NORTH SEA OIL — METHODS OF SURVEY

by J.R. DEAN

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Long confined to land areas, the search for oil has moved out into the waters of the continental shelf, particularly since the more easily worked territories are reaching the stage of full development. Examples of offshore oil drilling operations are to be found in the Gulf of Mexico, Venezuela, California, Arabian Gulf, Nigeria, Borneo and Japan. In all these areas are to be found sedimentary basins or marine basins of deposition in which oil or gas (hydrocarbons) derived from decayed minute sea animals and plants have accumulated. They are areas where there are considerable thicknesses of rock formations laid down under the sea, and the North Sea is another example of such a marine basin, having been wholly or in part a sea area for the past 270 -odd million years, i.e. at least since the Carboniferous Period.

Since the North Sea is the most recent example of a marine basin to be explored for oil the problems there to be faced by the engineers illustrate the difficulties likely to be encountered in any under-water exploration. The first step is to carry out exploratory surveys — magnetic, gravimetric and seismic — to determine the location, structure and thickness of the rock formations. Test drillings must then be made from fixed or floating platforms in the most promising areas, for only the drill can reveal whether oil or gas accumulations are present. It was late in the last century that engineers turned to the sciences of geology and geophysics for assistance in finding the most propitious areas in which to drill for oil, since these sciences alone could provide the knowledge of the nature and composition of the underground layers. Indeed, the advice of the geologist and the geophysicist can often lead to the tracing and discovery of oil in areas devoid of any surface indications such as seepage. Thus it was that barren featureless plateaux, swampy river basins or below the sea on the continental shelf proved to be good examples of areas that were found to be rich in oil.

Equipped with modern drilling platforms which are designed for operations in depths of at least 100 metres, the bathymetric chart of the North Sea indicated that no special difficulties would be encountered by the drilling crews. Spared any great anxieties with regard to the depth of the North Sea, the engineers were confronted with serious problems when considering the meteorological conditions prevailing over the region, particularly during the winter months. They were often reminded of the disastrous consequences of the storm surge which occurred during the winter of 1953, and were induced to take exceptional precautions for the safety of the drilling rigs operating in every part of the North Sea. No less important was the provision of a helicopter landing deck on each drilling platform.

Notwithstanding the efficiency of the latest drilling rigs in operating in any part of the continental shelf, the oil companies paid particular attention to the hydrography of the North Sea basin, which they studied in relation to the geological structure of the region. One of the salient features of the North Sea bathymetric chart is the Norwegian Deep (max. depth 800 metres) fringing the long western and southern coastline of Norway. Apart from this deep trench, average depths of 40 metres are found in the southern portion of the North Sea off the Dutch coast and in the Dogger Bank area before the mean depth gradually increases to 200 metres in the extreme north-east of the region near the 62nd parallel.

During the survey of a region, field geologists usually work in conjunction with geophysicists and, as already noted, the methods of survey include the magnetic, the gravimetric and the seismic, each of which will be considered in turn.

Magnetic Survey

For reconnaissance, the airborne magnetometer is the favourite tool. It measures the variations in the magnetic field caused by the rocks of the basement underneath the sediment, and it is above all an instrument that works as well over the sea as over the land. Skilful use of the airborne magnetometer will provide information relating to some or all of the following factors in the area under study :

a) Depth of the crystalline basement
b) Shape and structure of the basement
c) Thickness of sedimentary layers above the basement
d) Distribution of igneous intrusions
e) Estimations of the nature and type of rocks responsible for the anomalies in the records.

The aircraft used in these surveys carry the magnetometer either built into the tail fairing or slung below the fuselage in a special mounting.

Gravimetric Survey

Another device used in prospecting for oil is the gravimeter which measures differences in gravity caused among other things by variations in the density of rocks underground. It is useful in finding masses of relatively light rock such as salt-domes, which are often associated with oil-bearing strata. In comparison with other surrounding sediments, rocksalt has a low specific gravity and it is often possible to identify large masses of it underground when distinct minima occur on gravimetric records. Gravimeters can either be used on the sea bottom or, more efficiently, mounted in a surface ship. Whichever way they are used, however, they are averaging devices and cannot provide local detail.

Seismic Survey

Reflection seismic surveys give more precise information on tectonics, mainly because they record planes of velocity discontinuity deep underground by the serial reflection and refraction of shockwaves generated at the surface by means of a small explosive charge. An advantage of the seismic method of survey is that it is quicker and perhaps even cheaper to employ at sea than on land, since no time or expense is required for drilling shot-holes for the explosive. On the other hand, it is most important to know the precise position at which each charge is detonated and, at sea, this necessitates a navigational aid of the highest accuracy. To meet this need, a position-fixing facility known as the Decca Sea Search Precision Radio Chain was provided; transmitting stations being located in Friesland, East Anglia and Denmark. Established originally as a navigational aid for ships engaged in seismic surveys, the Radio Chain now provides the same service for aircraft following the recent use of helicopters for the first time in making over-water seismic surveys. The reason for using helicopters was that large areas of the North Sea are shallow, subject to difficult tides and, above all, because the risk to surface ships of wartime mines could not be ruled out. The helicopters work in pairs, one carrying the seismograph equipment and towing a 1 000 metre self-buoyant cable to which are attached a series of super-sensitive geophones; the other placing and detonating the explosive charges.

Rather different methods have been adopted to produce continuous seismic profiles which give information on the shallower deposits near the sea bottom. In these methods use is made of extremely powerful echo-sounders or fathometers in which electronic sparks or exploding gases are the energy sources. The profiles so obtained are known as "sparker pictures", but the energy sources used for them have not yet been developed to give the penetrating power of dynamite shock waves.

The Prospects

As indicated on the sketch map showing the division of the North Sea Shelf on the median line formula, only seven countries (Great Britain, France, Belgium, the Netherlands, West Germany, Denmark and Norway) border the North Sea and they contain some of the greatest concentrations of economic activity in the world. Their need for energy seems to be quite insatiable, increasing as it does by some 200 million tons coal-equivalent every year. Western Europe's rapidly rising energy requirements and inadequate indigenous fuel supplies have furnished ample incentive for oil exploration. The remarkable success of the wells discovered in the Groningen province of Holland and their capacity to supply the whole of the Netherlands as well as the neighbouring countries with natural gas, soon led to conjecture that these rich deposits might continue below the North Sea. The success achieved in Holland was therefore largely responsible for the intensive exploration now being undertaken in the region.

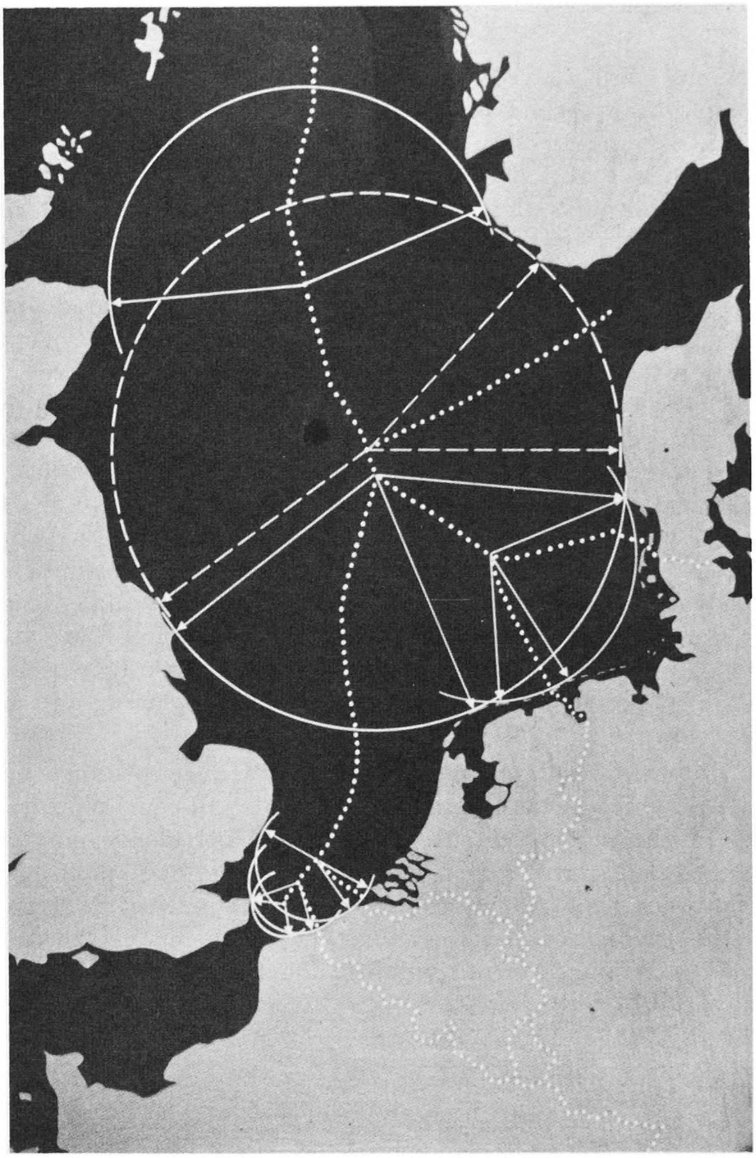

FIG. 1. — *Division of the North Sea on the Median Line Formula. A Shell Photograph.*

Should large quantities of oil be found beneath the North Sea, there will be no difficulty in refining it in the immediate neighbourhood. Western European countries now have refining capacity far in excess of their own needs and other new refineries are still being built to meet the ever growing demand for oil, both for export and for home consumption. The main supplies of crude oil for these refineries are still imported by tanker mainly from the Middle East and the Persian Gulf. What is now most needed is an abundant supply of crude oil of European origin.

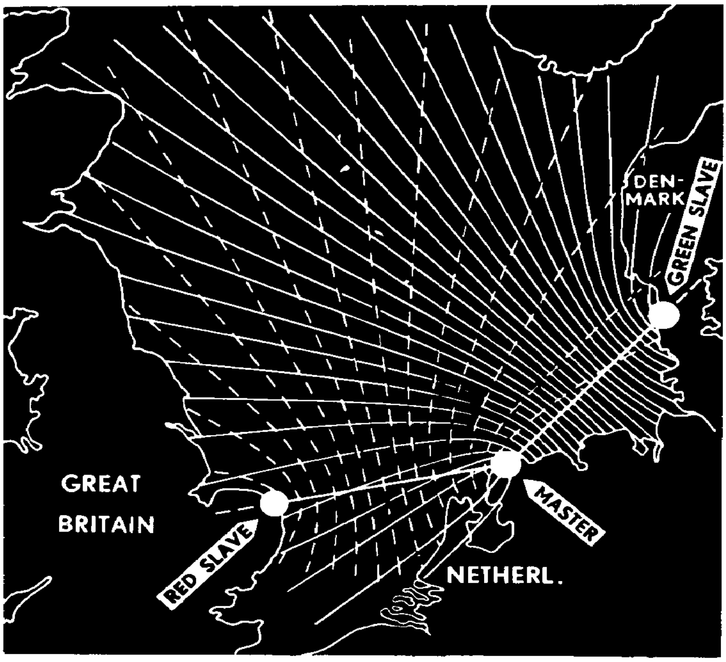

FIG. 2. — *The Decca North Sea Precision Radio Chain. A Shell Photograph.*

Whatever the results of the North Sea exploration for oil — and only the drill (which can penetrate to over 6 000 metres) can finally determine whether or not oil is present — the data now accumulating from magnetic, gravimetric and seismic surveys will be of great value to the geographer and the geologist. A new type of map, which we may describe as bathy-geological, will emerge which could complete the picture of the geology of Northern Europe, linking together the geological survey of Scandinavia with that of Britain and of Britain with the continent of Europe. It may well prove to be one of the most comprehensive surveys of a small part of the Earth's crust.