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Motor cycling MONTHLY

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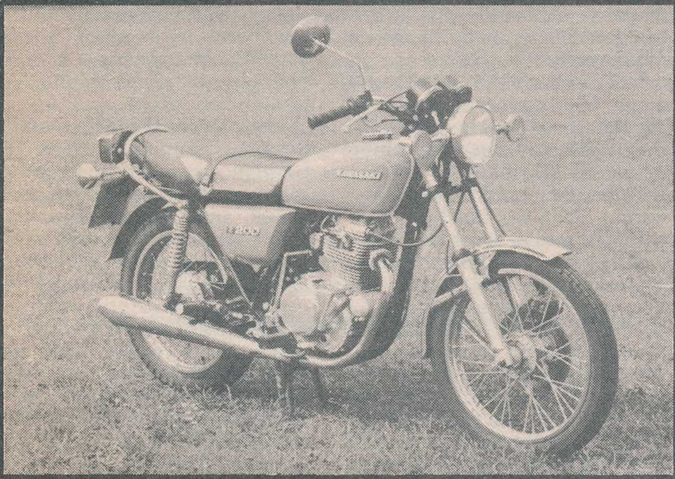

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Feature Writers:
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Sen. Tech. Artist:
Arthur Saluz

Sub-Editor:
Janine Turner

Editorial Sec:
Diana Simmonds

Adv. Manager:
Keith Price
(01-261 6731)

Class. Adv. Dept:
Room 2337
King's Reach Tower,
Stamford Street,
London SE1 9LS
(01-261 5762)

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how & why

PETROL

A gallon of petrol is a handy way of bottling 138,000 British Thermal Units of heat. It contains, in liquid form, enough concentrated energy to drive a moped over 100 miles or your big four-pot superbike maybe 40 miles.

That's why we use the stuff. How it gets to your tank is another story. Chris Webb explains . . .

So you want to be a millionaire. Don't we all?

How about the oil business? There's money to be made in oil and there are umpteen million gallons of the stuff virtually on the doorstep, under the North Sea.

Like any budding millionaire, it pays to do a bit of homework first, for despite the promise of fat profits the oil business isn't all T-bone steaks and helicopter rides. For a start, how do you locate the oil in the first place? The North Sea is around 600 feet deep around the oil production platforms that the opposition have already set up, and the oil is likely to be 10,000 feet below seabed level.

Let's get it down on paper.

FIRST FIND YOUR OIL

You'll need an aeroplane and a ship or two, some pretty sophisticated equipment and a team of geologists, geophysicists, petroleum engineers, drillers, computation experts and analysts. These will enable you hopefully to find the stuff and work out whether it's profitable to bring it to the surface.

Oil is a fossil fuel. It's formed from the corpses of living things such as plankton and millions of other tiny organisms which drifted to the beds of prehistoric oceans, lakes and rivers.

Over millions of years, the action of bacteria on the remains, plus the pressure from mounting deposits of sediment and rock above them, transformed this unholy mess into something almost as bad – black, sticky crude oil.

Under pressure the sediment became porous rock – geologists call it shale – and as the pressure built up, the crude, mixed with a proportion of water, was likely to migrate from the shale to nearby porous rock such as sandstone or limestone.

The fact that oil moves about over the years helps the geologist to find it. If he can pin-point an area of sediment and nearby sandstone and limestone then there's a chance there might be some oil about.

One way of sniffing out an area of deeply buried sediment is to fly or sail over it towing an instrument that measures the earth's local magnetic field. The older impervious rocks have a stronger magnetic field than the more recent shale and limestone. Interpret the magnetic readings properly and you can get a rough idea of the shape of things below ground. You can cross-check the results by measuring the earth's

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gravity over the same area. High-density non-porous rocks have a stronger pull than the porous ones.

But under the North Sea, the best way to map a possible oil field is by echo sounding.

You need a ship equipped with spark emitters or hydraulic "pingers" which send a shock wave through the sea bed, and the reflected waves are picked up by a pattern of sensitive microphones which record the sound electronically. Different rocks give different reflections, and if you feed this data to the right sort of computer it can practically draw you a diagram of the strata below.

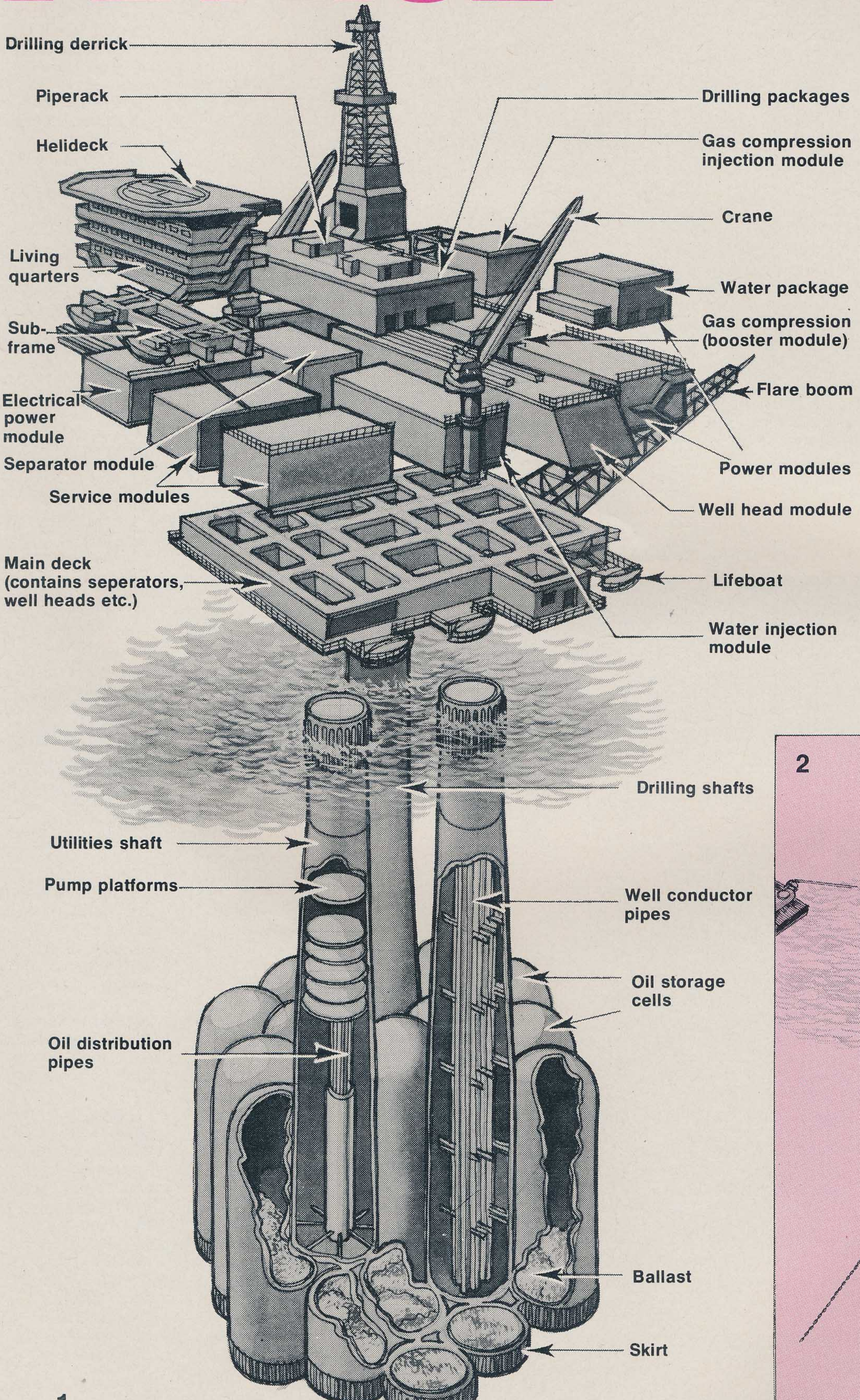
If the rock formations are right, the next job is to drill a hole, preferably near the highest point of your oil-bearing strata since this is where the oil and gas collect.

One of the problems with drilling a hole 10,000 feet into the earth is that as you go deeper the pressure increases, and if you inadvertently hit a pocket of oil — which is usually mixed with a fair quantity of North Sea Gas — it will squirt straight up the hole and you'll have a wild gusher. You can liken the effect to drilling a hole in the side of a soda syphon — the instant you break through, soda squirts everywhere.

A gusher is bad news to oil men. It not only wastes oil, but releases some of the gas which oilmen rely on to push the crude to the surface.

To prevent this happening, mud is pumped into the drill hole. Besides acting as a very long glutinous cork, the mud cools the drill bit and brings the drillings to the surface. Geologists will check these to see which layer the drill is passing through.

There are other means of finding out what's going on downstairs: a hollow drill can be used



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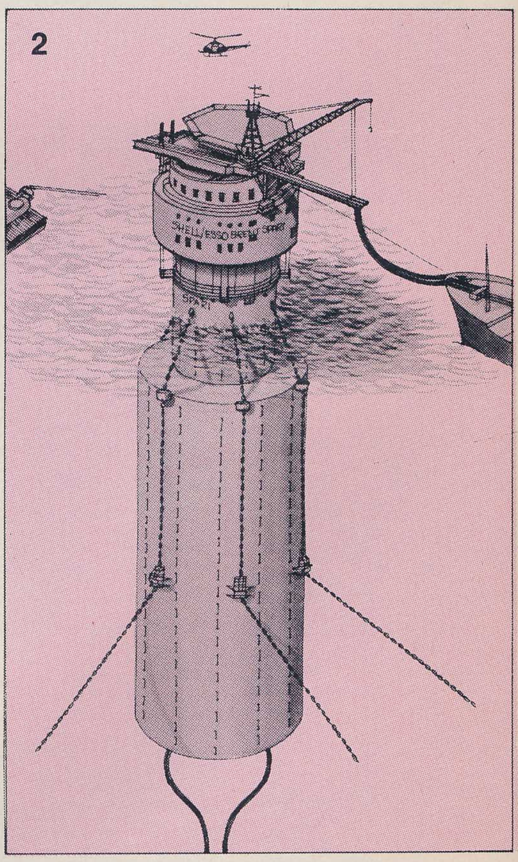

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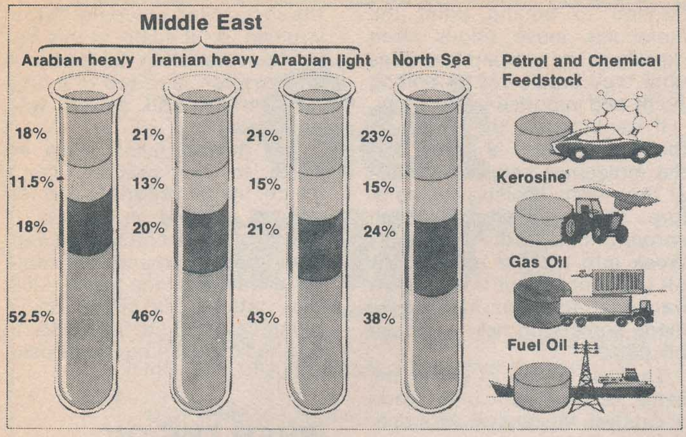

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room temperature or it may be practically solid. Sour crude oil which is rich in sulphur smells like rotten eggs.

Crude oil usually contains water, sand particles and other sediment, salt and sulphur. Water is easy to remove: you simply put the oil in settling tanks and it drops to the bottom. Sand, which would grind out the innards of the pumps, is filtered off and large quantities of salt must be removed otherwise it causes corrosion during refining. Sulphur is removed during refining.

Compared with Middle East crude, North Sea crude is 'lighter' in that it has the highest

The water, which has a lower boiling point, will boil first and the vapour will collect and condense on the plate. If you analysed it you would find it was an almost pure sample. Taken to its logical conclusion you would eventually boil off all the water and end up with just syrup in the saucepan.

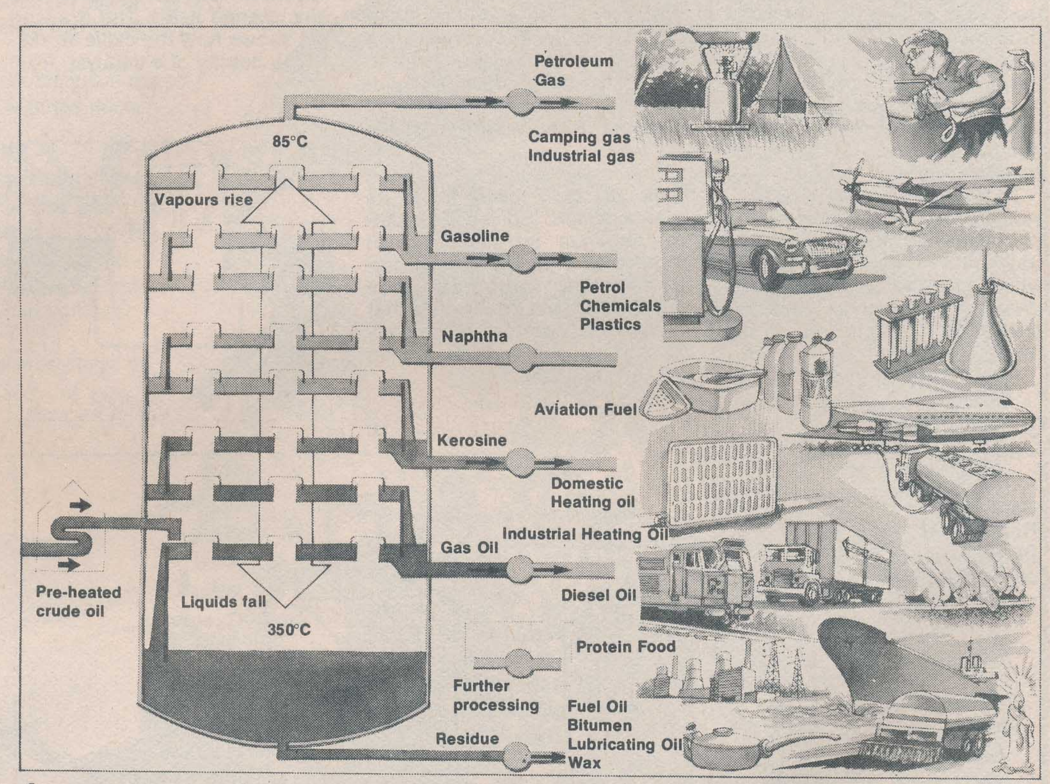
There's one other side of this boiling point business we must get straight. Perhaps because we make so many pots of tea, it's generally assumed that the boiling point of a liquid is the temperature at which it changes from a liquid into a vapour. Water, we all know, changes to steam at 100°C. But the reverse applies

to bring up a core of rock for sampling; you can lower electrical or radio-active instruments to measure the conductivity or radio-active "signature" of the rock.

As the drilling progresses a steel casing is fed down to surround the drill stem, and cemented in place by pumping liquid grout round the outside to seal the rock.

You need the casing because the well may pass through several layers of oil-producing rock, and you need to know the likely performance of each one.

To test a layer, you lower down the hole a tube containing a seal at its lower end. At the appropriate depth the seal is expanded to block the hole below it and you use explosives to blow a pattern of holes in the casing and check the pressure and flow rate as the oil pours into the well.



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BRINGING IT TO THE SURFACE

You might think your problems are over, but really they're only just beginning. The next job is to get the oil out.

Essentially we need some hardware — a drilling/production platform big enough to sit permanently on the North Sea bed to drill a series of wells that will splay out and tap oil and gas from the most productive areas of the oil field. Looking at what the opposition are using, something like the Shell/Esso Brent 'B' platform **(1)** will do. It has 38 well conductors (bores that receive gas and oil), its production capacity is 160,000 barrels of oil a day and it also produces 320 million cubic feet of North Sea gas every day too.

You'll need to set aside a large slice of bread to build it. Brent 'B' weighs about 190,000 tonnes. The three-legged concrete sub-structure, most of it underwater, is surrounded at its base by a series of caissons with a storage capacity of 1,100,000 barrels of oil.

Now if you've got your calculator handy you'll realise that 160,000 barrels a day will fill the storage tanks in a little less than seven days (if you're making the tanks like those on Brent 'B' they have a slightly lower pressure inside than the surrounding seawater, so should a crack develop in the concrete, water will seep in rather than oil leak out). So, what you need is extra storage — something like Spar **(2)** a sort of giant fishing float tied to the bottom which collects oil pumped from your production platform and off-loads it to oil tankers moored alongside (you did set aside a few bob for the odd tanker, didn't you?)

Spar displaces 66,000 tons, is 462 feet high overall, contains six storage tanks and can hold 300,000 barrels of oil. Good. You've got your oil into the tankers. But is it good oil? On to the laboratory . . .

HOW CRUDE?

Straight from the well, crude oil varies in colour from gold to black; it may pour like water at

proportion of petrol and less fuel oil and heavy bitumen **(3)**. So we're on the right track for our bike fuel.

EXTRACTING THE PETROL

A dollop of black sticky stuff smelling of rotten eggs isn't a lot of use to the likes of you and me. But in there somewhere is a little petrol, a whiff of petroleum gas, some paraffin, gas oil, fuel oil, wax, bitumen and a lot more besides.

We can transform this evil-smelling dollop of goo into all these useful products if we heat it up and pump it into a fractionating tower.

You can make a simple fractionating tower yourself using a saucepan and an upturned plate over it. Mix together some water and syrup. Put them in the saucepan, place it on the kitchen stove and boil the mixture.

too. If you reduce the temperature of steam to 100°C it will change back into water.

To separate crude oil it is heated externally to 350°C and then the bubbling mass is pumped into a fractionating tower about a quarter the way up **(4)**. The temperature at the bottom of the tower is 350°C, but it decreases gradually to about 85°C at the top.

As soon as it gets into the tower the various fractions of the crude go their various ways. Fractions like bitumen which remain liquid at 350°C fall to the bottom and are pumped away. But the remainder of the crude is in vapour form and this rises. On its way to the cooler upper regions it passes through a series of trays, perhaps 50 of them in all, each one on a higher level.

As each fraction meets a tray that is cooler than its boiling

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point, it condenses. The liquid is held by the tray and eventually piped away.

Heavier liquids with comparatively high boiling points like gas, oil and kerosene condense first, and in the higher, cooler areas near the top of the tower, lighter fractions like petrol condense out.

To help the condensation process, each tray has a series of bubble caps **(5)** which compel the rising vapour to pass through the liquid in the tray. This gives the appropriate fraction ample opportunity to condense, but doesn't hinder the lighter fractions, which need to become cooler, to condense, on their way up the tower.

To provide more accurate separation, each tray is allowed to spill some of its fluid to the tray below. So any fraction which gets carried to a higher level than it should, gets the chance to return to the correct tray.

As fractionating continues, the liquid in each tray is distilled and re-distilled, gradually growing richer in its correct components. In practice there are several towers as the range of temperatures is too great for one. Smaller towers then take the contents of a few trays to further improve the separation of the fractions.

MORE PETROL

You may think that now you've split the crude into heavy and light fractions that you've finished. But (and this is good news for budding millionaires) you can get still *more* petrol from the fractionated crude. But you'll need a catalytic cracker.

A catalytic cracker changes the molecular structure of some of the heavier fractions so they can be used to produce more petrol.

We need a touch of basic chemistry here. As you probably know all the earth's elements are made up of atoms — particles so small that you can cram millions on a single pin-head. Atoms join together to form molecules. Probably the best-known molecule is that for water which is H_2O or two hydrogen atoms and one oxygen atom.

Crude oil is almost entirely made up of hydrocarbons — atoms of hydrogen and carbon linked together to form molecules. But unlike water which always has two hydrogen atoms and one oxygen atom to each molecule, crude oil hydrocarbon atoms can be linked together in thousands of different ways.

The fewer carbon atoms each molecule has, the lower is its boiling point. So we find petroleum gas is made up of molecules with up to four carbon atoms, whereas each molecule of the gooey clag that drops to the bottom of the fractionating tower has more than 20 carbon atoms.

If you were a chemist you might ask yourself whether you could produce lighter petrol-like substances from a heavy fraction such as fuel oil by chopping the longer fuel oil molecule into shorter lengths. And the answer is yes.

There are various ways of adjusting the size of hydrocarbon molecules. You can crack them (break them down), polymerise them (build them up), or reform them (change their structure).

Originally molecules were cracked in a reactor using high temperatures and high pressures.

Ordinarily if you heat a crude fraction to boiling point the molecules move about more quickly as the temperature rises until they break free at boiling point and vaporise.

If we increase the pressure, the boiling point is raised and the molecules cannot vaporise at the normal boiling temperature. If the pressure is high enough, instead the molecules break into smaller units. Draw off the vapour, put it through a fractionating tower, and you've made something new — possibly petrol.

There is a way of doing the same job more efficiently using a catalyst. A catalyst is something that aids or speeds-up the reaction without undergoing any change itself. The drawing **(6)** shows how the cycle works.

The beauty of a catalyst, from the cost-saving viewpoint, is that you can use it again. In this set-up, the catalyst, in the form of a fine powder, is raised to a high temperature and mixed with pre-heated oil.

The mixing takes place en route to the reactor. Once inside, the oil vaporises and the catalyst, coated in carbon, is drawn off. The cracked oil vapours leave the reactor en route for a fractionating tower while the catalyst is piped to a regenerator, where the carbon is cleaned off allowing it to be used again.

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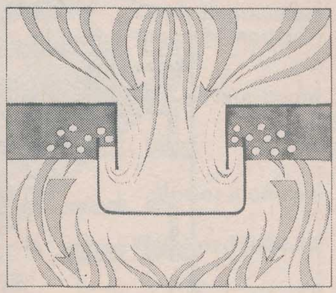

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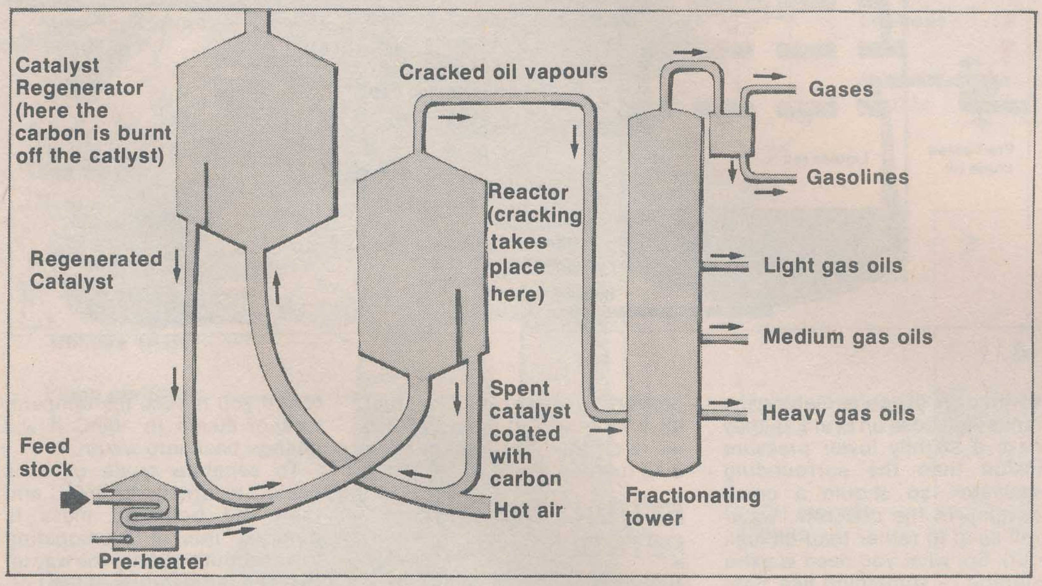

WHEN THE OIL STOPS . . .

If you are relying on natural gas to push the crude oil to the surface you will soon find that the pressure will drop and the flow to the well-head will slow down. If you do nothing about it, the gas will be used up and you will only have recovered about 10 to 20 per cent of the oil that's down there.

You can increase this recovery figure to around 30 or 50 per cent if you replace the pressure that's been lost. The favourite method is to pump water into the reservoir to push out the oil, although at the Brent oil field they started out re-injecting the natural gas back below ground. This kept the pressure up and was a useful place to store the gas until the shore pipeline was built.

Once the gas is 'on stream' the Brent field will be pressurised by treated seawater pumped down specially drilled wells.

THE CREDITS

That in a very small nutshell is what oil extraction and refining is all about. If you've changed your mind and decided to become a football manager, I don't blame you.

I'd like to thank the people who made this piece of homework possible for me — Shell/Esso who laid on a helicopter to take me to a production platform, and BP Educational Service who provided a lot of background information.