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DEPARTMENT OF
MINERALS AND ENERGY

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Record 1973/92

OVERSEAS VISIT TO USA & EUROPE

by

J.A.W. White

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OVERSEAS VISIT TO USA & EUROPE - J.A.W. WHITE

SUMMARY

A visit was made to USA, France, Norway, and England by Mr J.A.W. White over the period 24 April-3 June 1973.

The purpose of the visit was to attend the Offshore Technology Conference in Houston and to visit manufacturers, contractors, and operators to ascertain current and future developments in the offshore petroleum industry with emphasis on the problems of deep-water exploration and production.

Most of the information in this Record is derived from notes taken at the time and from tape recordings made each evening. The BMR tape-recorder proved to be extremely useful and is highly recommended for future visits of this nature.

Many important conclusions were reached and it is proposed to elaborate on these separately.

Offshore Technology Conference

This was the fifth of the annual Offshore Technology Conferences, all of which have been held in Houston, Texas.

The Conference was attended by 23 000 registrants (plus representatives of many student bodies) and more than 170 technical papers were presented during the three days of the Conference. The exhibition area of the Houston Astrohall housed most of the 1400 exhibitions, and the rest were accomodated in a neighbouring car park. All aspects of offshore petroleum technology were covered and one's first impression was that the technology is becoming increasingly sophisticated to overcome many of the problems associated with exploring in and producing from the hostile environment encountered offshore.

Compared with other countries, Australia's participation can only be described as minimal. Almost every other nation with offshore interests had many representatives; Norway, England, and Scotland are especially notable. Norway was represented by 138 people and the Norwegian Government and private companies had a total of 35 exhibits. In contrast, some 20 Australians were present but with no exhibits.

Although the technical papers were of a high standard, it is my opinion that the greatest benefit gained from attending the Conference was the opportunity to meet and discuss with senior representatives of contractors, operators, and suppliers. Many aspects of petroleum exploration can only be covered adequately by discussions of this nature and full use was made of the time available to discuss past problems and future requirements, especially with regard to pressure-control equipment such as blow-out preventers.

Sub-sea completions

At present, a very small proportion of the world's offshore wells have been completed on the sea bed; the more popular method is to drill and complete production wells from a fixed platform. However, there is a growing interest in completing wells on the sea bed and it appears that this technique will be utilized to a greater extent in the future.

Advantages claimed for sub-sea completions can be summarized as follows:

1) A considerable saving in cost under certain circumstances

2) The ability to be able to complete for production discovery wells and assessment wells

3) Vertical drilling is cheaper and leads to fewer production and drilling problems

4) Optimum well spacing can be chosen

5) Flexibility in planning - additional wells can be drilled if an extension of the field in question is demonstrated

6) Safety - the dangers of a multi-well platform fire are completely avoided

7) Aesthetically more acceptable

The opportunity was taken to visit and inspect the three existing diverless sub-sea completion systems developed so far.

a) Exxon Corporation Sub-sea Production System

By courtesy of Vetco Industries Ltd and Exxon Corporation of Ventura, California, I was able to inspect their sub-sea production system SPS. It is designed for 1000 m of water and can accommodate up to 20 wells. Wells are drilled in the conventional manner from a floating drilling platform through a specially constructed template located on the sea bed. Individual wells are deviated to obtain optimum drainage of the field. When all wells have been drilled with casing set and cemented as required, wells are completed and tubing run before moving off the floating drilling platform. Installation of flow lines and replacement of valves and chokes is achieved by means of a remote-controlled manipulator running on tracks around the periphery of the drilling template. This manipulator is normally carried on board a service vessel and is only sent down to the well heads when required. Provision is made for an observer (at atmospheric pressure) to descend in a bell integral with the manipulator, but it is not essential to the operation of the system. Several television cameras are installed to monitor operations. Sophisticated systems are in use to safeguard the observer and to carry out all foreseeable operations required on the sea bed. Although the initial application will be in shallow water, the system is designed to be completely diverless.

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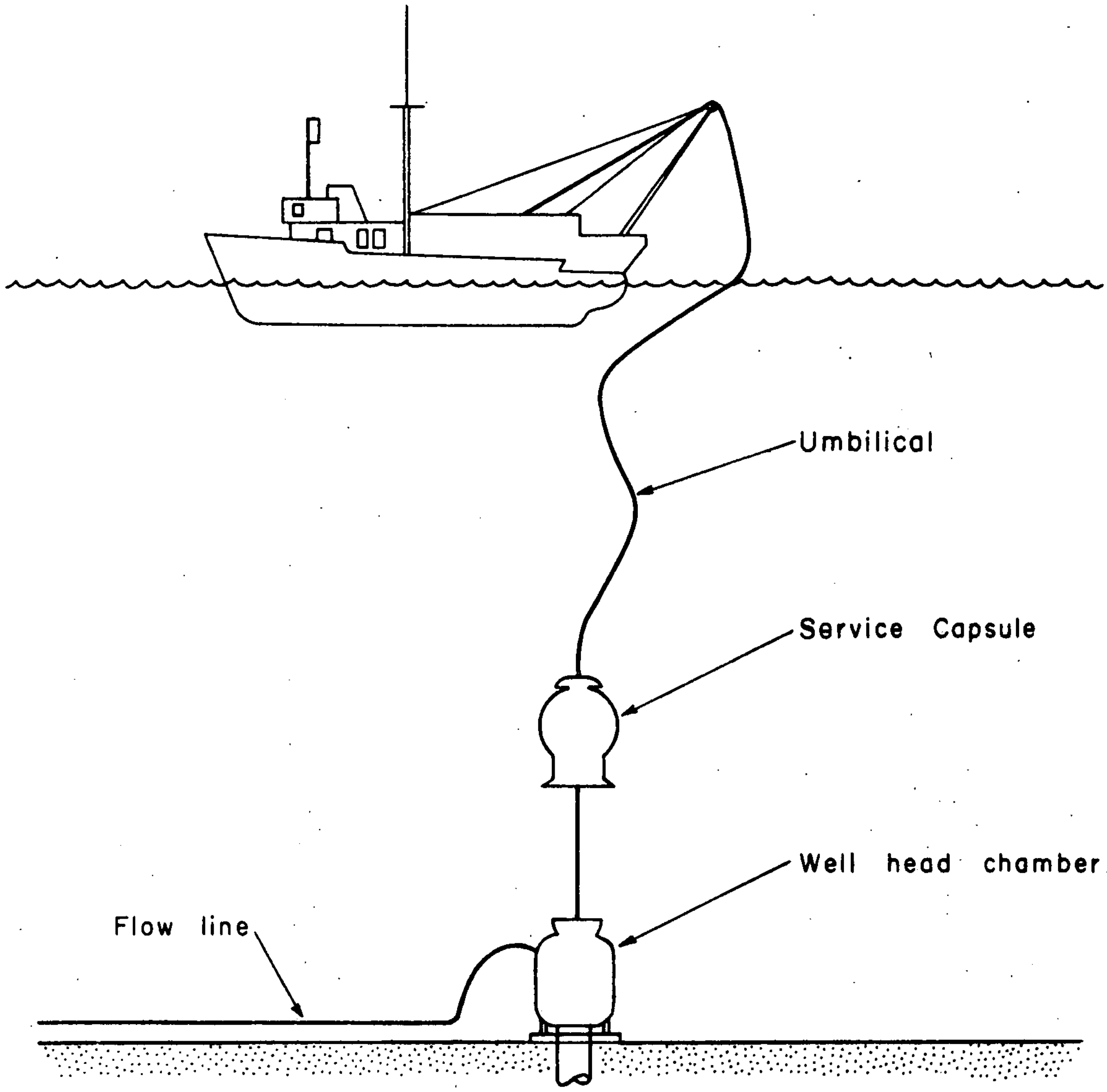

Fig. I Lockheed Sub - sea System.

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b) Lockheed Petroleum Services

In Houston, I visited the office of this company, which is a wholly owned subsidiary of Lockheed Aircraft. The 'Coastal Cruiser', a work boat converted by Lockheed to act as a launcher for their work capsule, was berthed outside Houston. I inspected this boat in company of Dan Bignardi, the senior capsule operator.

The main element of the Lockheed sub-sea system is a pressure vessel which surrounds the well head on the sea floor (Fig. 1). This pressure vessel is normally at atmospheric pressure at all times, but may be flooded if required. Virtually any make and type of christmas tree can be installed. The capsule is used to transfer equipment and personnel from the surface to the pressure vessel or cellar. A double lock system enables transfer of personnel at atmospheric pressure and no special medical standards are required for the men working on the well head. A wire-line service module can be attached between the cellar and the transfer capsule and all normal wire-line service operations can be achieved. The capsule is also used at the time of connecting the flow line which in the present system enters the cellar at an angle of 45°. This is necessary in the present design to allow a suitably large radius (1.5 m) to the flow line and tubing adapter so that normal TFL (through flow-line) tools can pass. Phase 2, as Lockheed calls it, entails the redesign of the sea bed cellar to enable horizontal entry for the flow line and a tubing loop inside the cellar.

Future developments also include the design of sub-sea manifolding and separators and a dynamically positioned service module.

The 'Coastal Cruiser' was in Houston undergoing routine maintenance and servicing with some modifications being made to capsule support systems. The capsule launching system is well designed and constructed and I consider that capsule launch and recovery could be carried out with safety even under adverse weather conditions.

Two wells have been completed for Shell Oil Company in the Gulf of Mexico in 123 m of water. They have been producing 1000 barrels of oil per day since October 1972 and no servicing of the well heads has been required which necessitated the use of the service capsule. Monitoring of the cellar environment is continuous and there has been no contamination of the air in the chamber. If such contamination were to occur, two separate means of replacing the air within are available without exposing personnel to the contaminants.

The present system of Lockheed is capable of operating in 425 m of water and with minor adaptations it could operate in 550 m. The new units now in the design phase will be able to operate in 910 m of water.

Lockheed's intention is to produce a package for each sub-sea installation - specifically tailored to the water depth. The personnel capsule would of course require the ability to service any well head in whatever depth of water exists at the location. Future developments include the provision for multi-well completions, sub-sea pumping installations, and semi-submersible or submersible support units.

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My general impression of the Lockheed system is that it is practical and available now for the safe and economic production of petroleum from sub-sea completions.

c) Seal Petroleum

In Marseilles, France, I was able to inspect two of the three Seal sub-sea systems. Later in London I had the opportunity to meet and discuss the application of these systems with senior personnel of the Company.

Lying at the dockside in Marseilles was the Comex-1, the vessel which is being used for launching the Seal system capsules. Compared with the Lockheed 'Coastal Cruiser' the Comex-1 is very simple and is not self-propelled. It is probably quite satisfactory for the experimental work Seal are conducting in the Mediterranean, but for practical oilfield work, a larger vessel with a more sophisticated launching system would obviously be required.

The Seal Shallow System (SSS) is a relatively simple servicing system for sub-sea well heads in shallow water (Fig. 2). The present system is designed for a maximum water depth of 72 m, but developments are under way to increase this to 275 m.

On the sea bed there is a comparatively large base-plate which is normally placed in position attached to the largest casing string. The well is drilled from a floating drilling vessel in the normal manner and before leaving the location, a string (or strings) of tubing is hung off at the well head; tubing plugs may be inserted if required for safety.

To bring the well into production, the Seal Working Enclosure (SWE) is lowered onto the base plate and a seal made. Water is then pumped out of the work enclosure and personnel, who travelled down to the sea bed in the attached control room, commence assembling the tree with its associated valves and manifolding. Any type of well head can be fitted, but a split-type tree is preferred. Upon completion of the work, personnel are transferred to the control room, the work chamber flooded and the SWE raised to surface. It should be noted that personnel are at all times in a 'shirt-sleeve' **environment and are breathing air at atmospheric pressure.**

The more sophisticated Seal Intermediate System (SIS) was also on the quay side at Marseilles. It is similar in many ways to the SSS but the major differences are:

1) The use of a split-type tree as mandatory

2) The ability to replace highly stressed tree modules (such as wing valves) by means of a specially designed handling tool operated from a surface support vessel

3) The manned working enclosure (MWE) is run independently of the personnel transfer chamber (PTC). Once the manned working enclosure is in place, personnel, supplies, and equipment can be ferried from the surface support vessel as required. Design depth rating is 100 m of water.

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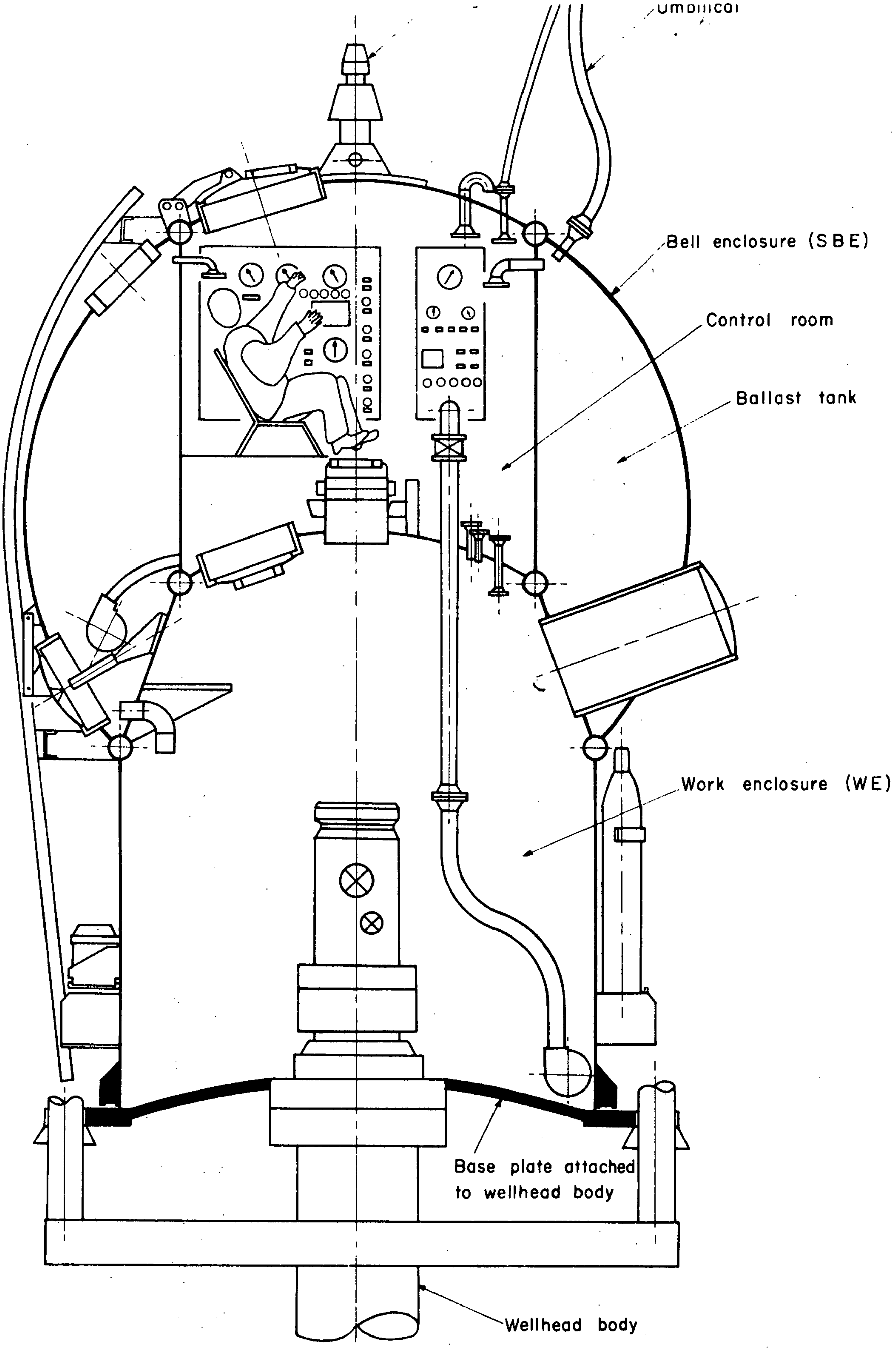

Fig. 2. Seal Shallow System (SSS).

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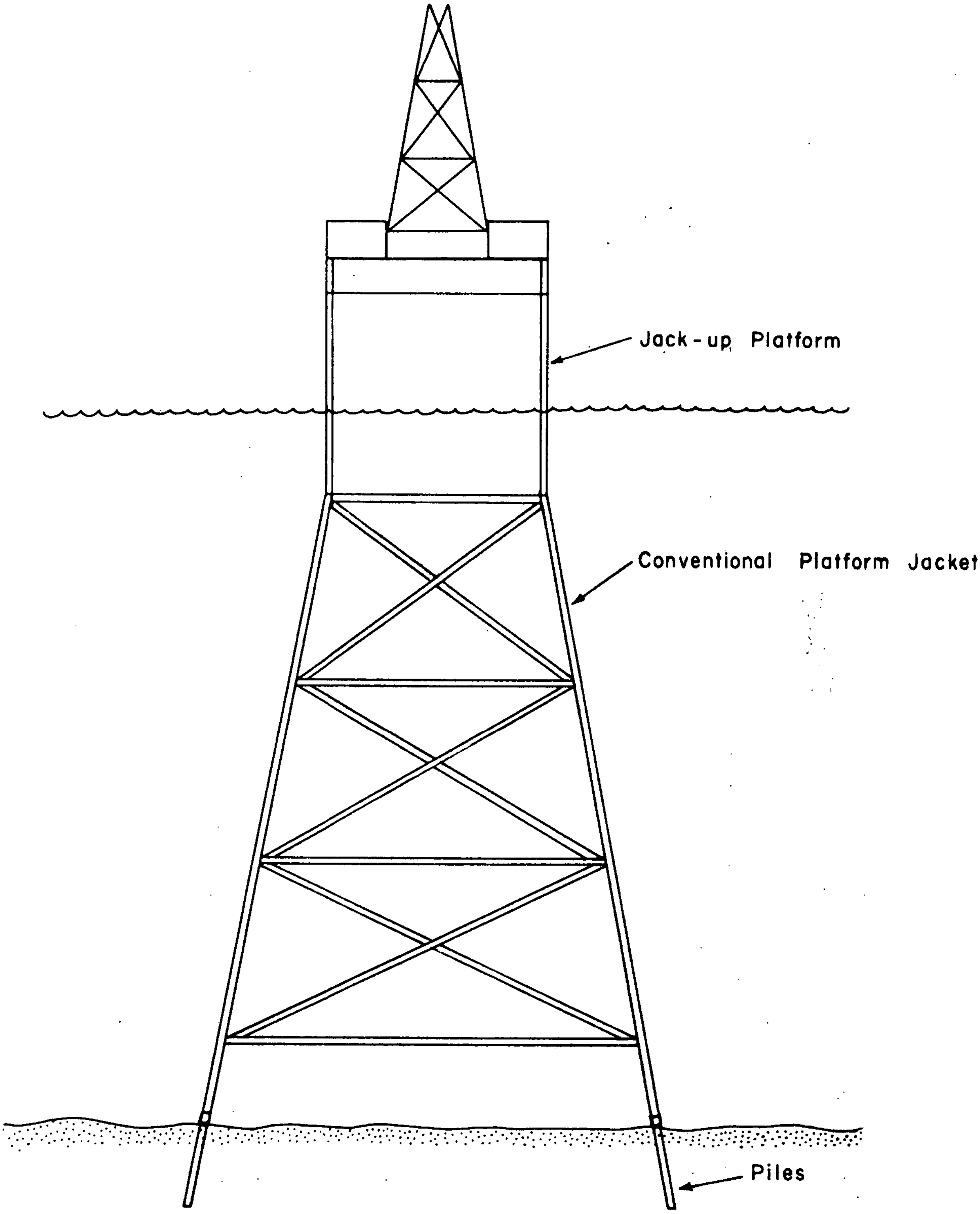

Fig. 3. Self - positioned production platform.

Sequence: 1. Float in conventional platform
2. Pile legs
3. Float in production package with legs retracted
4. Extend legs to give necessary air clearance

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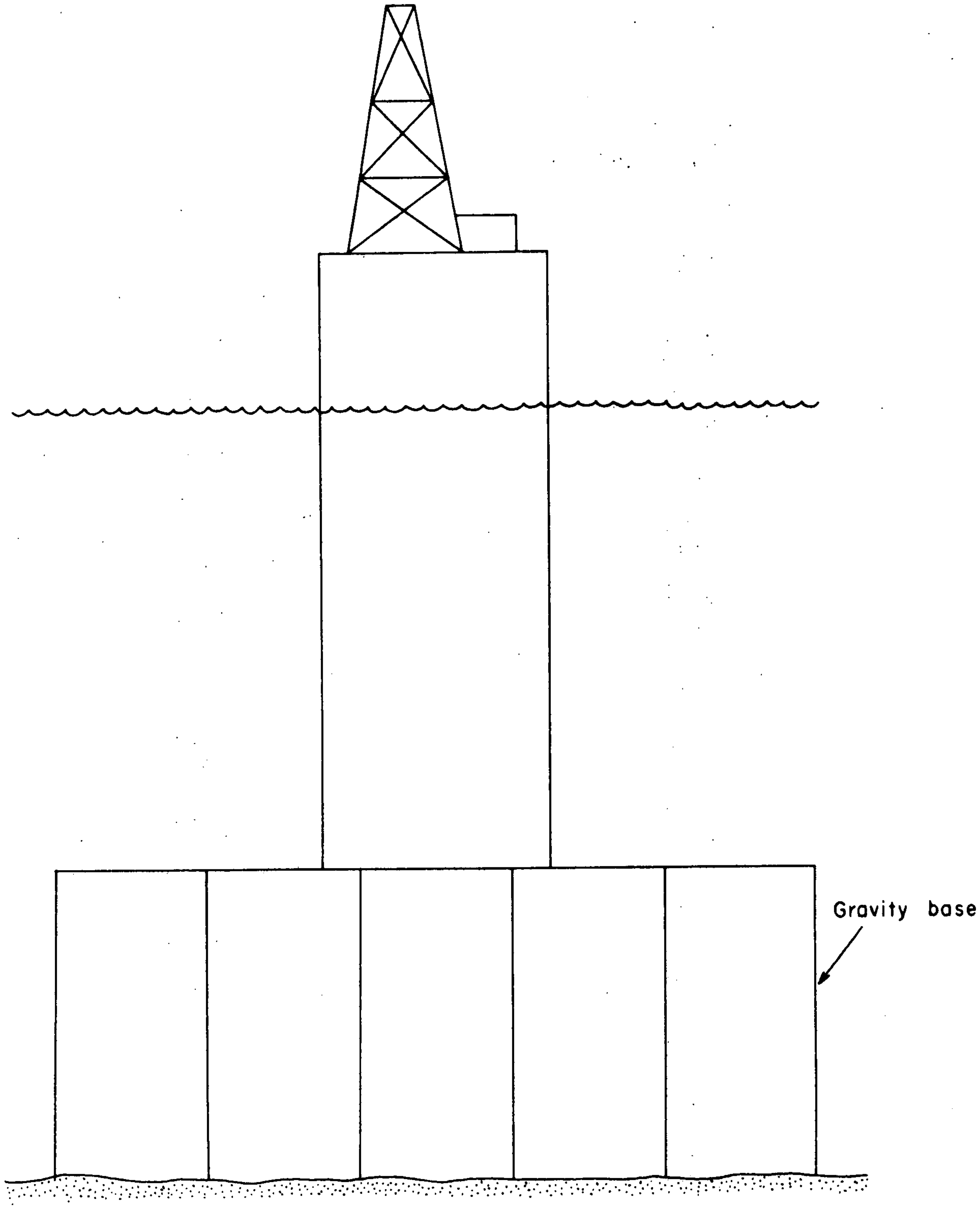

Fig. 4. Concrete drilling and production platform for 200-metre water depth.

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The third Seal system, SAS (Seal Atmospheric System) is a multiwell sub-sea completion system and is being developed in the Gulf of Mexico.

The company of Seal was formed several years ago by British Petroleum (BP), Compagnie Francaise des Petroles (CFP), Westinghouse Electric Corp. and Groupe DEEP. Mobil later joined the parent group. Other companies now associated with Seal are Continental Oil Co., Sun Oil Co., Phillips Petroleum, Erap (Elf) and SNPA (Aquitaine).

d) Wet-tree sub-sea completion

The three systems described above are all designed to be remotely operated and to be installed without the aid of divers.

Several supply companies have produced equipment for sub-sea completions based on the use of divers for installation and maintenance. At Ventura, California I was able to inspect Vetco equipment designed and built for this purpose. This well head incorporated a tubing loop to enable TFL tools to be run in the well.

Platforms

The design of fixed platforms is becoming increasingly complex. Until very recently, only the conventional cantilever-type steel production platform would be considered as a concept for drilling and production offshore.

From the results of talks with many operators and contractors in North America and Europe, it is quite evident that there are now many different types of platform which may be considered for any particular application.

Some of the new developments are:

a) Jack-up Deck (Fig. 3). A conventional jacket is placed on the sea bed with the top surface positioned 30 m or so below the water surface. The entire deck section is built as a watertight unit with, for example, six retractable legs attached to the sides of the deck. When in position over the jacket, the legs are extended, lifting the deck section to give the required air-gap. Piles can be driven to anchor the jacket in the conventional manner. The advantages of this over the conventional platform are that the jacket can be floated into position without the use of special barges and no lift or derrick barges are required to install the deck section.

b) Concrete Gravity (Fig. 4). This consists of a large concrete base (100 m or more in diameter) containing buoyancy and ballast compartments upon which is mounted either a single column or a multi-columnar structure. The platform is floated into position and sunk to sit on bottom. The base can be loaded to increase stability and no piling is required.

Advantages claimed are the ease of positioning, the simplicity of construction and the ability to store liquids (fuel during drilling phase, petroleum during production phase) within the structure.

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c) Inverted Pendulum (Fig. 5). In Paris I visited the offices of CFEM and Elf. The former company has designed and constructed a prototype platform for the Elf-Erap group of companies. The 'Elf-Ocean', as it has been named, consists of a cylindrical tower attached by a universal joint to a heavy base-plate on the sea bed. The tower is buoyant by itself and to increase the buoyancy, the prototype had modules mounted near to the top of the tower. Any deflection from the vertical because of wind or current forces will be resisted by the movement produced by the buoyancy forces. I was shown a film of the construction and positioning of the prototype and was invited to inspect it at Brest. However, owing to pressure of time, I was unable to accept this offer. The basic design is suitable for a drilling or production platform in water depths to 300 m. By installing a second articulation at around mid-depth, this type of unit could be built for 450 m of water (Fig. 6). Advantages claimed for this system are relatively low cost, ease of installation, and the ability to be able to move the unit to another location.

d) Guyed Platform (Fig. 7). One of the major international oil companies, whose offices I visited, has completed detailed design studies for a guyed drilling and production platform. It can best be visualized as a long slender tower resting on a base-plate on the sea bed. It is restrained by a system of guy-wires (typically twelve) which are anchored at the sea bed, pass over sheaves mounted approximately 50 m below water level and pass up to the above-water platform where their tension can be adjusted. The tower would be suitable for water depths to 400 m. In deeper water, considerable cost savings could be predicted using a guyed tower instead of a conventional jacket-type platform.

e) Tension Riser Platform (Fig. 8). The Fluor Corporation of Houston, Texas described its concept for a floating platform, similar in many ways to the conventional semi-submersible drilling rig (Ocean Digger for example). It is maintained in position by heavy cables, descending vertically from the platform to very heavy ballast anchors on the sea bed. Motion compensators on the platform take care of tidal movements and of heave caused by swell. A development of this concept for extreme water depths (3000 m and deeper) would utilize dynamic positioning for locating the platform. My opinion is that both these concepts have their application, but development and construction are many years in the future.

Pipelaying

Considerable effort is being made by several companies to develop new techniques of pipe-laying and to refine existing techniques. The conventional lay barge is used for most pipe-laying at present.

a) Semi-submersible barge. One barge of this type has already been operating in Australian waters ('Choctaw'). The greater stability of this type of barge will undoubtably lead to further barges of this type being constructed especially for hostile environments. A development of the semi-submersible barge whereby the assembly ramp is inclined to the horizontal is under active study by one of the contractors I had discussions with. It is claimed that by inclining the assembly ramp, pipe stress at critical points (such as at the stinger joint) is much reduced, minimizing the dangers of pipe buckling and allowing pipe to be laid safely in relatively deep water. The possibility of using dynamic positioning instead of conventional anchors is under active consideration.

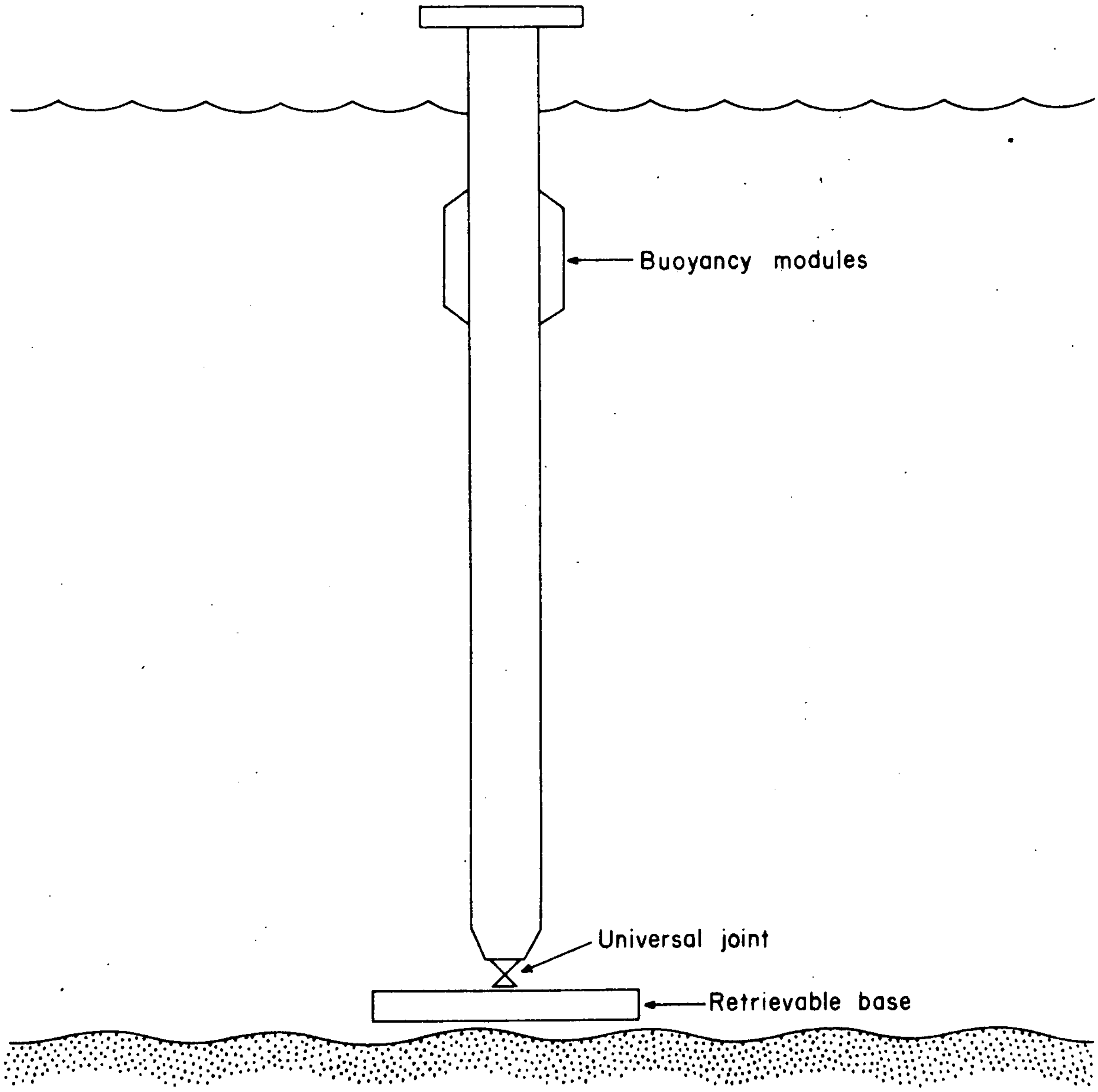

Fig.5. Inverted Pendulum - 'Elf-Ocean' drilling and production platform for 300-metre water depth.

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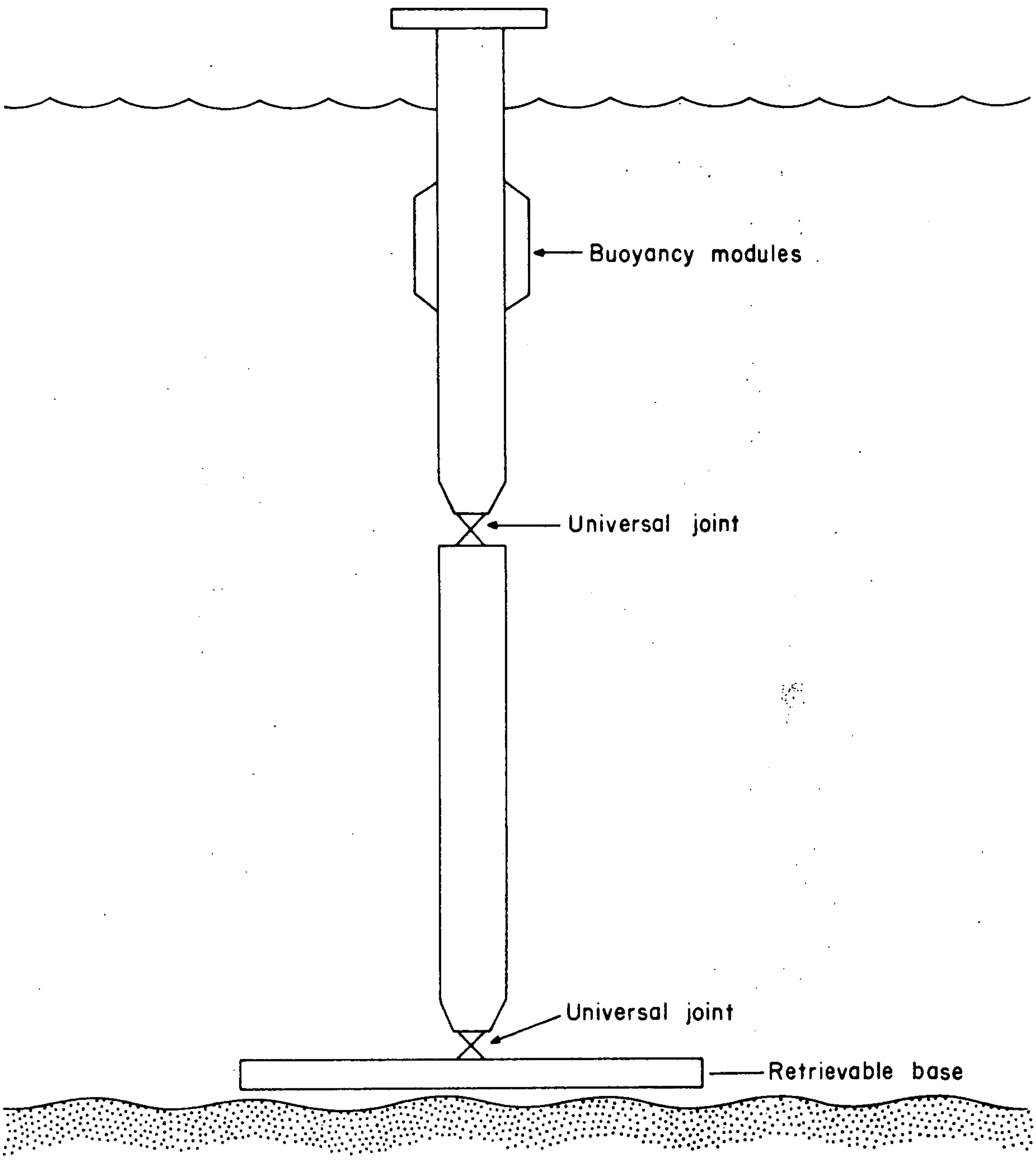

Fig. 6 'Elf-Ocean' platform for 500-metre water depth

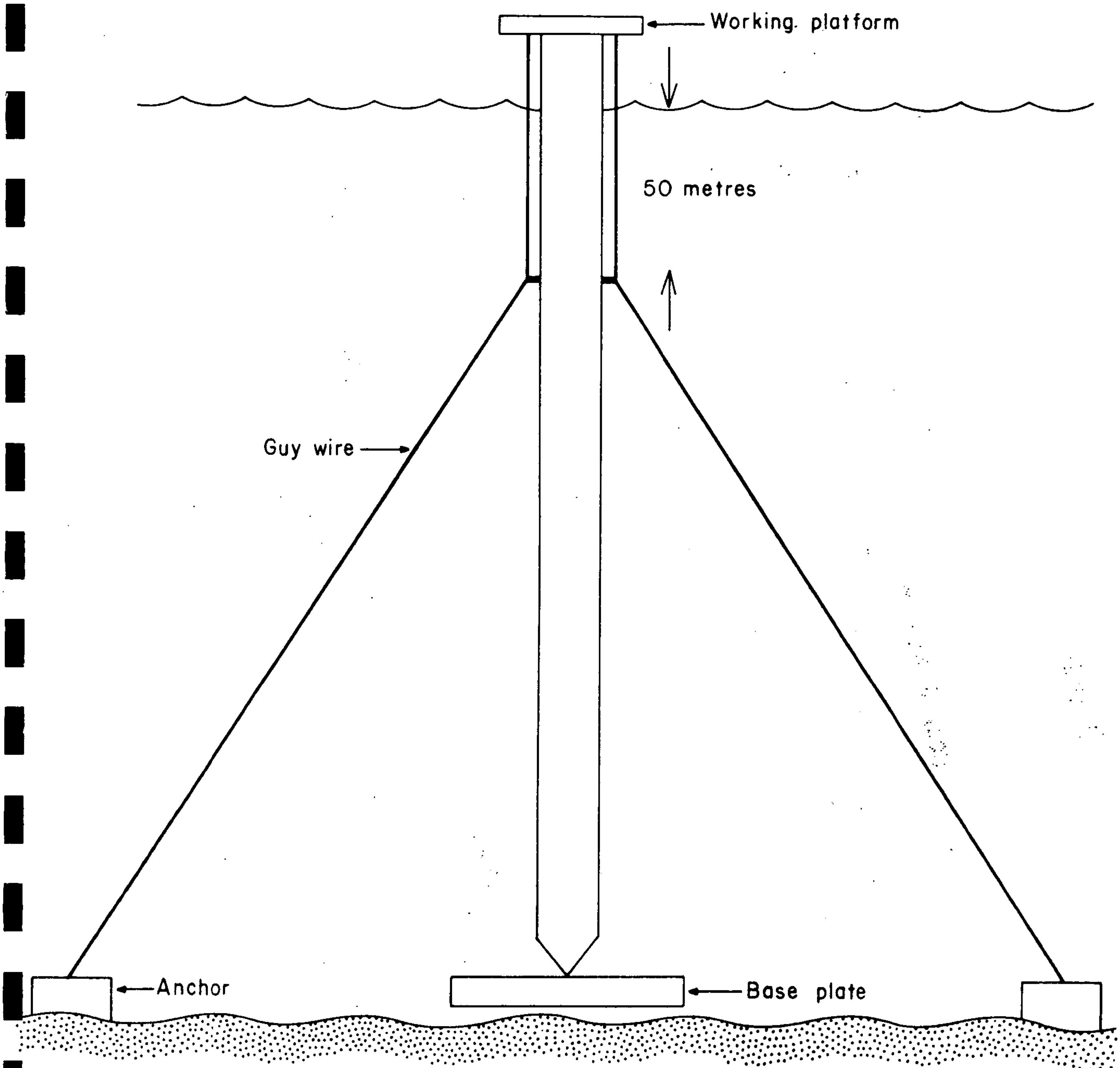

Fig. 7. Guyed platform for 400-metre water depth.

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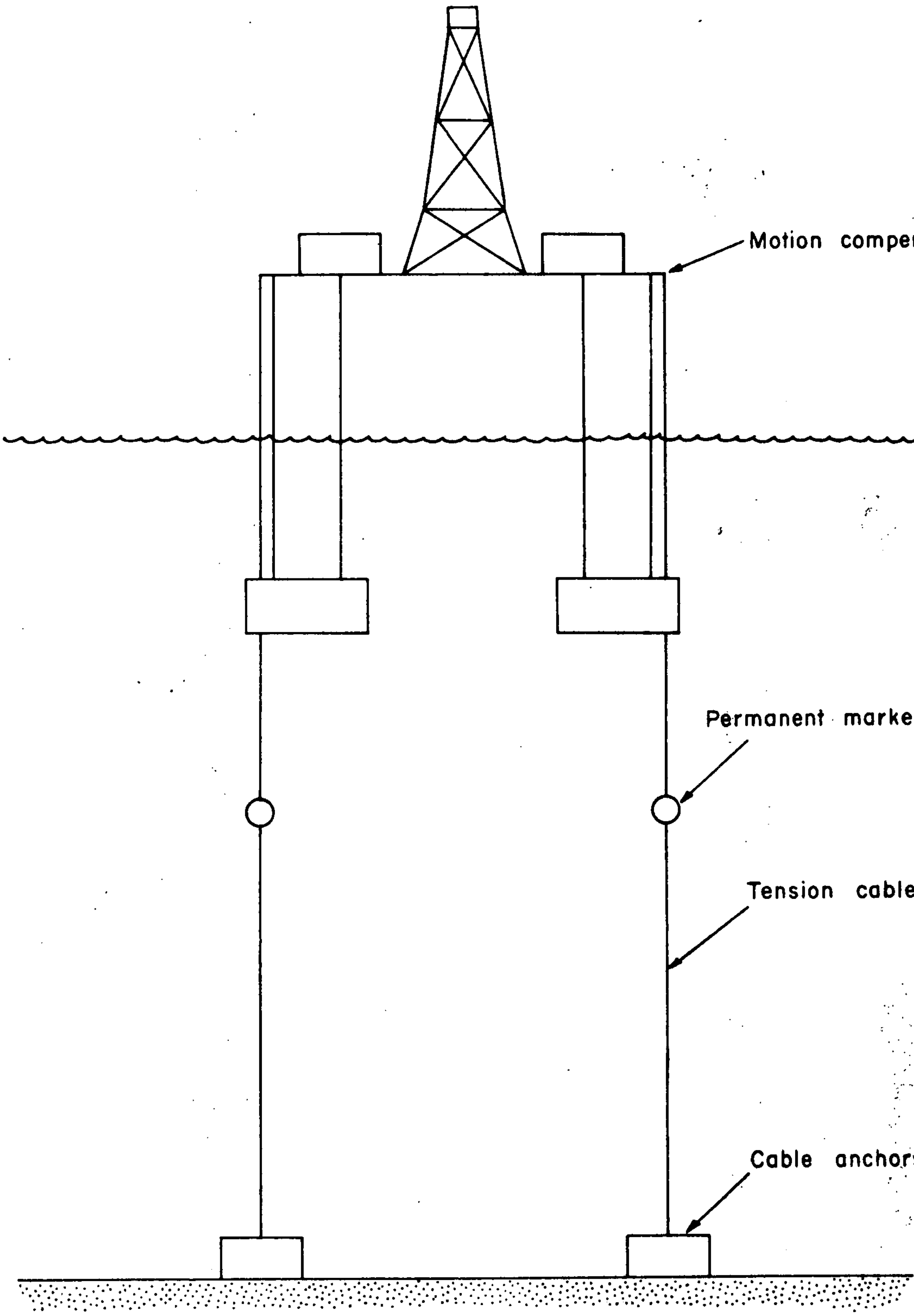

Fig. 8 Tension Riser platform for deep-water drilling and production (Fluor).

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b) Reel-type barge. The Fluor Corporation, which I visited in Houston and New Orleans, has developed the reel-type lay barge with considerable success. Pipe is stored on the barge reeled on to a drum (with a vertical axis). On location the barge is moved ahead and the pipe is pulled off the reel under tension, straightened by rollers, and fed off the stern of the barge. Pipe diameters up to 24" (610 mm) can be handled, but normal usage is for pipes of 6" and 8" diameter. Capacity is 12 miles of 8" pipe with pro-rata capacity for larger diameters. When all the pipe has been reeled off, the end is buoyed and dropped to the sea bed with the barge returning to the supply base to wind on a new length of pipe. A feasibility study is under way of a lay vessel of 150 000 gross tons. It would be 1000 ft long and would have a capacity of 2000 miles of 8" diameter pipe. It would be capable of laying pipe in deep water at relatively high speed (several knots).

The reel type lay barge has now established itself and is in use, particularly for inter-platform pipes. One big advantage is speed of laying which is faster than the conventional method. Only short periods of fair weather are required to lay a length of pipe and cost savings can be effected.

c) Flexible pipe. Institut Francaise des Petroles, which I visited in Paris, is developing flexible pipes for the petroleum drilling and production industry. Smaller sizes (to 6" diamter) are available now, while sizes to 24" diameter are being developed. Although manufacturing costs are high, cost of pipe-laying and of pipe connections are much reduced, and overall it is claimed that flexible pipes can realize significant cost savings in certain conditions.

Hook-ups

The problem of connecting pipelines to fixed installations, whether they be fixed platforms or sub-sea completions, is one that many companies are working on. I was able to discuss with Lockheed Petroleum Services in Houston its concept of a diverless hook-up system based on a sea bed pressure chamber in which men can work under normal atmospheric pressure. In deep water, this method should be considerably cheaper than a conventional tie-in.

At McDermotts yard in Morgan City, L.A., I was shown jackets fitted with J-tubes. When the jacket and associated platform is on location and anchored with piles, the production pipeline is pulled into a large pipe fixed to the jacket which has been pre-bent to enable the pipeline to be led from the sea bed to the platform. This is a very cheap method, but can only be used for relatively small diameter pipes.

Offshore drilling

Drilling in the deeper offshore waters does not appear to be as big a problem as some other facets of the offshore petroleum industry. The introduction of three dynamically positioned offshore drilling vessels (Sedco 445, Pelican, and Saipem 2) has demonstrated the ability to drill in water depths to 700 m with full pressure control equipment installed. Minor modifications are planned to enable water depths of 1000 m to be accessible and detailed engineering studies are in hand to allow drilling in 3000 m of water. I was fortunate, through the courtesy of Compagnie Francaise des Petroles, to be able to visit the 'Pelican' on location in the Mediterranean.

Having had an earlier opportunity to visit the Sedco 445 on location in Australian waters, it was interesting to compare the two vessels. Although there were many major points of difference, both vessels had the following in common:

- Full dynamic positioning
- Multiple computors (2 in Sedco 445, 3 in Pelican)
- Motion compensator
- Electro-hydraulic BOP controls
- Guide-line-less re-entry
- Automatic shear rams
- Large tubular storage capacity to facilitate operation in remote areas.

Developments noted during my overseas visit can be summarized as follows:

a) Downhole sensors. A great deal of interest and development is being shown in sensors situated near the drilling bit gathering data on formation resistivity and other formation characteristics, gas contained within the mud (down-hole gas detection) and annulus pressure and temperature. It is hoped that workable tools will be available to industry in the next few years.

b) Turbodrilling. Turbines are becoming more reliable and more versatile. They have for example virtually replaced the whipstock for deviated drilling and are finding increasing application with flexible drill pipe. The Flexodrill, developed by Institut Francais du Petrole, is becoming more widely accepted for drilling shallow wells. Developments are in hand to enable deeper drilling using this method.

c) Power-swivels. An electrically driven power-swivel of 700 hp output has now been developed and is available to industry. If adopted, it will lead to the elimination of the kelly and rotary drive and will enable the hole to be drilled in triples or doubles instead of a single length of drill pipe at a time as at present. It will have other advantages, particularly in fishing operations.

d) Motion compensators. There is no doubt, in my opinion, that motion compensators will be fitted as standard to all new floating drilling rigs and that existing rigs will be retro-actively fitted as operators discover the advantages of this new mechanism. Several manufacturers make these compensators and I was able to observe those made by Vetco, Rucker, and IHC. The motion compensator enables the driller to maintain the drilling string motionless with respect to the sea bed. The main advantages of the system are:

1) No bumper subs are required
2) Weight on bit can be maintained constant with consequent increase of bit life and increase of penetration rate
3) No scrubbing through the blow-out preventers
4) Greater safety and ease in handling BOP stack and landing casing strings

It is claimed that the cost of a motion compensator can be recuperated through increased drilling efficiency in six months or less.

e) Blow-out preventers. In working out the itinerary of this overseas visit considerable emphasis was placed upon the importance of pressure control equipment, especially blow-out preventers and their associated control systems. To this end, visits were made to Vetco Offshore Inc. in Ventura, California, Shaffer Tool Co. in Beaumont, Texas, Cameron Iron Works in Houston, Texas and talks were also held with the Hydril Company.

(i) Vetco Industries Inc.

This company, based in Ventura, California, does not manufacture blowout preventers, but specializes in the manufacture of other pressure-control equipment and in the assembly of BOP stacks. Many of its forgings are supplied by Overall Forge in Sydney. Most of the BOPs used in its stacks are Cameron. Its most popular annular preventer is now the Shaffer which has taken over from the Hydril in most of the new stacks they have assembled. The company firmly believes that electro-hydraulic control systems will become the standard for the offshore industry although strong competition may be experienced from all-electric and the conventional all-hydraulic system.

(ii) Shaffer Tool Company

This company is located in Beaumont, Texas and is a division of Rucker. It manufactures conventional ram-type preventers and also a new annular preventer with a spherical seat. The latter is impressive and full closure under 5000 psi was demonstrated. The company has installed an automatic stripping machine for testing these spherical preventers and one preventer had been subjected to the equivalent of 250 000 ft of drill pipe being stripped through it. The element had suffered considerable wear in this process, but at the end of this test was still sealing against the well pressure. Several types of element are available and a new rubber compound has just been developed which is showing outstanding characteristics. The annular preventer is compact and appears to be an improvement on existing annular preventers.

(iii) Cameron Iron Works

This company, located in Houston Texas, has to be considered the leader in the industry. The size of its plant is immense and some idea of its capabilities can be judged from the fact that at one time it possessed the two largest forges in the world; one in Houston and one in Scotland. It manufactures virtually everything itself and does very little subcontracting. No castings of any description are used in its preventers and all equipment is subject to pressure testing before leaving the plant. I also had the opportunity to visit the Payne Division of Cameron, also located in Houston, which is doing a lot of experimental work in electrohydraulic and electrically controlled systems. The Cameron annular blowout preventer is a compact unit and appears to be giving good service. It is slightly more complicated than the equivalent Shaffer unit, but in field operations it has proved to be reliable.

(f) Subsea supplies

In discussions with the drilling departments of several major companies, suggestions were made for the establishment of supply depots on the sea bed away from the air/sea interface. The idea would be to place materials such as tubulars and properly packaged bulk supplies on the sea bed in good weather conditions. These supplies could then be picked up from the sea bed as required for use on a platform (either fixed or floating) as required. One problem is that the contractors are not very happy with this suggestion, and some difficulty may be experienced in getting this concept accepted by contractors.

(g) Sea-bed mud pump

One major problem being experienced in deeper waters lies in the relatively high pressures that can be developed at the sea-bed level caused by the weight of mud in the marine riser. This can be troublesome, especially in the case of low-density surface formations and only a short string of conductor casing. To overcome these problems it has been suggested to place an electrically driven suction pump on the sea bed to pump mud under pressure to the drilling vessel. The back pressure in the annulus at the BOP would then be effectively zero.

(h) Simulator

In many parts of the world drilling simulators have been built in order to train personnel especially in problems related to well kicks and blowouts. Simtran Corporation manufactures simulators of this nature and I am impressed with its capabilities and consider that one could be of great advantage in Australia.

(i) Logging

Talks with several logging companies shows that work is being conducted to provide logging tools with deep investigation characteristics. The Schlumberger deep-investigation device already in use has obvious defects and further work is being conducted to produce a less sophisticated and more easily used system which will reveal resistivity anomalies relatively far from the bore hole. This would obviously be of use in detecting fault planes, salt domes, etc. Work is also being carried out to investigate strata beneath the bottom of the bore hole and various techniques are being studied. It would appear that none of the logging contractors will be able to produce a device within the next few years, but eventually equipment will be available to investigate formations distant from the bore hole both horizontally and vertically.

(j) Well control vessel

In London I was invited to attend a presentation by Red Adair to BP. His proposal is that the major North Sea operators get together to lease a specialized well control and fire-fighting vessel to be known as Redco-1. It will be a dynamically positioned semi-submersible equipped with mud storage, mud pumps, fire-fighting pumps, a cherry picker, and many other pieces of equipment. While its chief purpose would be as a floating fire engine it could also be used for several other purposes, including the launching of capsules and submersibles for pipeline inspection and subsea well servicing. Red Adair asserts that the cost

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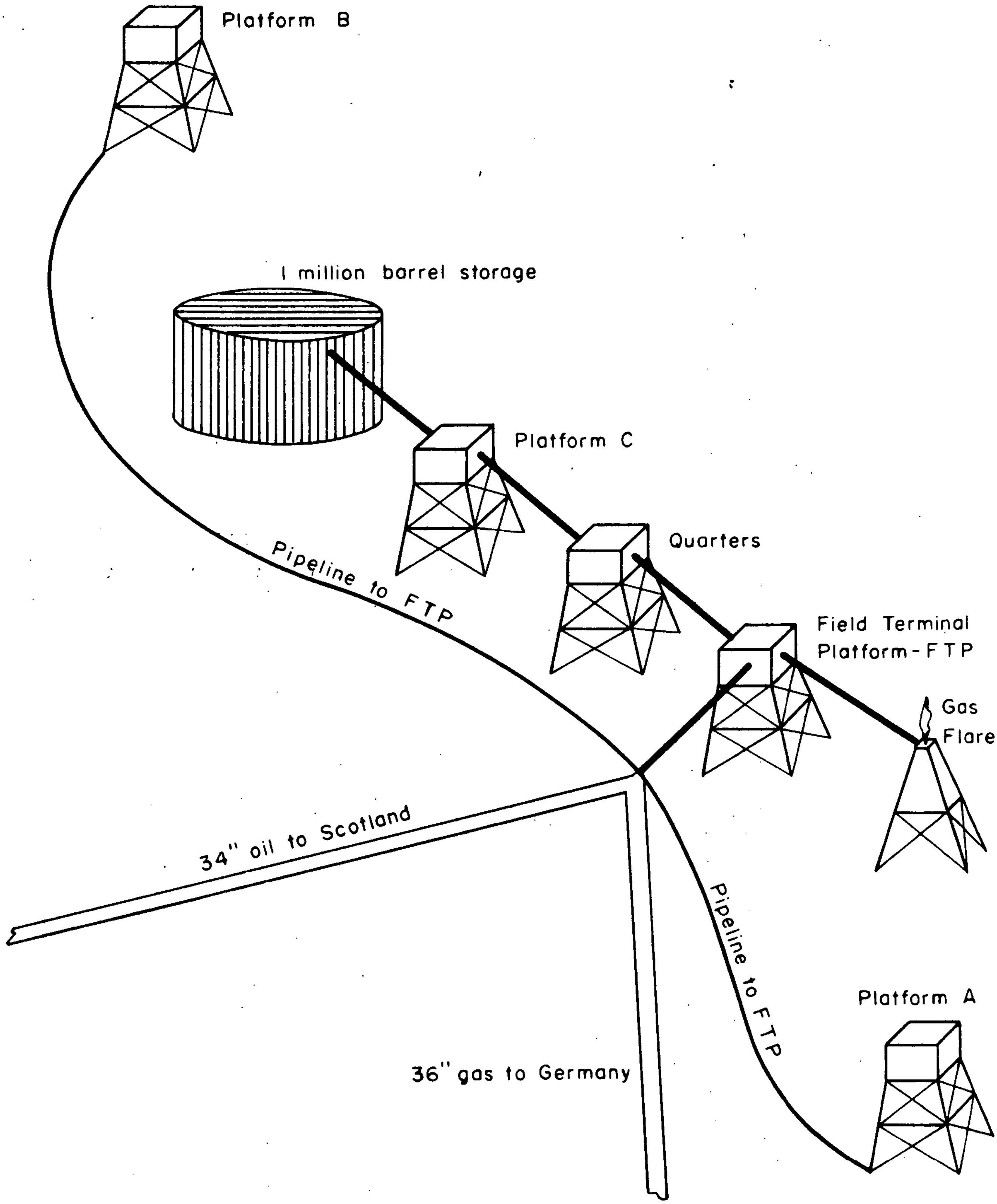

Fig.9 Ekofisk field - Phase 3

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of the unit could be saved by just one blowout or fire, and it is interesting that one example he used was the Marlin blowout in Bass Strait. It would appear that drilling activities may not warrant such a vessel being stationed in Australia at the moment, but would appear to be a need for this type of vessel if the offshore industry expands to any great extent around Australia.

Diving

A visit was paid to the Comex headquarters in Marseilles, France. This company must be acknowledged as the leader in deep-diving techniques, and shortly before my arrival a dry dive had been made by two divers to 2001 feet in a chamber in Marseilles. While I was there preparations were under way to prepare the chamber for some monkeys to dry dive to depths considerably in excess of this with a view to human divers bettering the 2000 feet record next year. Wet dives have been made to 1300 feet and Comex considers that working dives to 900 feet should be practical now. One problem I discussed with Comex was that of divers who may be trapped in the water or in the decompression chamber on a drilling vessel with the vessel either on fire or in danger. Comex have developed a system for coping with this problem and I was shown the equipment which it has built.

The company also manufactures diving bells and submersibles. Many of its new diving bells are equipped with propulsion to enable the bell to be positioned without the use of guide lines. I was able to inspect one such bell while on board the dynamically positioned 'Pelican' in the Mediterranean. All companies I spoke to were of the impression that submersibles would be used to a greater extent offshore in the future. One of the first areas of use would be pipeline inspection where considerable cost savings and greater efficiency could be expected from the use of submarines rather than divers.

North Sea

By courtesy of Phillips Petroleum I visited the Stavanger, Norway supply base and the Ekofisk field (Fig. 9). Production at the moment at Ekofisk is from four subsea completions with flow lines led to a jackup-type production platform (the Gulftide). Production is now 40 000 barrels per day and the oil is transported by pipe from the platform to a single buoy mooring (SBM). Gas is flared off at the moment. The complex now being erected at Ekofisk will comprise three drilling and production platforms, the central one being connected by a walkway to a fixed production platform (FTP). Another platform will house the living quarters and a smaller platform will accommodate a flare line for gas. The FTP will be connected to a million-barrel storage tank which has just been completed in Stavanger. This tank, built in a fiord, is of reinforced concrete construction and in its present configuration draws 65 m of water while floating. It will be towed to the Ekofisk location and will be sunk to sit on the sea bed. Oil will be stored in this storage tank and will be transported via two SPM. Eventually pipelines will transport gas to Germany and oil to Scotland and the storage tank at this stage will not be required but will remain on location. Eventual production from Ekofisk is scheduled to be 400 000 barrels of oil per day and the system is designed to handle up to 1 million barrels per day, and it is hoped to connect several of the other fields in the area to the Ekofisk production system. Activity at the moment is very high and in the area there is one pipeline barge, 4 derrick barges, and numerous tug boats and supply boats. A helicopter service to Stavanger is maintained and in addition a small helicopter is used for moving personnel between the various platforms and barges. Water depth is 79 metres and weather conditions vary between the extremes of calm summer weather to severe winter storms with wave heights exceeding 65 feet and wind strengths exceeding 80 knots.

Offshore development

One conclusion that can be arrived at from talking to numerous offshore operators is that while the fixed platform will continue to be the most important means of producing petroleum from the sea bed in the foreseeable future, many other systems will become accepted by the industry and multiple type schemes such as that developed for Ekofisk will become more widely adopted, mainly for economic reasons.

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