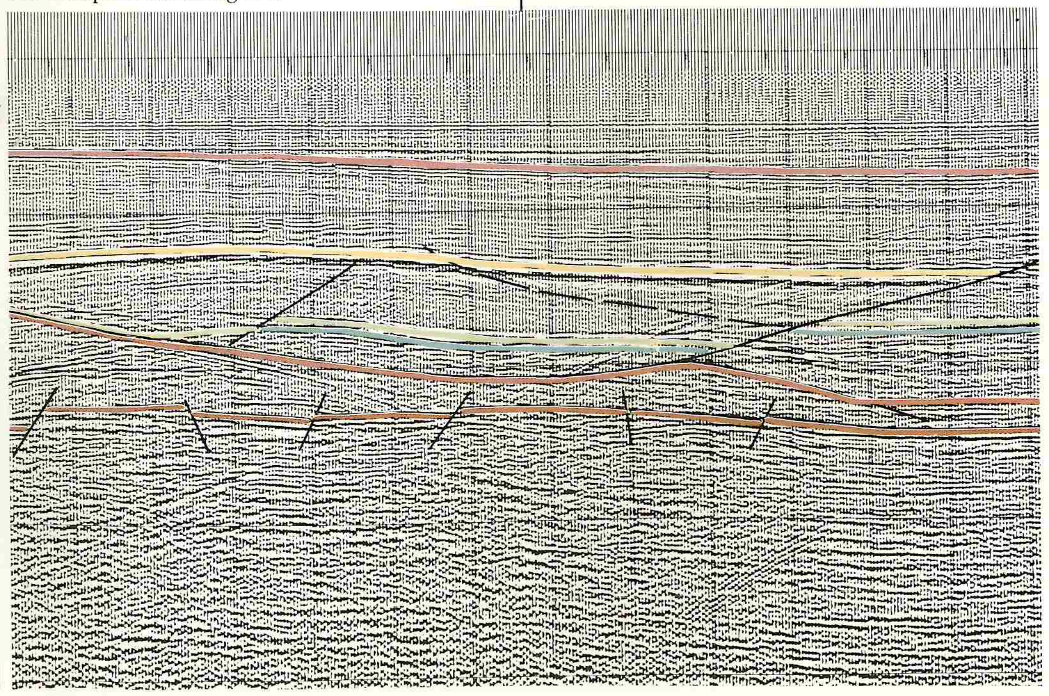


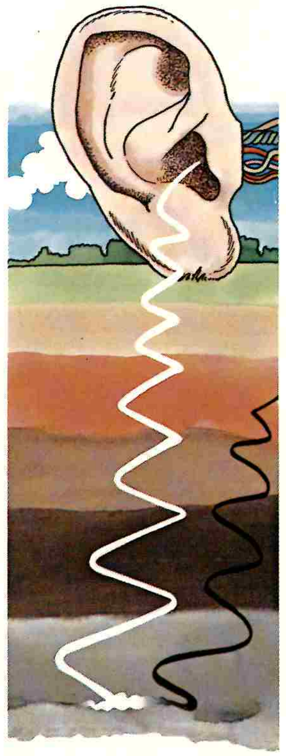


* Magnetometric: based on the magnetic field present in various strata.
* Remote sensing: infra-red measurements with the aid of satellites and airplanes.
* Field geology: investigation of the earth's surface.
* Seismic survey: based on the generation of vibrations.



An interpreted seismogram.





The only method described in detail in this booklet is that of seismic surveying, as it is this method alone which is used in the Netherlands. This is because the strata of interest are concealed from view by later strata.

The basic technique underlying seismic surveying is the generation of vibrations. Various methods are available. It is possible to detonate small charges of explosives in shallow holes. Another method is called vibroseis. With this method, vibrating plates secured beneath vehicles are pressed against the ground. This is often used when investigating sites in towns and villages.

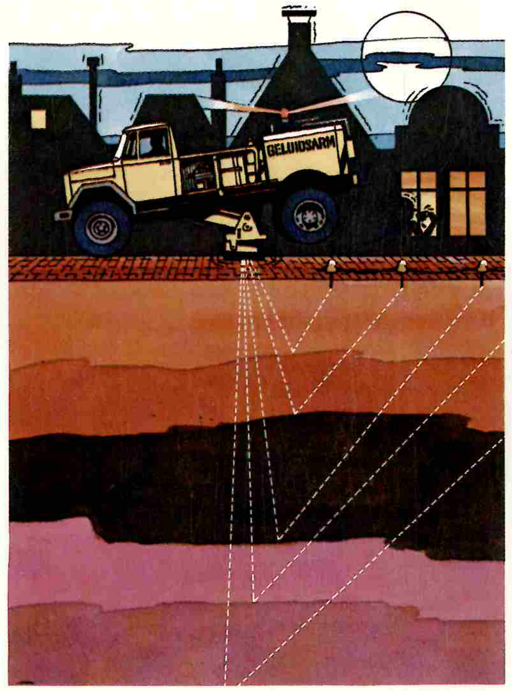
At sea a device known as an airgun is used, involving the sudden release of compressed air.

The vibrations generated are propagated through the ground. At the boundary planes of the various strata, they are reflected to the surface of the ground or water and detected by sensitive instruments known as seismometers.

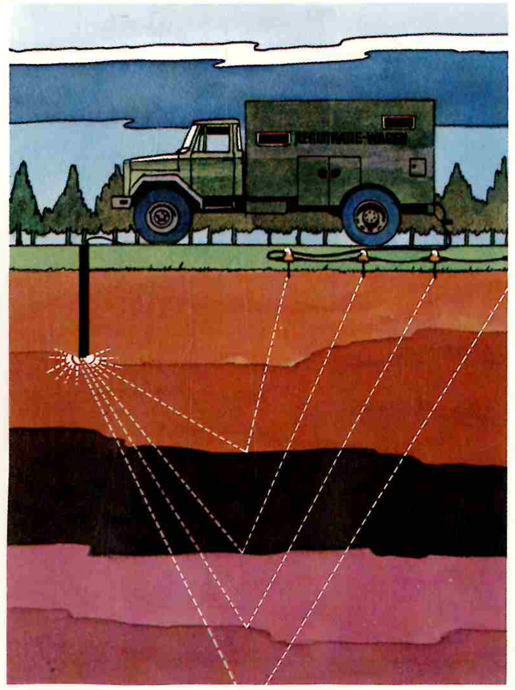
These detectors record the reflected signals onto magnetic tape. The data is subsequently processed by computer.

The resulting chart is called a seismogram and is used by the seismologist to compare the points in time at which the reflected signals were received and so to read off the times taken by the signals to travel from the ground to the boundary planes and back again. As the propagation velocities through various strata are known, the depth of the various boundary planes can be calculated. A number of seismograms are then put together to acquire a picture of the configuration of the strata. By comparing the seismogram with the data acquired from subsequent drillings, the original picture can be revised or adapted where necessary. This can in turn lead to new investigations.

Vibroseis.



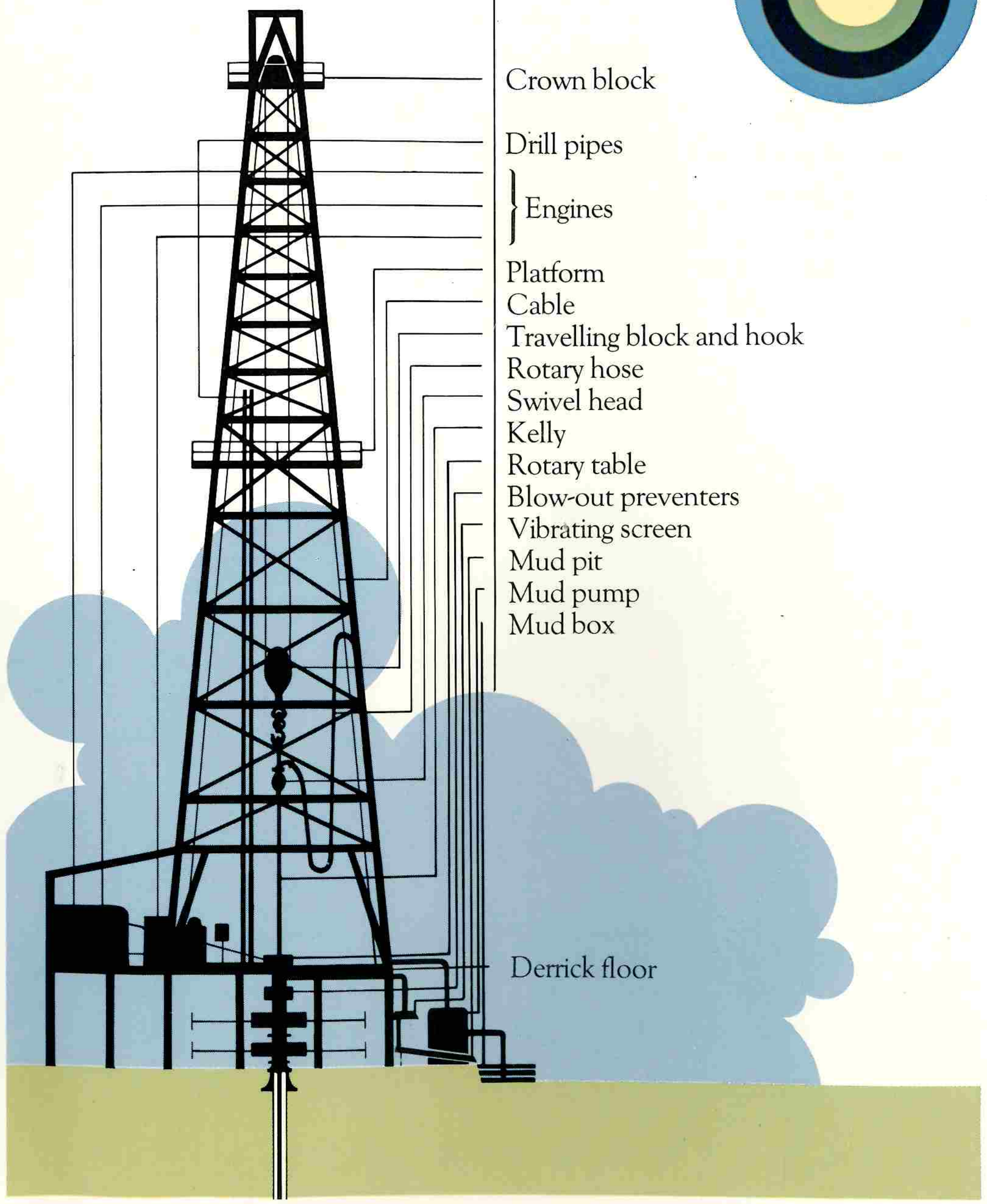
Conventional seismic technique.

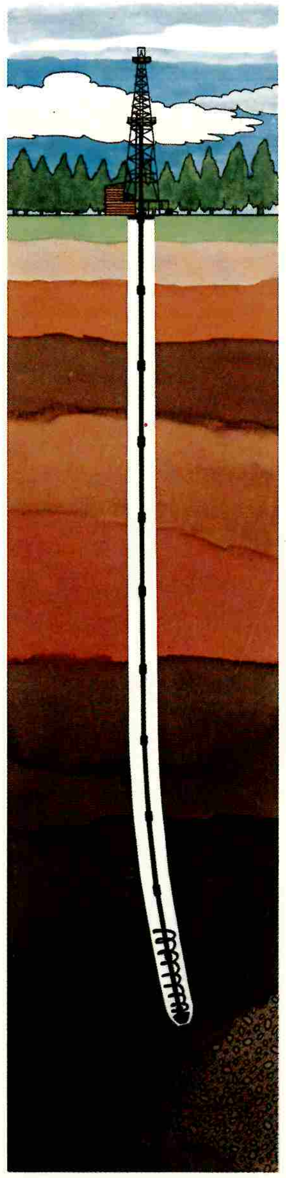


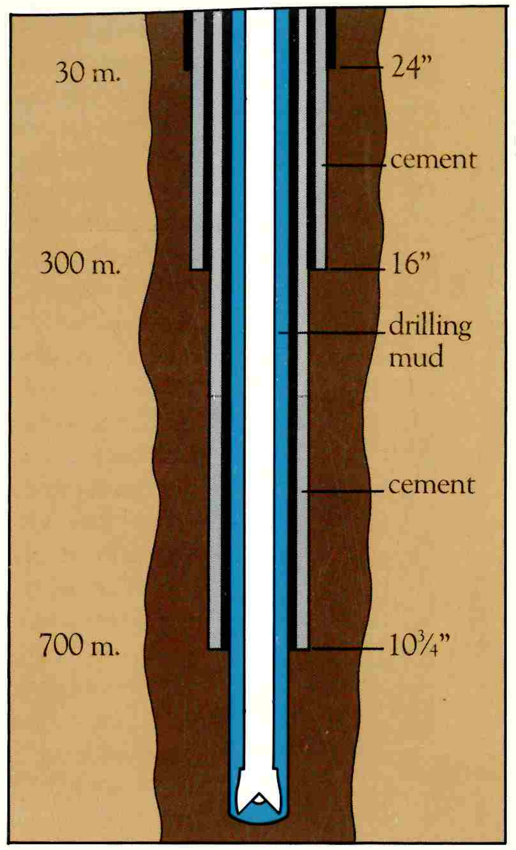
Into the depths of the earth.

To find out whether the geologists are right in presuming that a given spot deep below the earth's surface is the place where oil or natural gas can be found there is only one thing to do: start drilling.

Once the Government has granted permission for drilling to be carried out, ground must be rented for the drilling derrick to be installed. Sometimes a road must be made, and before the derrick can be actually erected, a great deal of preparatory work is needed. The actual drilling can last a few weeks or several months. If no oil or gas is struck (the well is 'dry'), NAM restores the site to its original condition. A test drilling on land costs several million guilders. The costs of an offshore drilling are often five times as high.







This sketch shows the arrangement underground in the drill hole. It gives an idea of the string of casing needed to reach a depth of approximately 3000 metres.

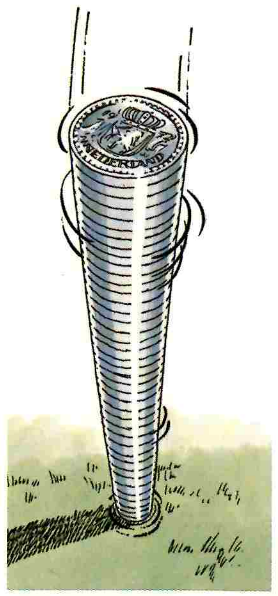
Every drill hole is provided with blow-out preventers which can be shut by remote control.

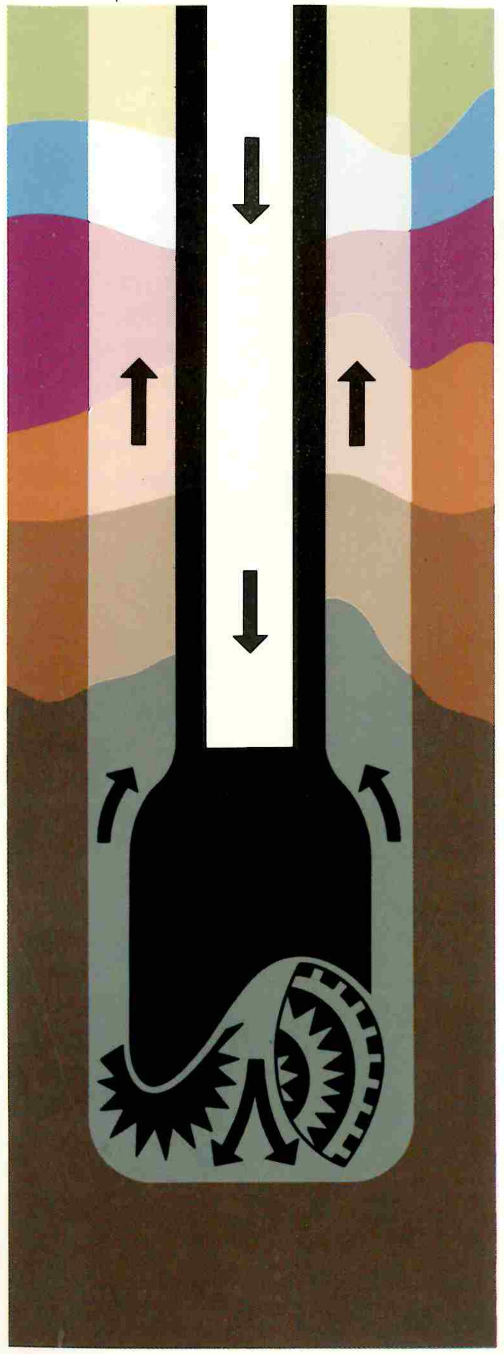
In principle, drilling proceeds vertically downwards. However, situations may arise where this is not possible. In such cases, directional drilling may be a remedy. Directional drilling means that the borehole is initially vertical and then proceeds at a slant. Because of the Netherlands' high population density and strict environmental regulations, most drillings on Dutch territory are directional. However, this technique is subject to a number of restrictions, simply because the angle of deviation is limited.

Between the top of the 50-metre tall derrick and the floor, a number of heavy devices are slung which the driller must keep under control. At the top of the derrick there are a number of pulleys over which a cable carrying a 5-ton hoisting block runs. Underneath this block there is a hook on which a spherical device, the swivel head, is suspended.

The rotational movement required is supplied by the rotary table, a steel disc mounted in the heart of the derrick: the derrick floor. The 'kelly', a pipe length of square or hexagonal cross-section, is rotated by the rotary table and is free to turn in the swivel head. When drilling starts, a bit is fitted to the bottom of the pipe. When the whole length of the pipe has descended, the driller hoists the drilling string and another length of drill pipe is secured between the kelly and the bit, thus enabling the bit to drill further downwards. The length of the drilling string thus grows with the depth of the hole.

The power needed to drive this complicated machinery is supplied by electric motors which are in turn driven by their own generators. Of course, drilling involves much more than has been summarized in these few lines.





The path followed by the drilling fluid.
The density of the fluid prevents escape of gas or oil through the borehole.

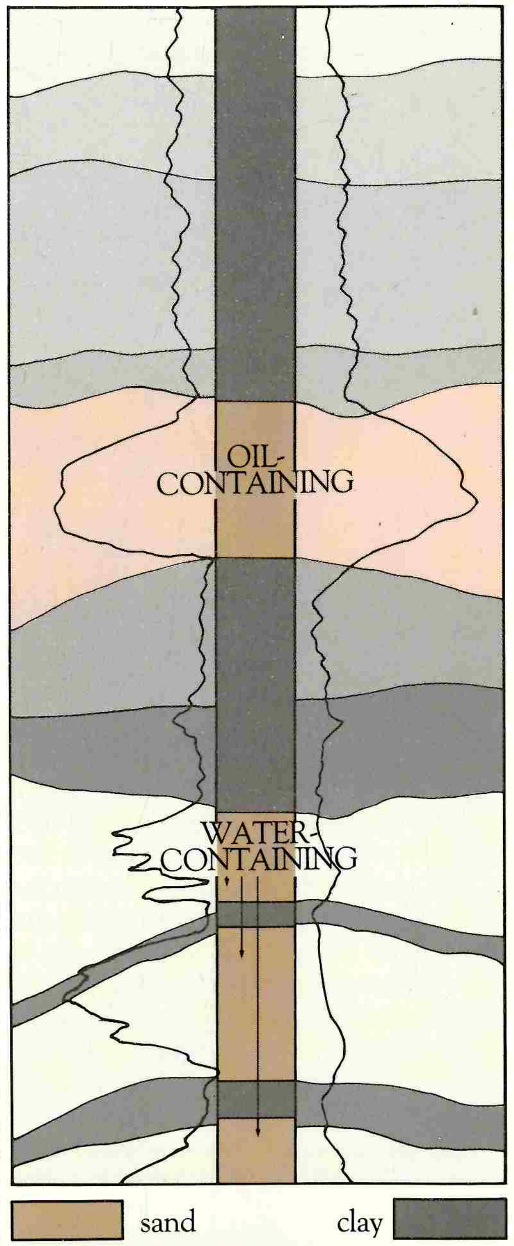
A special liquid, known as drilling fluid or mud, is forced through the above-mentioned swivel head and down the drilling string to ensure that the rock crushed by the bit is brought to the surface between the drill pipe and the side of the hole. Additionally, the drilling fluid prevents the walls of the borehole from caving in and prevents gas or liquids from drilled strata from entering the borehole. A number of blow-out preventers are fitted above each borehole, and can be closed at any moment, by remote control if necessary. In order to strengthen the borehole, it is 'cased' (lined) by means of steel pipes cemented to the borehole wall.

The depth of the hole and the type, thickness and content of the strata determine the length of the casing and the number of casing strings that have to be installed. At present, boreholes are often lined with up to five strings. The steel lining for a 3000-metre hole can involve an expenditure of about 1,500,000 guilders on casing pipes.

In a steel-lined borehole of e.g. 3000 metres in depth, casing pipes worth about 1,500,000 guilders may be installed.

In the mid-1930s, the French brothers Schlumberger invented a method for acquiring data about geological strata without any actual material having to be brought to the surface. Various measuring instruments connected to an insulated cable are lowered into the borehole. These instruments measure certain properties of the rock, such as electrical resistance, sound propagation velocity and natural radioactivity. The diagrams produced from these measurements enable experts to determine those geological properties which are of interest in the search for oil or gas: porosity, permeability and the presence of oil or gas.

ELECTRIC LOGGING



The Schlumberger company at work.

Oil.

There are two regions of the Netherlands where oil is extracted: Schoonebeek, in the south east of the Province of Drenthe, and the west of the Netherlands, where there are a total of 10 oilfields: Rijswijk, Pijnacker, de Lier, Berkel, Wassenaar, Zoetermeer, Moerkapelle, IJsselmonde, Ridderkerk, Werkendam.

Various methods have been developed to bring oil to the surface:

Vegetation is planted around oil well-heads near Wassenaar to hide them from view (KLM Aerocarto).

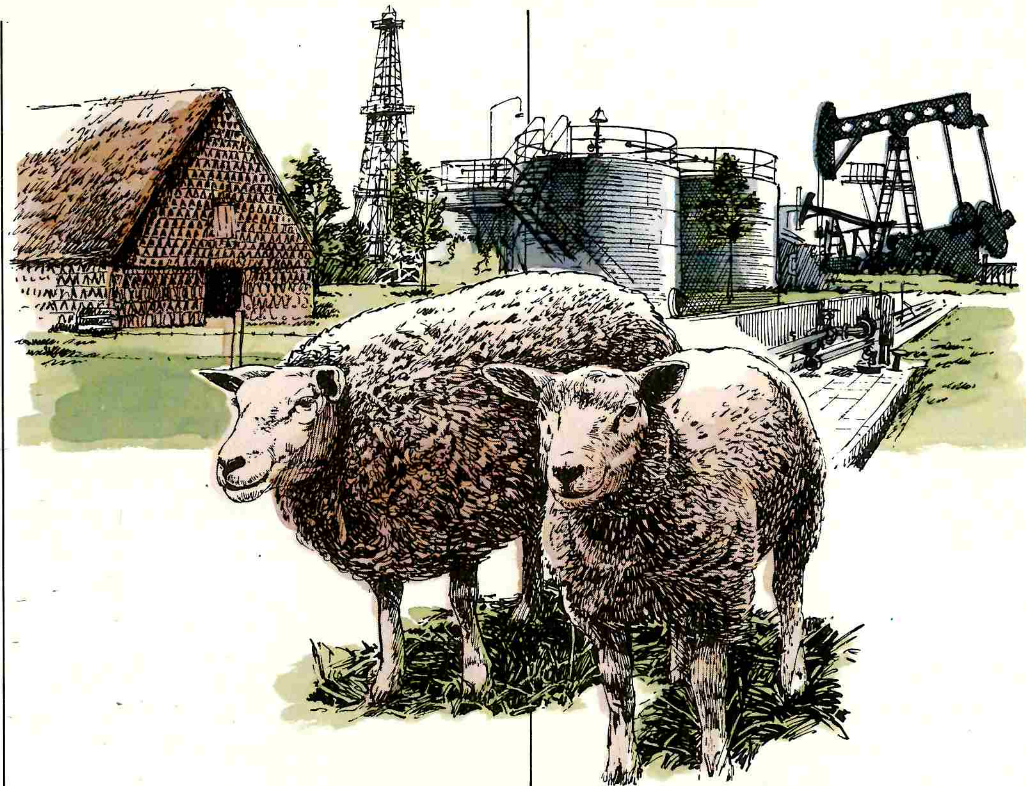
- Natural flow, where the pressure in an oil reservoir is so great that the oil is forced through the tubing to the surface.

Regrettably, this occurs neither at Schoonebeek nor in the west Netherlands fields.

- Pumping, whereby a subsurface pump is driven electrically, hydraulically or by means of a beam-type surface unit.
- Gas lift, whereby the oil is brought to the surface with the aid of high pressure gas.

However, in many cases pumps and water drive or gas lift systems are unable to bring all the oil to the surface. If the oil to be extracted is very heavy and highly viscous, other techniques must be used. These are based on the fact that oil becomes thinner when heated and it is therefore reasonable to expect that underground heating of the oil will raise the rate of production. The supply of sufficient heat involves a wide range of problems and a great deal of capital expenditure.
NAM uses two methods for subsurface heating of oil:
* Hot-water injection
* Steam injection.

Both methods are used in the Schoonebeek field.



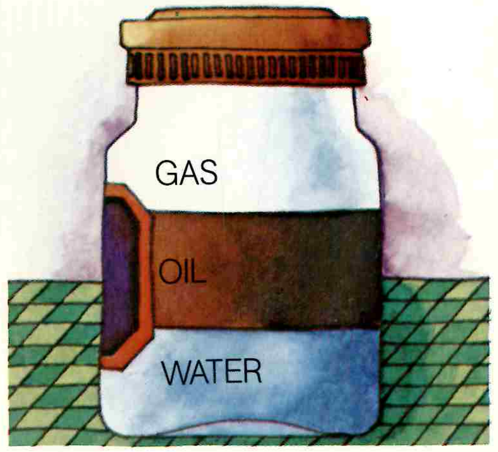
Until 1980, steam injection was only used on a very limited scale at Schoonebeek. Since mid-1980, however, there has been a marked increase in the use of steam injection in this area. It is expected that Schoonebeek's production rate, which ran to about 2000 cubic metres per day in 1980, will be doubled by this means.

The daily production rate of oil in the west of the Netherlands is about 1800 cubic metres.

Central steam installation.
(Schoonebeek steam injection area)

Schoonebeek has been called the 'model field' of Europe. Numerous installations have been set up in accordance with a strict plan. Several hundred beam-type pumping units are spread over an area measuring 18 kilometres in length and an average of 3 kilometres wide.

The liquid actually produced at Schoonebeek consists of 8% oil and 92% brine and is handled in 18 gathering stations. Here, the dissolved gas is separated and the remaining liquids accurately measured. Subsequently the brine is separated too.



The oil is pumped through a pipeline network to a central shipment station where more salt and water are removed.

With the aid of chemicals and fresh water the water and salt contents are reduced to comply with refinery requirements: less than 1% water and less than 75 milligrams per litre salt. The oil is then transported by train to the Shell and Esso refineries near Rotterdam.

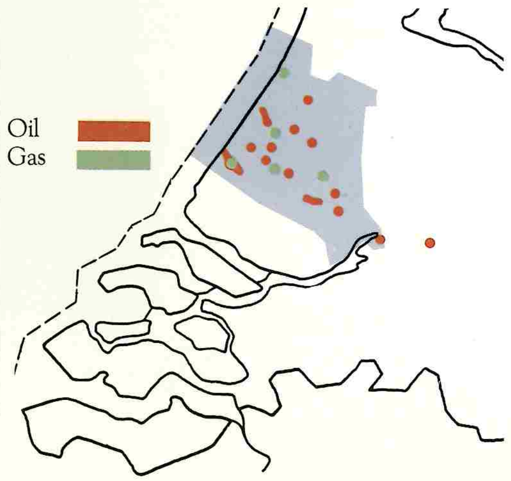
The brine is returned underground by being pumped into injection wells: some is used for cold water drive purposes in various areas of the field, while most is injected into the flank of the field.

In the west of the Netherlands, the fluid extracted consists of 7% oil and 93% water. The 10 oilfields in the west of the Netherlands have a total of 23 central stations.

In this region, production is processed field by field in the same way as at Schoonebeek. The oil is transported to the refineries by pipelines, train or ship.

The rule is that Shell and Esso each refine 50% of all oil extracted in the Netherlands by NAM.

Rijswijk Concession



Gas from Groningen.

'The Slochteren gas bubble': a cliché in the Netherlands since 1959. We have already seen that oil lakes and gas bubbles do not exist, but the enormous Groningen gasfield, with proven reserves of about 2000 milliard cubic metres, is still referred to as a 'bubble'.

Ever since 1959, when the discovery well Slochteren 1 was drilled, public interest has been focussed on the Groningen gasfield. Barely three years after 'Slochteren' had hit the headlines, it was already possible to let 600000 cubic metres of natural gas per day flow to the first consumers. In 1977 the 28th group (cluster) of wells came on stream. At present, natural gas can be produced at a maximum rate of 450 million cubic metres per day. This means that in less than two days the total yearly requirement of a city such as Amsterdam can be produced.

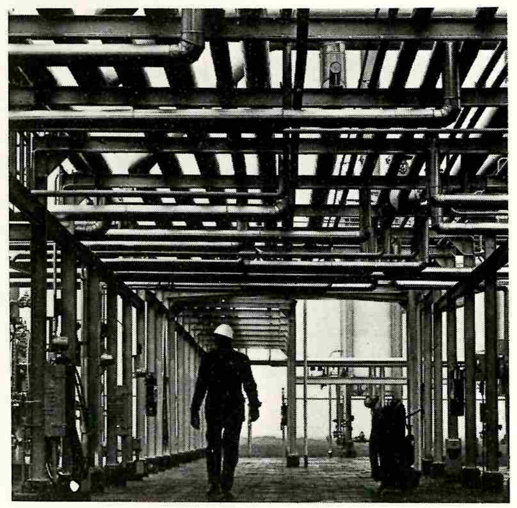
The 28 clusters are spread over an area measuring about 900 square kilometres in all.

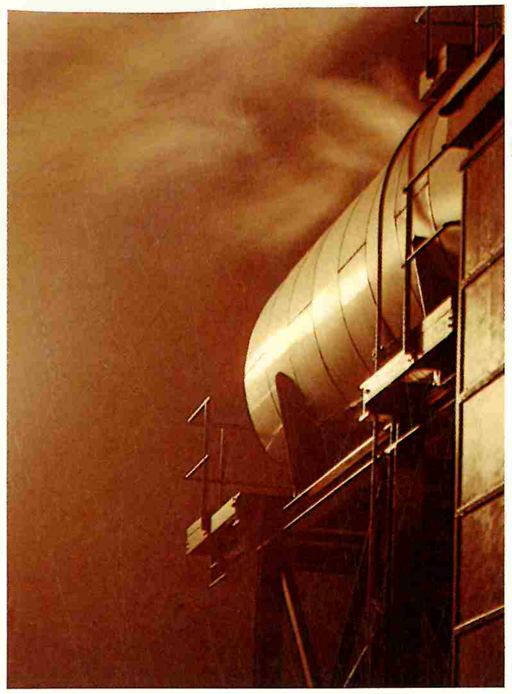
Well cluster "De Eeker" in the Groningen gasfield. The village of Scheemda is in the background.

In order to deliver such enormous quantities, a perfectly functioning system is essential. Maximum safety is achieved by means of sophisticated automation systems. All production sites, also known as well groups or clusters, each consisting of about 10 wells and 5 dehydrating plants, operate without people being present. Even the control room present at each well cluster is not manned. If installations do not operate correctly, a signal is automatically given to a Central Control Room located near Sappemeer. The duty officer can then send the flying squad, which is always present on the field, to the well cluster concerned. This squad can investigate what the problems are and adjust the installation if necessary. If such a flying squad cannot get to the spot on time, that part of the plant for which the alarm has been given is automatically depressurized. The gas still present in the plant is flared off by means of a pilot flame burning constantly at each well group. The well groups are monitored by an automatic 'look and listen' system in which computers and television cameras have an important part to play. In addition, special surveillance staff rove around the Groningen gasfield.

The gas produced cannot be piped direct to consumers. It must first be treated. In most cases, natural gas is a mixture of several gases, some toxic, others highly corrosive. Water vapour and gaseous higher hydrocarbons in the gas can, if pressure and temperature are lowered, be precipitated as solid crystals which accumulate in the lowest-lying regions of the piping network.

These crystals can cause blockages. The natural gas from Groningen is 'clean'. This means that it contains no toxic substances in the form of sulphur



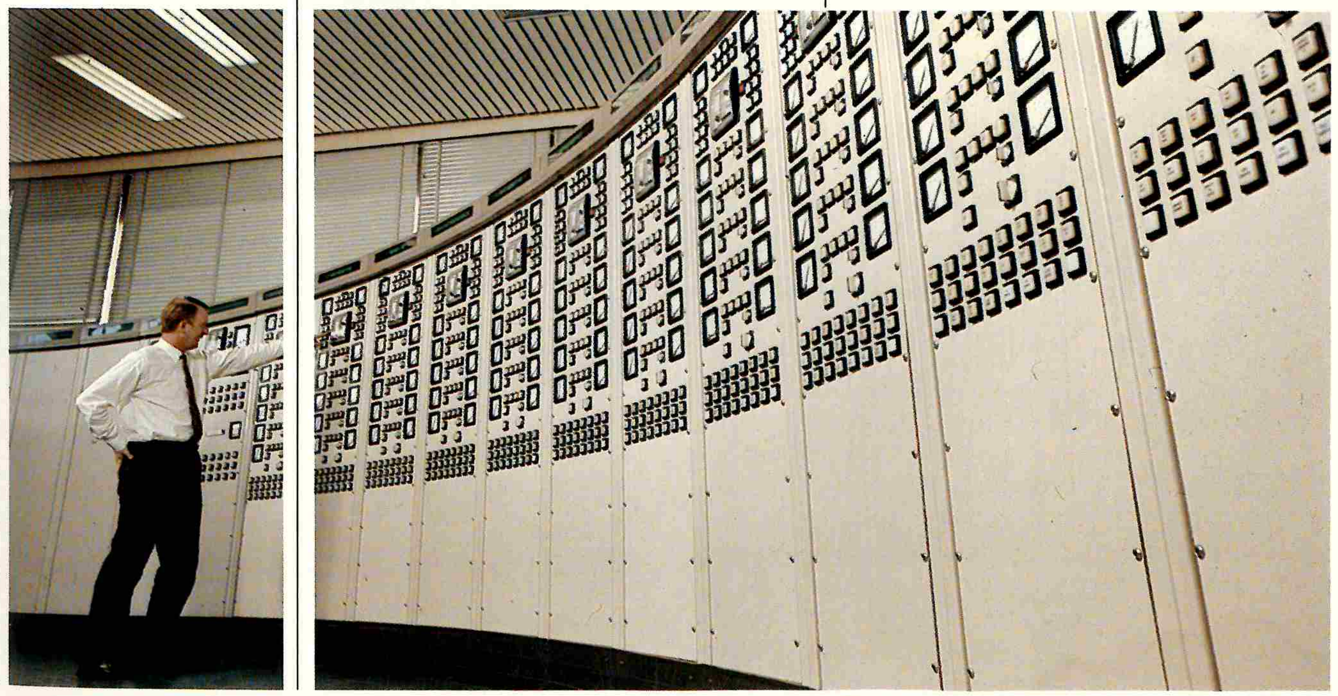


compounds, or other contaminant gases. But it must still be treated before it is suitable for transport and use.

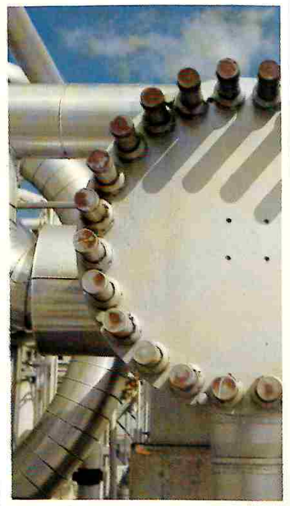
Before being transported for ultimate use, the gas produced is dehydrated and depressurized. At a depth of 3000 metres, the gas has, at present, a pressure of approximately 230 bar and a virtually constant temperature of around 100°C. In the treatment plant, the gas is cooled by means of coolers, heat exchangers and gas expansion to -12°C and is depressurized to 74 bar. For each million cubic metres of gas, about 5 cubic metres of liquid are separated: 4 cubic metres of water and 1 cubic metre of condensate, a liquid resembling light gasoline.

This treated gas is transported to five gathering stations where the quantities are gauged before it is delivered to N.V. Nederlandse Gasunie, the company responsible for further distribution. At this stage, the gas has a constant pressure of approx. 65 bar and a constant temperature of approx. 15°C.

Central Control Room, Sappemeer.



Strategic reserve.



A field with a proven reserve of around 2000 milliard cubic metres of natural gas. One of the largest fields in the world, situated in the Netherlands and representing enormous wealth for that country. Many people therefore fail to understand why it was suddenly stated in the 1970s that '. . . the Groningen gasfield is, as far as possible, to be saved and reserved for the future . . .'

To clear this up, we need only think back to 1963. In that year, the Dutch Government realized that the Netherlands would have used about half of the Groningen gas by the year 2000. At that time it was expected that other energy sources would have displaced gas by the turn of the century.

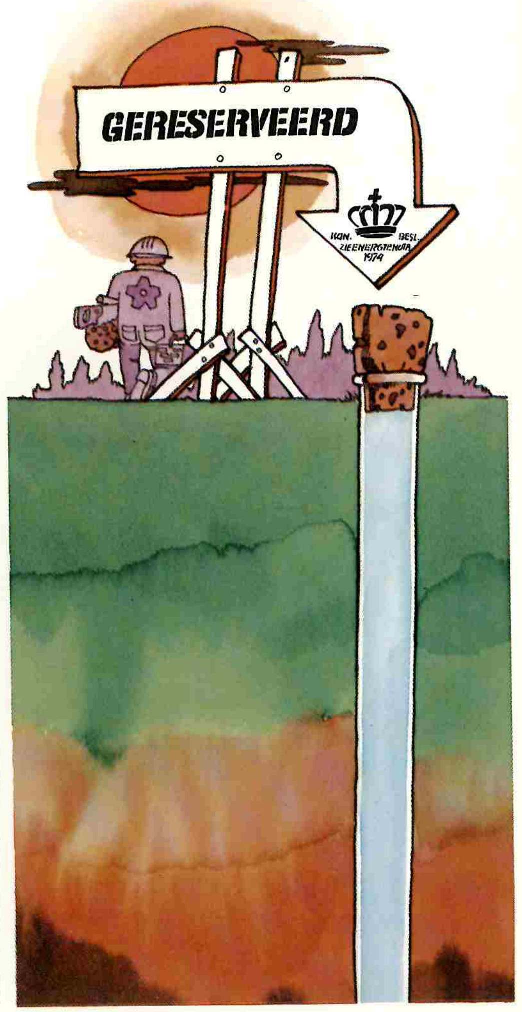
This means that by the turn of the century there would still be about 1000 milliard cubic metres of natural gas in the Groningen field. It was thus decided to sell these 1000 milliard cubic metres on the open market. The Dutch Government was successful in this endeavour: five West European countries have been receiving gas from Groningen since the mid-sixties. The income from these exports was, and still is, of major significance for the Dutch economy.

However, the energy crisis in late 1973 made it clear how dependent the Western world is on oil supplies from the Middle East. Furthermore, it was increasingly realized that the new energy sources – in particular nuclear energy – would not be so far developed by the turn of the century as to make Groningen gas redundant. And that had been the philosophy underlying the 1963 sales policy.

For these two reasons, the Dutch Government decided to reappraise its energy policy. In the 1974 Energy Memorandum, the Groningen gasfield was designated the coming century's energy store. To achieve this goal, measures had to be taken to retain a strategic reserve at Groningen. These measures are detailed in the 1974 Energy Memorandum. This policy document makes the following points:

* Power stations and industry must change over from gas to coal or oil.
* Public information to encourage more economical usage and improved efficiency of gas appliances.
* Purchasing of gas from abroad to supplement domestic stocks.
* Gas supply contracts concluded with foreign countries will not be renewed.
* Other gasfields in the Netherlands to be explored, inventorized and brought on stream as quickly as possible.

It is the last point in particular which is of great importance for NAM: greater emphasis is being placed on the exploration, inventorization and bringing on stream of other gasfields.



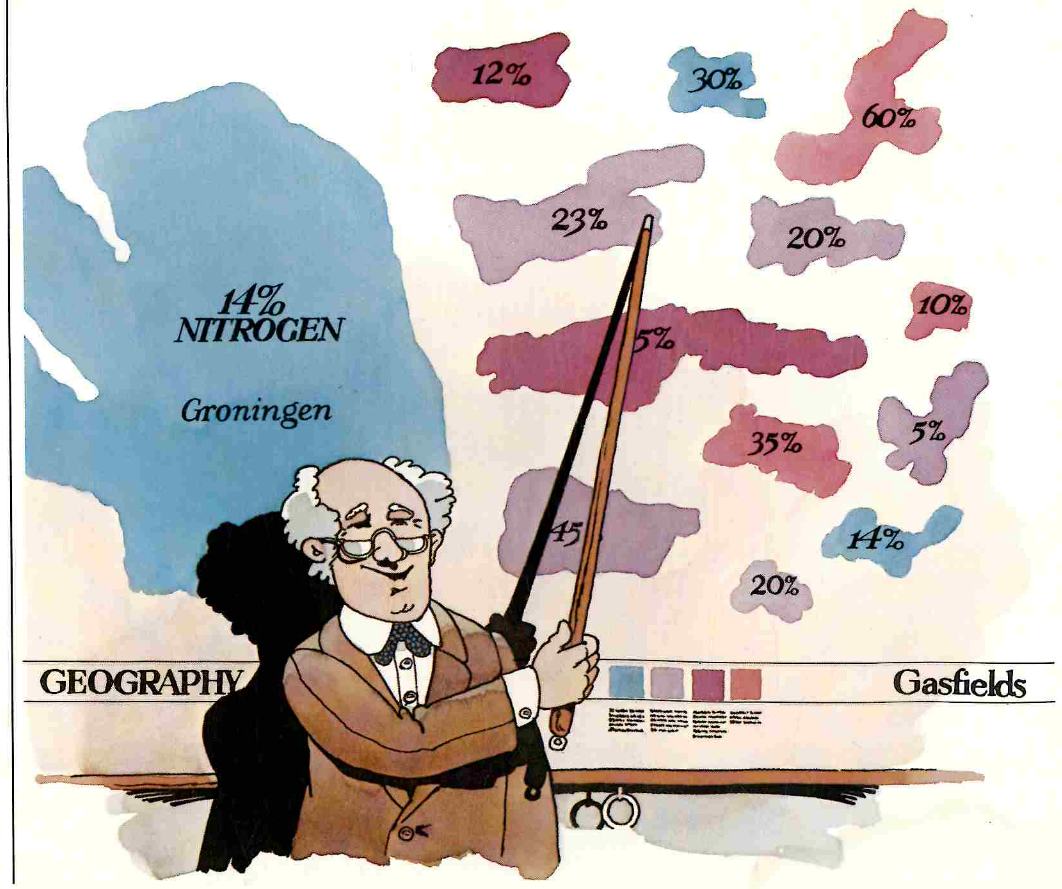
The small gasfields.

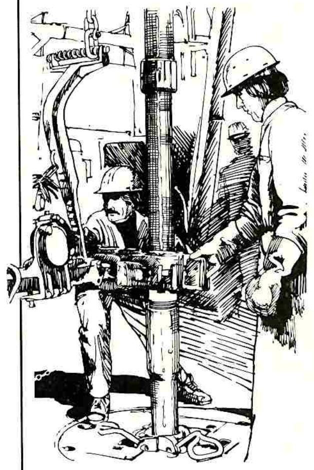
How small is a small gasfield? In comparison with the enormous Groningen gasfield, with its original reserves of around 2000 milliard cubic metres of natural gas, fields of 1 to 10 milliard cubic metres must indeed be called small. But their importance must not be underestimated; since 1973 they have become increasingly significant. Following the 1974 Energy Memorandum, official Dutch policy is to accelerate the exploration, inventorization and bringing on stream of these small fields. This is no simple task, as the fields are widely scattered. They vary in size and in product composition.

The smaller gasfields – about eighty in number at the start of the 1980s – are almost all to the north of a line connecting Amsterdam and Zwolle. Most are located in the Provinces of Drenthe, Friesland, North Holland and Groningen (on the flanks of the Groningen gasfield) and on the Dutch part of the Continental Shelf. The fact that they are so widely scattered means that a large number of production plants must be built and extra piping networks laid.

Evidently, it is the quantity of gas struck and its composition which go to determine whether a field is economically viable or not. There is another factor involved: the linking of natural gas prices to oil prices on the international market. The effect of this price linking has been that fields originally considered to be uneconomic have become commercially viable in the course of time.

It is the wide range in gas composition which makes the bringing on stream of small gasfields such a difficult task. It should first be noted that there is no standard composition for natural gas. In the Netherlands, all household gas appliances are adjusted to take gas from Groningen. The main constituents of this gas are flammable methane (82%) and non-flammable nitrogen (14%). These percentages determine the heating content per unit mass, known as 'calorific value'. Groningen gas has quite a low calorific value because of the





amount of nitrogen it contains. In the Netherlands, however, gases are also produced which have quite a high calorific value. It is mainly large industrial users and power stations which take these gases. Apart from the extensive distribution system which brings Groningen gas to the consumer, there is also a second system in the Netherlands specially for conveying high calorific gases. Depending on product composition, the minor gasfields are linked up to one of these two pipeline systems. The North Sea fields and most of the Drenthe fields supply their gas to the high calorific network, while the Tietjerksteradeel field in Friesland supplies gas to the low calorific (Groningen) network.

However, there are also fields where the gas quality is such that it cannot be fed into either of the two systems straightaway, for example the Sleen (53% nitrogen) and Roswinkel (24% nitrogen) fields. In such cases the extracted gas first has to be brought to the correct quality by mixing.

On the continental shelf.

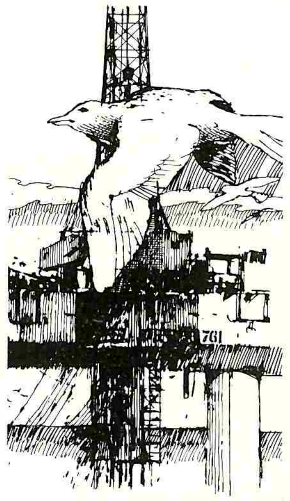
The 1810 Mining Act, dating from the time of Napoleon, applies to the Dutch mainland including territorial waters. After the Second World War the oil companies, in their quest for gas and oil, no longer confined their exploration activities to such areas. The open sea beyond territorial waters has also been opened up as prospecting area. Who owns the open sea? Who owns the minerals found there? Who may drill for and extract oil or gas?

In 1958 the United Nations held a conference in Geneva on these questions. The main item on the agenda was the division of the Continental Shelf, the underwater continuation of the mainland, between the various coastal states.

The Geneva Convention rules that neighbouring countries (such as the Netherlands and Belgium) or countries on opposite sides of the same sea (such as the Netherlands and the U.K.) must draw up the borders of their Shelf regions themselves, using what is termed the principle of equidistance: the lines formed by points equidistant from the coasts were to be taken as borders. Within those borders the coastal states, while respecting the principle of the freedom of the seas, were to decide themselves who was to be permitted in their regions and under what conditions they would have to operate.

Nederlandse Aardolie Maatschappij has been performing offshore seismic surveys since 1956. The first exploration well in the North Sea was drilled by

Production platform (gas).

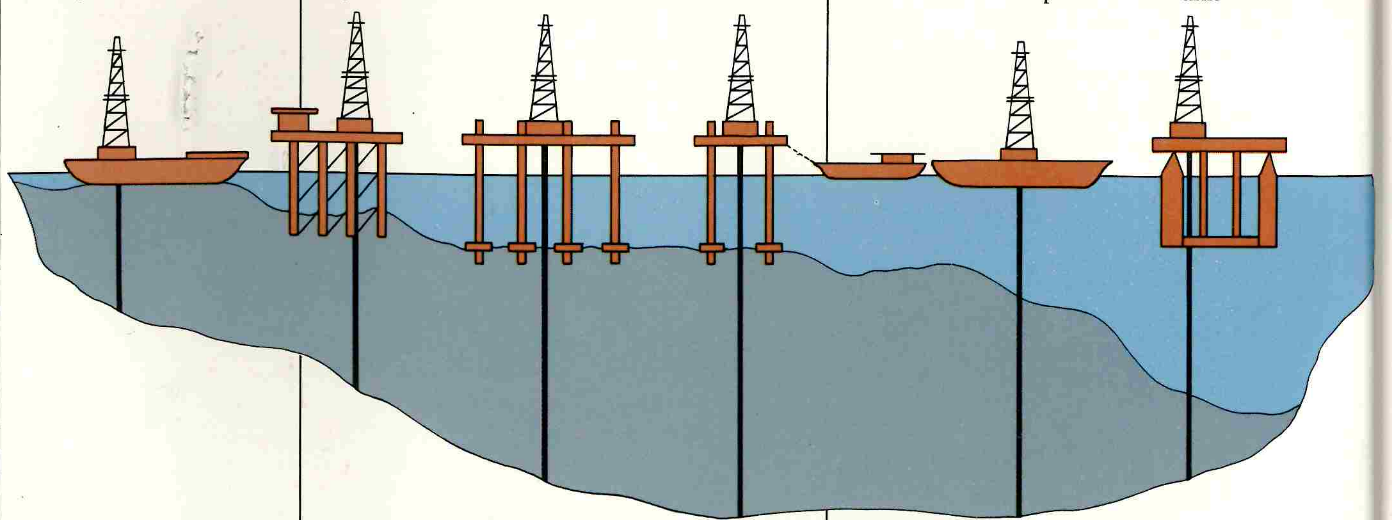


NAM in 1961. At the same time, this was the first offshore well in Western Europe. The well was unsuccessful, as were the next three.

Following discovery of the Groningen gasfield, many oil companies suddenly showed a great deal of interest in the North Sea. The Dutch Government was not very happy with this turn of events. It did not relish the idea that the same chaotic drilling activities would break out on sea as had already done so on land. Between 1963 and 1968 things remained quiet in the Dutch part of the Shelf.

During that period, many questions were settled in the Continental Shelf Mining Act, also known as the 'Wet Mining Act'. NAM was the first company to commence drilling operations in the Dutch part of the Shelf after the Act had been passed. At that time, the British Minister of Economic Affairs had stated that, thanks to the discovery of four gasfields, the U.K. now possessed natural gas reserves of 700 milliard cubic metres. Major oil and gasfields were also found in the Norwegian part of the Continental Shelf.

The results achieved in the Dutch part are modest compared with those attained by the British and Norwegians. Nonetheless, a number of gasfields have been discovered, particularly north west of Den Helder, by Nederlandse Aardolie Maatschappij and other companies. Taken all round, these fields form a significant gas-producing region. By means of a 120-kilometre pipeline, the gas extracted – and partially treated offshore – is brought to land near Callantsoog. It is forwarded to a treatment plant near Den Helder, where it undergoes final treatment before being delivered to N.V. Nederlandse Gasunie. Another pipeline has been laid to the north of the Waddenzee mud flats, coming on shore in North Groningen.

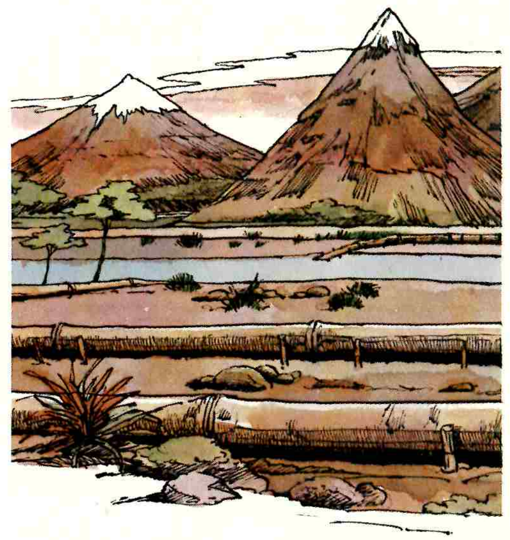


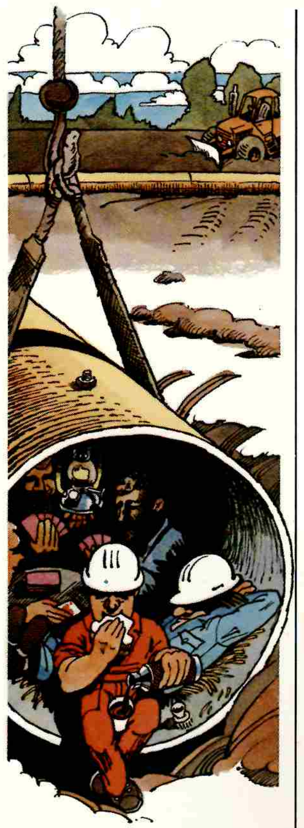
The type of platform used depends largely on the sea depth.

En route to the consumer.

Oil and natural gas are mostly conveyed by pipeline. Miles and miles of lines have been laid to transport both of these precious resources to their various destinations. This is particularly true of natural gas. Although pipelines are used for oil as well, in the Netherlands oil is very often transported by rail, road and ship.

The history of the pipeline goes back more than a thousand years. To convey natural gas, the Japanese used bamboo. The Americans were the first to transport natural gas underground. The first pipeline, laid in 1870, was 40 kilometres long and ran from Bloomfield to Rochester. The pipes consisted of hollowed-out tree trunks, wrapped in jute and coated with tar. In 1872 the first metal pipe was buried, made of heavy wrought iron. It was not until 1891 that a pipeline was devised in which gas could be transported over long distances under high pressure.
In fact it was only in 1925 that manufacturers succeeded in making seamless thin-walled steel pipes.



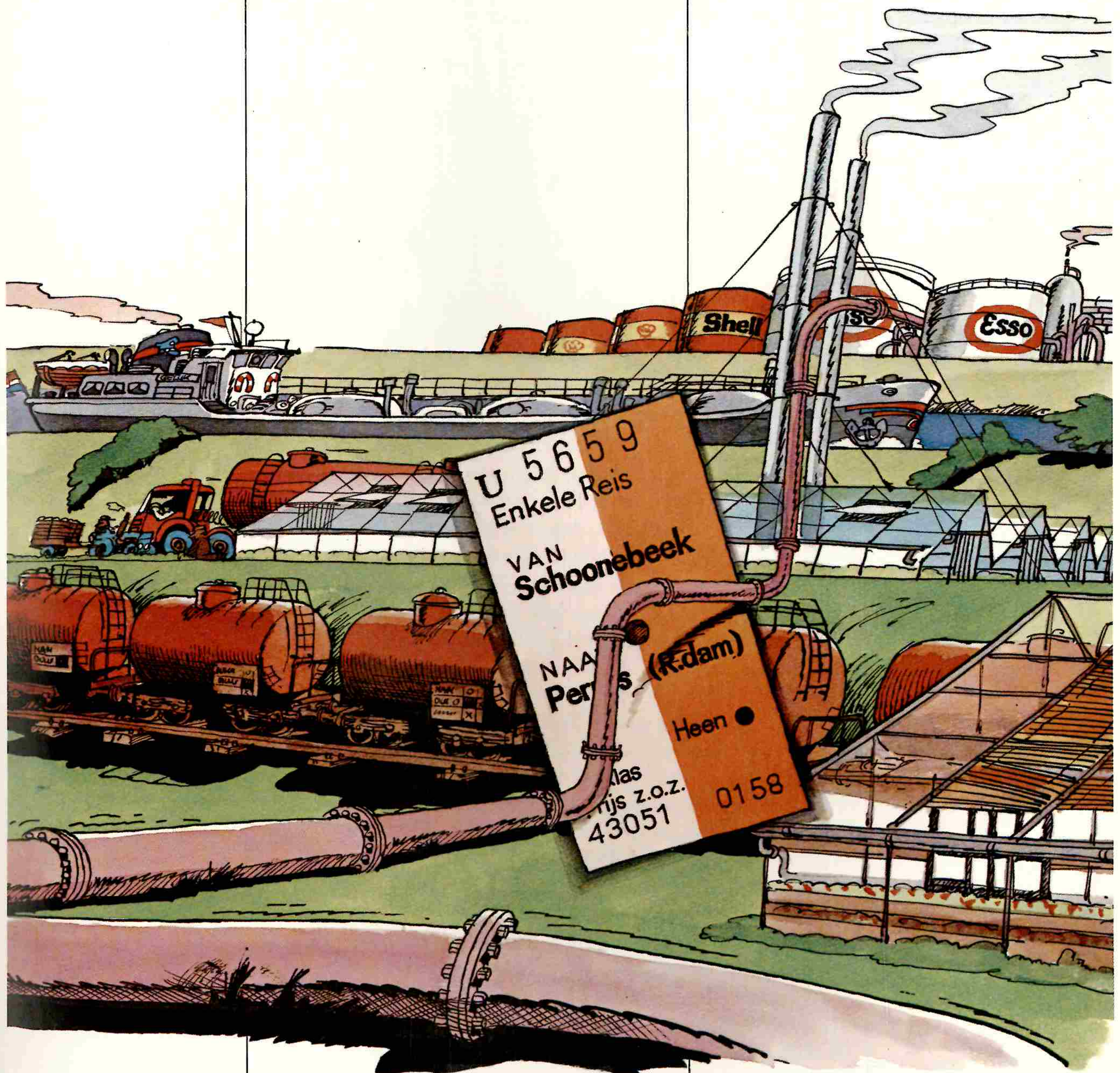


The chapters dealing with natural gas in this brochure have all concluded with the sentence 'the treated gas is subsequently delivered to N.V. Nederlandse Gasunie'. It is this company which ensures that every household gets natural gas through the local gas companies and that industry and large-scale users receive the supplies they need. N.V. Nederlandse Gasunie was set up in 1963 and its head office is in Groningen. It is jointly owned by the State Mines (40%), the State (10%), Shell and Esso (25% each). The Gasunie purchases, transports and markets all gas produced in the Netherlands. In addition it imports natural gas – from Norway and other countries – to supplement Dutch stocks.

The Gasunie also ensures that the natural gas it markets, which is practically odourless, is given a distinctive smell. At the various measuring and control stations an odorant is added for safety reasons. If gas escapes anywhere, it can then be smelt.

As already stated in the chapter titled 'OIL', the oil extracted in the Netherlands is transported to the Shell and Esso refineries near Rotterdam, each company takes 50% of the oil produced.

From Schoonebeek, oil is transported by train, and from the west of the Netherlands oil is carried by train and pipeline to the refineries, the latter region being located closer to the refineries concerned. The oil train from Schoonebeek runs several times a day, carrying about 1400 tons of oil on each trip. The first oil train ran on 20th December, 1946.



The crude oil shipment station at Schoonebeek.

There were various reasons why, soon after the Second World War, it was decided to transport oil by train rather than by pipeline, ship or road tanker. Schoonebeek oil is particularly viscous and readily solidifies. To keep the oil fluid, a pipeline would have to be kept warm over the several hundred kilometres of its route. Moreover the laying of such a pipeline would take years. The advantage of the train over the road tanker was that larger quantities could be transported.

Water-borne tankers might have been a possibility, were it not for the fact that there was a shortage of shipping immediately after the war and that transport to the west would come to a standstill if canals froze in the winter. Large storages facilities would then have had to be constructed at Schoonebeek.

For the transportation of oil from Schoonebeek, the train won hands down.

The Environment.

Oil companies appreciate that the public and the Government may be concerned about the possible consequences that exploration and production work may have for the environment. However, by means of a wide range of countermeasures and by working with the greatest of care, it has proved possible to explore for and extract natural gas and oil without causing permanent damage to the environment.

Another point: nearly all of the natural gas extracted in the Netherlands can be viewed as an environmentally acceptable fuel in that it contains no sulphur compounds.

Prospecting starts with seismic surveys. In the Netherlands, there are in principle no restrictions on such surveys, although local government has to be kept informed and permission of the owners of the land is required. On completion of surveys in which explosives were used, the route followed is inspected in the presence of the owner of the land. Any damage is rectified or appropriate compensation paid.

If a built-up area is to be surveyed, working with explosives is, of course, out of the question. Instead, use is made of the 'vibroseis' system outlined in a previous chapter. One disadvantage of this method is that it can only be used at night since daytime traffic would upset the recording procedure. Apart from supplying mandatory information to the Government, NAM keeps the public at large fully informed, for, however short the survey lasts, some nuisance is inevitable.

For offshore prospecting, too, seismic techniques have attracted a great deal of attention in recent years for environmental reasons. Whereas explosive charges were used at sea in the past, use is now made of what is termed an 'airgun', a device involving the abrupt release of compressed air.

Once a seismic survey has been undertaken, the drilling of an exploration well can be the nex step.

Both onshore and offshore, these drilling activities are subject to many legal restrictions. On land, two consultation procedures must be followed prior to the erection of a drilling rig: one within the framework of the Mining Act, the other within the Physical Planning Act (Wet op de Ruimtelijke Ordening).

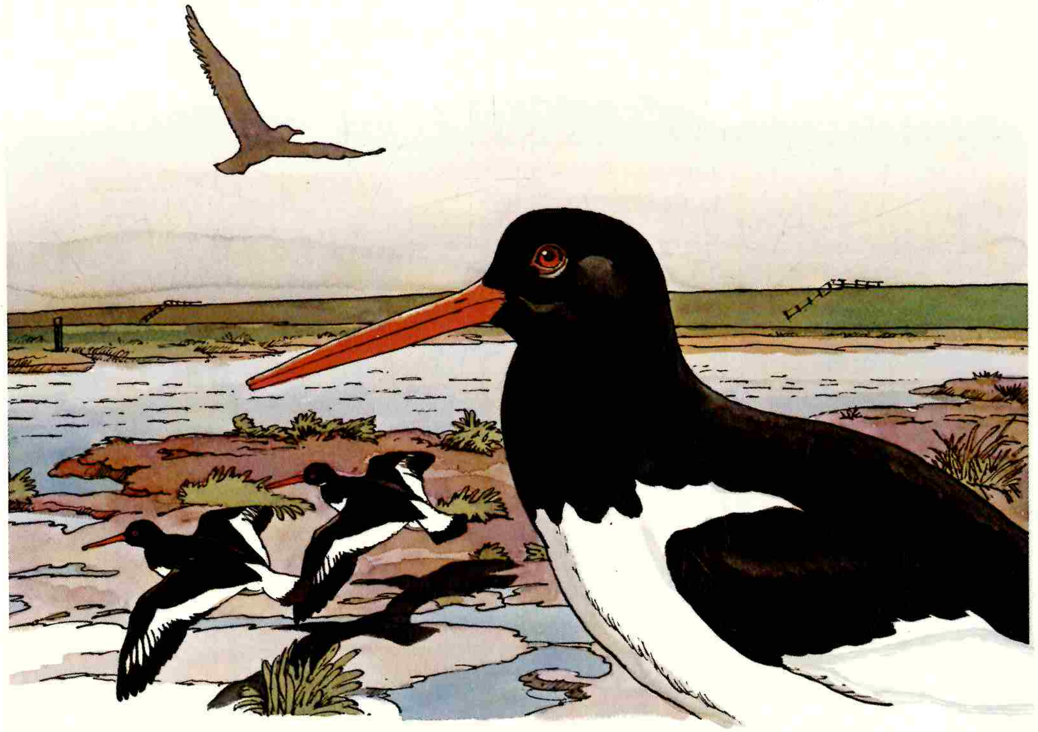
An acceptable location has to be found for the drilling. This is often not an easy task, since the place where prospecting activities are to be carried out is, of course, largely determined by the subsur-

face geology. Sometimes the location can be shifted so as not to disturb local residents and the natural environment. A directional (slanted) well is then drilled.

In the drilling permit granted by the Government, a wide range of measures for the conservation of the environment are stipulated. The drilling of a well on land rarely takes longer than two months. Each drilling site is provided with a hard surface through which liquids cannot pass and is surrounded by concrete gutters leading into a collecting tank. Liquids spilled onto the site which could cause pollution are removed, together with the drill cuttings (mostly consisting of sand, clay, chalk, lime or marl), to disposal sites designated by the Government.

Steel casing pipes ensure that no liquids can find their way into the water table from the borehole.

A drilling rig makes a lot of noise – particularly the diesel generators supplying power to the rig. This is why all generators are now acoustically insulated. At particularly sensitive locations, certain parts of the rig may be additionally insulated.



Apart from all these measures, it is sometimes possible to schedule drilling operations so that they fall outside birdlife breeding times or the holiday period.

As regards offshore drilling, no environmental hazards can occur as long as operations comply with specified procedures. The composition of the fluid used to raise drill cuttings is specially selected so as not to adversely affect the marine environment.

If drilling demonstrates that no gas or oil is present, the site is cleared and the area restored to its original condition.

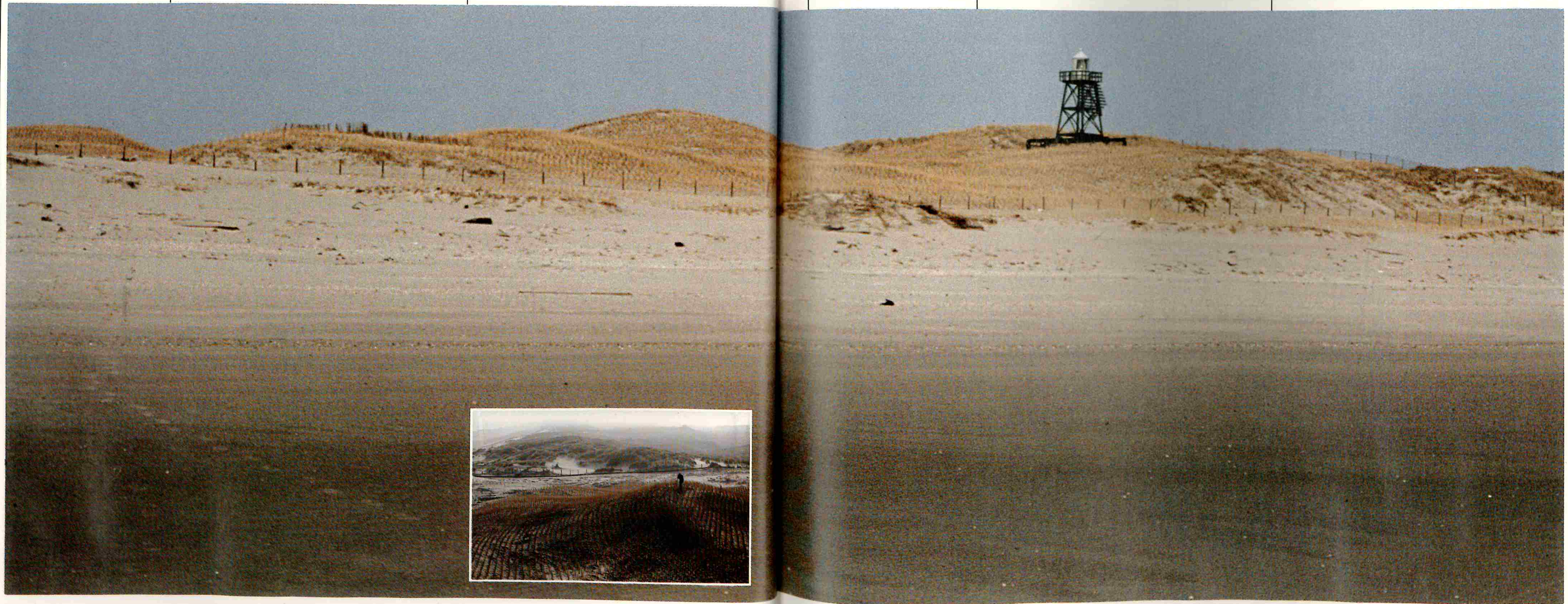
If oil or gas is struck in commercially viable quantities and the decision is taken to commence production, new planning procedures must be followed before a production plant can be erected. What generally happens is that a number of

other wells must be drilled. Subsequently, the production phase – usually 20-25 years – proceeds very quietly.

Production is highly automated and virtually silent. The production plant can often be landscaped much more readily than a drilling rig. If vegetation has to be planted around a site, the landscape officer is consulted. Where environmental considerations are paramount, special measures can be taken: the site can be 'camouflaged'; noise can be limited by the use of specially designed pressure-reducing valves; the plant can be constructed in an artificial hollow in the landscape; flare pipes can be raised or lowered as required. These are just some of the special measures available.

One example demonstrating NAM's concern for the environment:

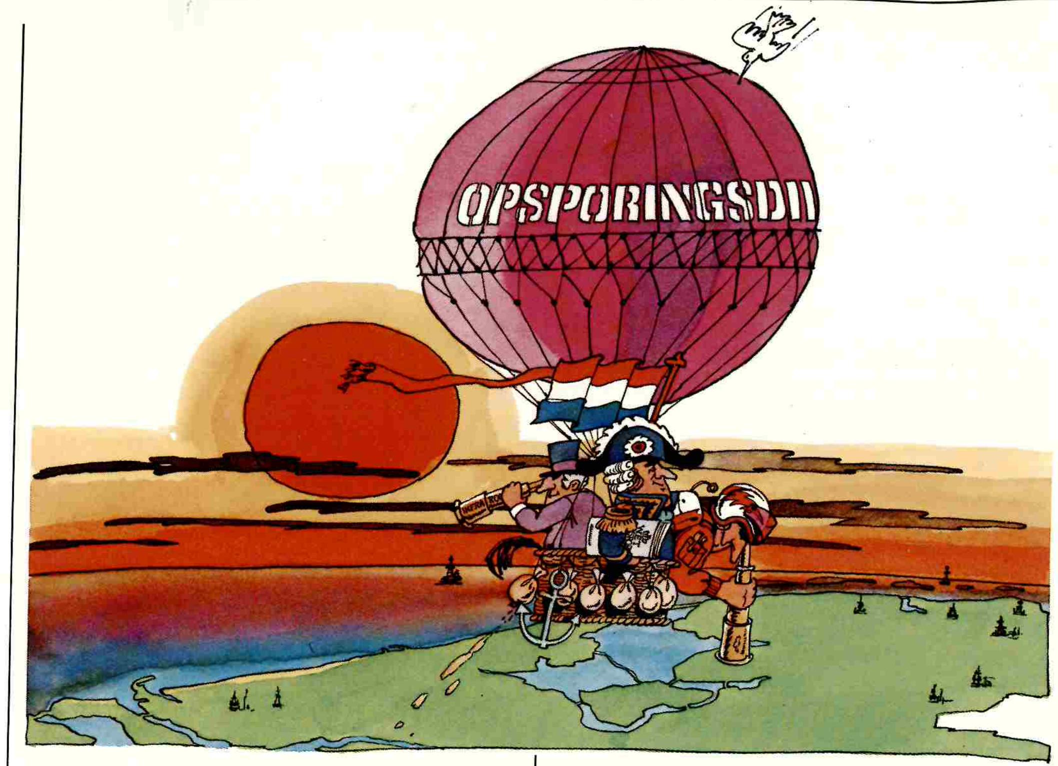
In 1975 a pipeline had to be laid through the dunes near Callantsoog to bring gas extracted from the North Sea onshore. First the area was scrupulously inventorized in situ. Cuttings were taken from various plants under expert guidance and planted elsewhere, while the outline of the dunes was photographically recorded. Once a trench had been dug through the dunes for the pipeline to be laid at the correct depth, the dunes were restored to their original outline and the original vegetation was brought back to the area. Although this was a major earth-moving operation, there was, before one season had fully elapsed, little visual



evidence that the dunes had been disturbed.

Preliminary surveys, drilling and production – what do these activities imply for flora and fauna and for the human environment? These are questions with which the people at NAM are deeply concerned.

Rights and obligations.

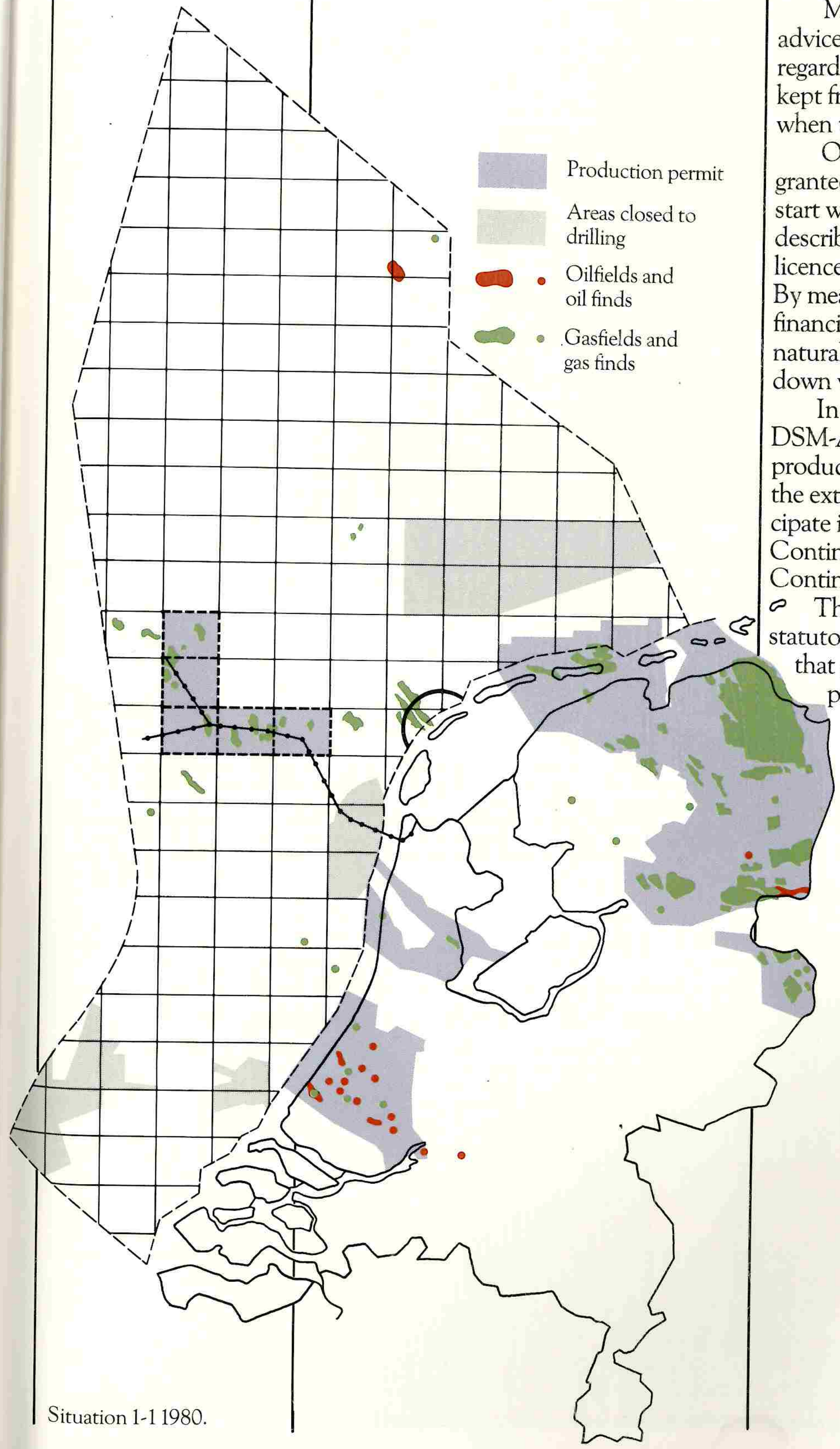


Since 24th May, 1967, the Minerals Prospecting Act (Wet Opsporing Delfstoffen) has been in force in the Netherlands. This Act places no restrictions on the freedom to conduct seismic surveys, but for a well to be drilled a drilling licence from the Minister of Economic Affairs is required. Once this drilling licence has been granted, the oil company . . . still cannot begin. First, another permit must be acquired, this time for the setting up of a drilling site. This involves a dual-channel procedure. One procedure channel runs through Provincial advisory committees and the Physical Planning Working Committee in The Hague. The other procedure channel is prescribed by the Physical Planning Act (Wet Ruimtelijke Ordening).

The Physical Planning Working Committee seeks guidance from Provincial advisory committees. In this way, the application for setting up of a drilling site is considered by the Provincial Physical Planning Service, local authorities, the Provincial Executive Council, Provincial and Government Departments of Public Works, the Physical Planning Inspector, the Housing Inspector (Environmental Department), waterworks companies, water management boards and the State Forestry Department.

If the Physical Planning Working Committee cannot arrive at a unanimous decision, the Minister of Economic Affairs decides. In practice, this means that he raises the applications in the Ministerial Physical Planning Council. It usually takes about a year for this Council to arrive at an expert opinion.

As stated above, the applicant must also follow the procedure laid down in the Physical Planning Act, as the drilling site must conform with the zoning plan of the municipality concerned. This is rarely the case. The zoning plan must then be amended before the municipality can grant a construction permit. This amendment of the zoning plan can sometimes take years. By applying for a concession, an oil company seeks to acquire the right to extract a discovered mineral. A concession is granted by the Crown after it has been approved by the Council of State. However, the application must be submitted to the Provincial Executive Council of that Province where production is to take place. After a four-month period, the application, together with any objections raised and the recommendations of the Provincial Administration, is forwarded to the



Situation 1-1 1980.

Minister of Economic Affairs. He in turn obtains the advice of the State Physical Planning Committee, the State Geological Service and the Mining Council.

Moreover, the Minister will ask the advice of the Advisory Committee with regard to vulnerable areas that are to be kept free of drilling operations, as he did when the drilling licence was applied for.

Once the concession has been granted, the company cannot actually start work before the two procedures described for application for a drilling licence have again been followed.

By means of separate agreements, the financial conditions under which the natural resource may be extracted are laid down whenever a concession is granted.

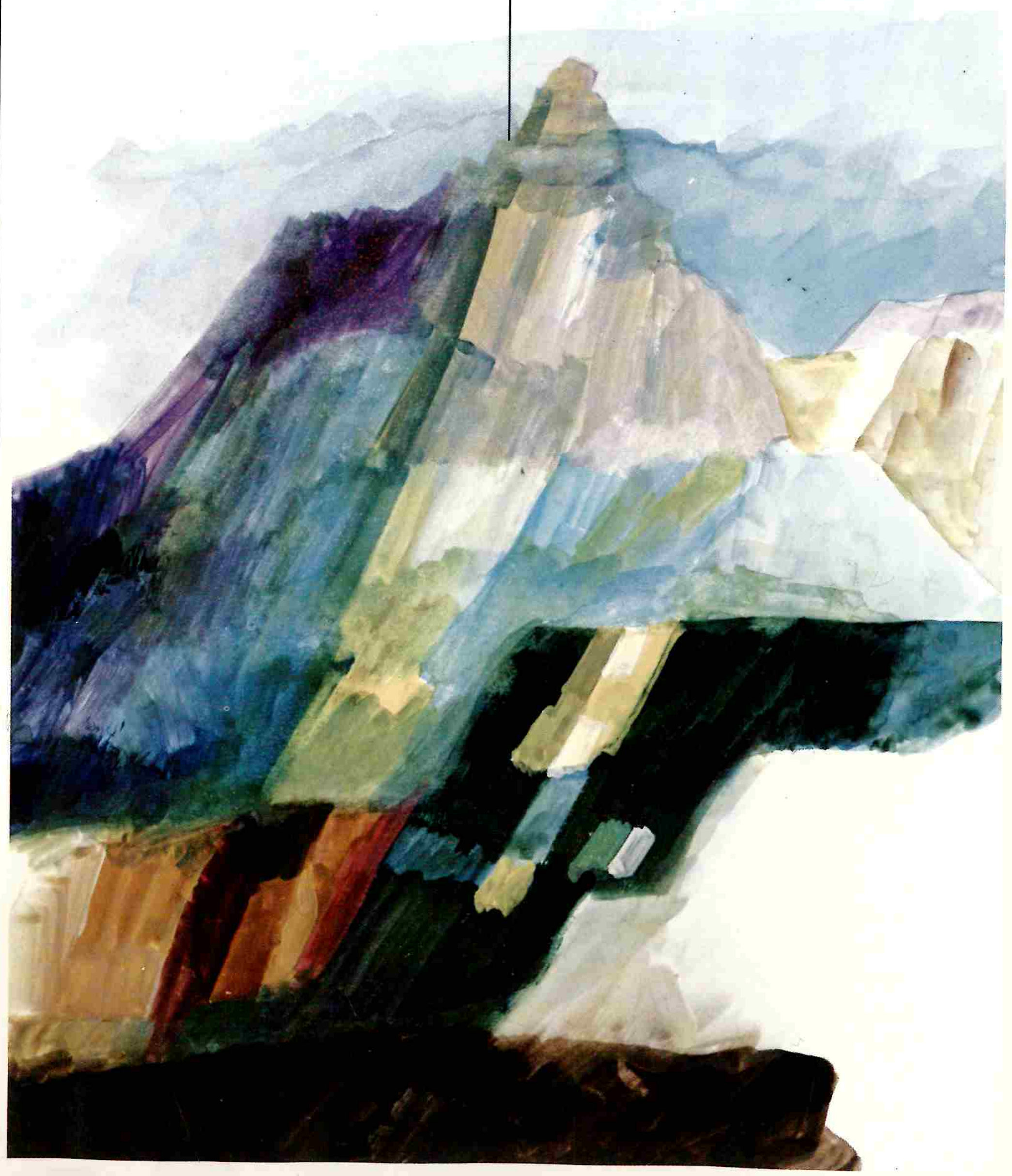
In many areas, the State has, through DSM-Aardgas B.V., a 40% share in gas production. For the Continental Shelf, the extent to which the State can participate is laid down in the 1967 Continental Shelf Mining Act (Mijnwet Continentaal Plat).

This Act was amended by further statutory decrees in 1976, one effect being that greater scope was created for State participation.

Energy from the depths.

'Energy from the Depths' is published by Nederlandse Aardolie Maatschappij B.V. (NAM). NAM was founded on 19th September, 1947, as a joint venture of N.V. De Bataafsche Petroleum Maatschappij (Royal Dutch/Shell Group) and the Standard Oil Company of New Yersey (Exxon Group). Through subsidiaries each company owns 50% of the share capital.

NAM explores for and produces oil and natural gas in the Netherlands and on the Dutch part of the Continental Shelf. In addition to the exploration and production activities which NAM conducts independently, there are a number of operations in which it co-operates with other companies. A number of natural gas fields are also jointly exploited on behalf of DSM-Aardgas B.V.



NAM facts and figures.

Seismic surveying. From 1947 to 1980 over 121,500 km of seismic profile were recorded (almost three times the earth's circumference).

Boreholes. Eighty holes were drilled in the period 1937-1947. From 1947-1980 1557 holes were drilled (including 109 offshore).

The following are required for a well sunk to a depth of about 3000 metres: a drilling derrick with engines and pumps, combined weight 370,000 kg; 130,000 kg drill pipes; 4800 metres of well casing weighing 200,000 kg; 200 tons of drilling fluid; 150 tons of cement; 140 tons of fuel.

Production. NAM produced 1.4 million m^3 of oil in 1979.

The amount produced between the discovery of oil in the Netherlands and 1980 was approx. 55.2 million m^3, of which the Schoonebeek oilfield accounted for approx. 30 million.

Since the first discovery of gas in 1948, a total of approx. 810 milliard m^3 of natural gas has been produced by 1980.

784 milliard m^3 came from the Groningen gasfield and 24 milliard m^3 was produced elsewhere in the Netherlands, while 2 milliard m^3 of 'wet' natural gas was recovered from oil wells.

The production of the Groningen gasfield in 1979 was approx. 76.8 milliard m^3.

Depth of oil-bearing and gas-bearing strata:
Schoonebeek (oil): 650-900 metres
West Netherlands (oil): 700-2000 metres
Groningen (gas): approx. 3000 metres.

Offices:
The head office of NAM is at Assen, with regional offices at Schoonebeek, Rijswijk, Hoogezand and Den Helder. There is a supply base for North Sea activities in the dock area of Rotterdam.

At the start of 1980 NAM employed a staff of over 2000.

Dates

- 1944 Schoonebeek 3 well brought on stream.
- 1947 N.V. Nederlandse Aardolie Maatschappij founded.
- 1948 First natural gas find near Coevorden.
- 1953 First oil find in West Netherlands near Rijswijk.
- 1959 Groningen gasfield first proved by Slochteren 1 drilling.
- 1961 Drilling rig Triton positioned for first drilling in the North Sea.
- 1963 First delivery of gas from Groningen gasfield.
- 1968 First drilling in North Sea (K17) under the 'Wet Mining Act' unsuccessful.
- 1969 NAM makes first gas find in North Sea.
- 1975 NAM acquires first offshore production permit (for block K14).
- 1977 NAM starts bringing North Sea gas (from block K14) onshore.
- 1977 First drilling of Devonian strata by NAM near Winterswijk (5010 metres).
- 1980 Start of steam injection project at Schoonebeek oilfield.

NAM

The information in this brochure is based largely on the situation as it was at 1st January, 1980.

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