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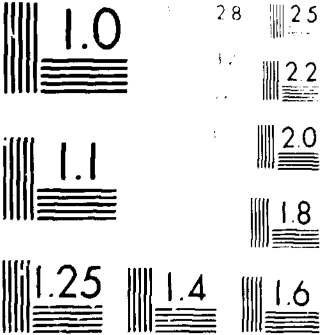

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OFFSHORE RIGS AND MODULES FOR THE EXPLORATION OF HYDROCARBONS IN SPECIAL CONSIDERATION OF THE MANUFACTURING AND DEVELOPING OF RIG COMPONENTS *

VOLUME II

by

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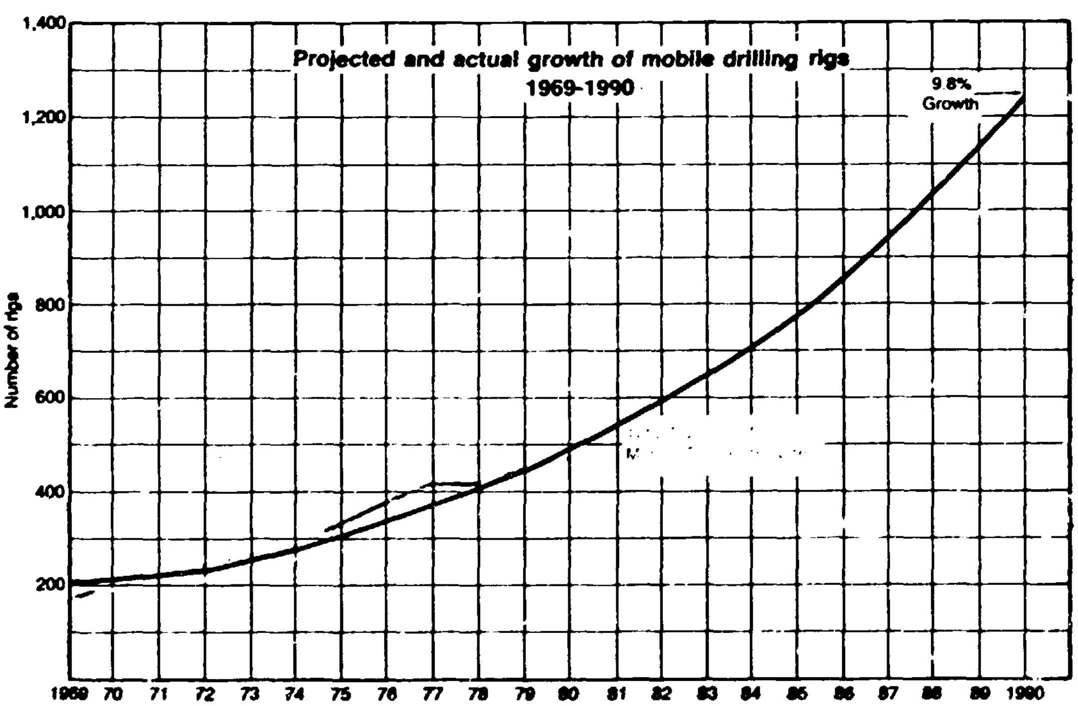
PREFACE

In a world of rapid technological changes and progress, no part of the petroleum industry faces greater technological changes and expansion than that part of our industry active in offshore exploration and development. Of all the offshore work, none is expanding and changing faster than floating drilling operations Through the use of floating drilling rigs, the petroleum industry today has drilled exploratory wells in water depths in excess of 4000 ft.

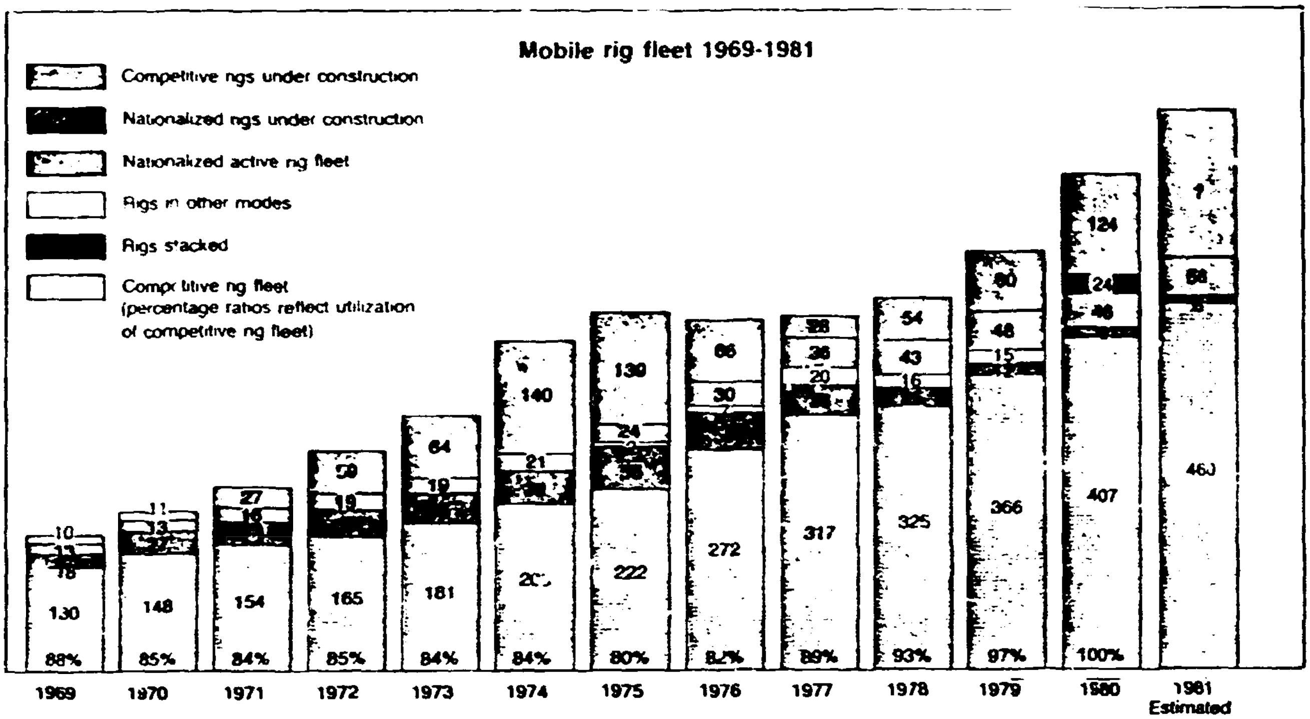
Things have never looked better for most segments of the offshore industry. Nearly all drilling contractors, engineering and construction firms are feeling the effects of a very strong upturn in business. A recent survey reported that 578 platforms and 169 well protectors are under construction or planned. Some of these have been ordered for fields that have yet to be discovered.

Most booms are cyclic to some degree, but, as indicated on the drilling chart, there has been a steady 0.098 exponential increase in the number of rigs over an 11 year period and it appears this trend may continue. (See figures 1. and 2.)



SINCE 1970 THE MOBILE RIG FLEET has grown at an average rate of 9.8 percent per year. The actual growth varies from the exponential plot because of political, economic and inflation factors.

Figure 1.



All figures reflected in the above chart were compiled for *Ocean Industry's* annual "Directory of Marine Drilling Rigs" which is published in mid-September. Hence all figures relating to mobile rigs are based on statistics as of Sept. 1, of the year shown rather than the usual Dec. 31.

Figure 2. shows the increase in Mobile Rig Fleet in detail from 1969 to 1981.

Drilling contractors are caught up in a soaring spiral of favourable day rates, almost 100% rig utilisation and substantial contracts. Financing for new rigs is easy to arrange, even for new entrants into drilling who are able to acquire two year drilling commitment letters from oil companies.

Figure 3. indicates drilling activity and trends:

OFFSHORE WELLS DRILLED 1970-1985

Year	U.S.	Outside U.S.	Total
1970	1,058	312	1,370
1971	884	280	1,164
1972	993	601	1,594
1973	888	856	1,744
1974	830	986	1,816
1975	1,028	1,067	2,095
1976	1,028	1,070	2,098
1977	1,211	1,310	2,521
1978	1,236	1,520	2,756
1979	1,241	1,444	2,685
1980	1,360	1,856	3,216
1981	...	...	3,500
1982	...	...	3,800
1983	...	...	4,100
1984	...	...	4,500
1985	...	...	4,850

Figures are from shoreline out and do not include lakes drilling
(*1980-1985 figures are estimates.)

So much has the picture changed, that it seems impossible that just two years ago many rigs were stacked and almost new semi-submersibles could be purchased for about $17 million. The same rigs would possibly sell for three times this amount today, and new rigs on order are costing up to $73 million.

New and improved technology is being developed in response to the need to 1) instal platforms in deeper water; 2) cope with icebergs in such areas as off Eastern Canada; and 3) hasten the return on investment by commencing production at an earlier date.

Drilling for oil and gas is absolutely the most attractive and vital form of industry to meet today's energy demands. We all see daily in our work, in our cities, and in our homes the ravenous appetite our society has for energy. Our dependence on power supplied by oil and gas is immense. What we do not see nearby is the effort required to supply this energy on a consistent basis. The figure of 65,000 wells drilled in 1980 within the U.S.A. only is awesome, yet removed. The wells seem abstractions.

A well can effectively produce oil or gas from a relatively small area of hydrocarbon-bearing formations which may extend underground for miles. Numerous wells must be drilled, initially to outline the perimeter of the productive formation and then to produce the oil or gas. Some wells are drilled to the reservoir in order to inject water, gas or other substances to maintain pressure and stimulate production.

The industry's commitment to rotary drilling, which is still the most cost efficient technique to drill a hole in the ground, has been made. Already a tremendous amount of capital has been spent by oil companies and contractors to increase the number of drilling rigs and to purchase the supporting tools to meet the demand.

Basically, the following conclusions can be drawn :

Continuing dependence on oil and gas is a fundamental premise for the continuing viability and growth of civilization as we know it today. Future generations may learn to rely on alternate sources of energy - from the sun, from wind and tidal power, from biomass, from shale or synthetic fuels derived from coal and from nuclear fission or fusion. But our near future - stretching at least into the 21st century - will continue to depend largely upon the power produced from oil and gas, which presently supply approximately three quarters of the world's energy needs. The quest for petroleum to power our society has become intense - beyond any previously known degree.

Three factors predominate among the many that stimulate this great worldwide outpouring of capital and resources in search of more oil and gas. First, although energy conservation and initial uses of alternate sources of power have been effective, demand for petroleum products will increase as population growth, coupled with industrial expansion, characterizes most of the countries of the world. Without the energy derived from petroleum and gas, the economy of the world would come to a halt.

Secondly, petroleum has become a political and economic weapon used with increasing skill by certain nations and groups of nations for their self interest, producing a new division between the countries of the world into "energy haves and have-nots".

Finally, since 1973, the price of oil on world markets has risen more than eight-fold, imposing a new economic framework on the costs of doing business, on national defence and on the way people live.

These factors and others demonstrate clearly that the near future outlook for oil and gas exploration development and production is very strong

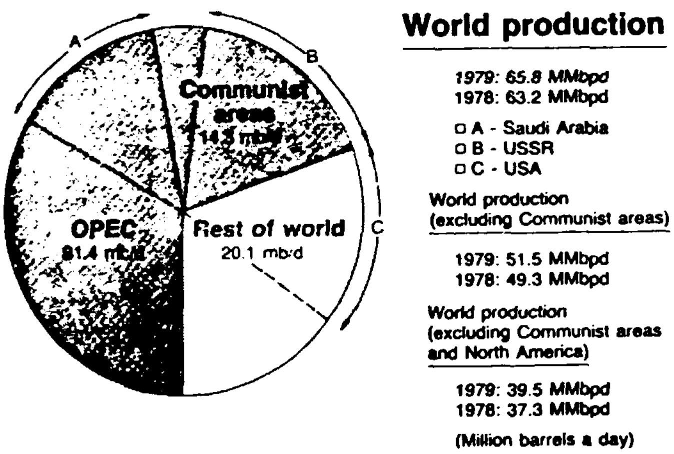


Figure 4.

OIL PRODUCTION—WORLD AND OPEC (Source: Shell)

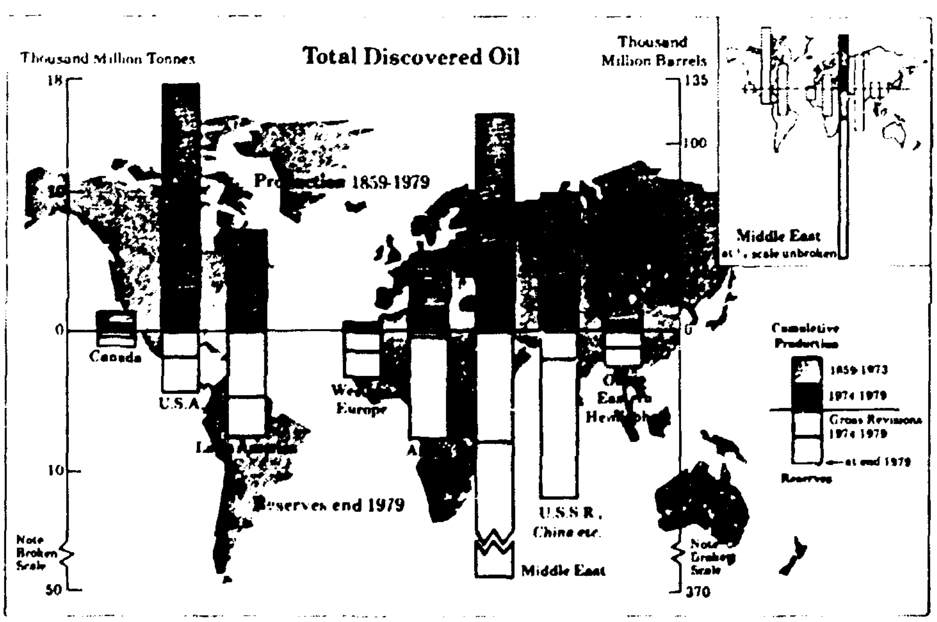


Figure 5.

Executive World

Figures 4 and 5.
show the world oil production and the total discovered oil and estimated reserves (1979).

Drilled footage and the number of wells will necessarily increase in the foreseeable future as capable nations strive to produce more oil and gas, particularly in the North American market, Mexico and Europe.

Nations realise they must develop domestic reserves. Although many may never become self-sufficient in oil and gas, they can make enough additions to their reserves to reduce their flow of funds for importing oil.

Following this introduction, it is obvious that the drilling business shows one of the most dynamic growth patterns within the hydrocarbons and earth extraction industries throughout the world and has to be recognised as playing the main part in the exploration of energy resources.

Valuable conclusions can be derived from analysing the described trends and aspects in order to establish, invest and participate in this most active kind of industry.

INTRODUCTION

The presented technical report is one part of a comprehensive study on drilling rigs for offshore and onshore exploration work. The original study has been split up in three parts in order to correspond to the requirements of actual conditions which are different from country to country. On top of that is makes it easier to the respective reader who decided on special projects already to deal with a more handy brochure rather than with a bulky book. Nevertheless, it should be pointed out that besides this brochure, two other booklets have been published at the same time which cover very similar equipment but with another application and different design.

The study discusses the different components, equipment and parts which are to be found on a drilling rig. To support this intention a rather detailed bibliography has been furnished for some of the chapters.

In some paragraphs of the report the equipment is explained part by part with regard to the eventuality of going into manufacture of these parts or components without any delay and anticipating the products which have already been given priority.

The overall objective of the report is to speed up the manufacturing and production of drilling rig components in countries where this line of industry is more or less in its very early beginnings or does not even exist as yet. The study should contribute to the intentions, planning and projects of the government concerned to increase or establish the local manufacturing of drilling rig parts within the very near future.

It is evident that certain groups of products have to be deferred from the start because of their complexity and R&D work involved. However, this does not mean that this equipment is eliminated as far as consideration for manufacturing is concerned, but that, as a time factor is involved, the less sophisticated equipment has to be focussed upon first.

Furthermore, the respective local existing facilities have to be taken into account, which represent a basic requirement for the spudding of production.

First priority should be given to the product line of drilling components in order to employ the existing national industrial capacities and human resources intensively within a booming branch of industry.

The many varied parts and equipment of a drilling rig represent a large spectrum of supply from all kinds of different branches. Unutilised capacities of plants and production facilities and unemployed, qualified or unqualified human resources can be drawn to meet the drilling industry requirements.

In some countries many companies increased their capacities remarkably in order to meet the demand of the drilling business. Many other companies were able to establish themselves as it was an absolutely new market for special products as well.

Manufacturing the components by the domestic metal working industry decreases the imports from other countries and saves the funds for other important investments needed.

Furthermore, domestic manufacturing of drilling rigs advances the exploration activities and increases the competition on a world-wide rapidly expanding market.

The study emphasises certain features, designs and material qualities which have to be met without exception in order to produce components without any defect. Some paragraphs do show basic comments and explanations of rig components which might seem to the experienced design engineer trivial or unnecessary. However, it is the intention, among other objectives of this study, to furnish readers who are not familiar with a drilling rig with the necessary basics in order to proceed more easily to the more sophisticated chapters of the brochure and other professional literature.

Besides, the content of certain paragraphs takes into consideration readers who have a mechanical, electrical, or construction engineering background, but have not been confronted with the drilling rig terminology and who know certain components on the drilling rig very well but are not experienced with their special application to the drilling operation or with the special operational features which the drilling work requires.

The instructions of API (American Petroleum Institute) with regard to standardization and specification of drilling equipment have to be followed by every manufacturer. These regulations include tolerances, maximum factors for tensile stress and yield, material qualities, dimensions (longitudinal and lateral), advice for maintenance, safety factors, etc. Usually each drilling rig component is referred to by a separate API Bulletin.

The study covers also modern drilling rig auxiliary equipment which is not a necessity but increases the efficiency of the drilling operation and facilitates the speeding up of the different working processes on the rig floor. Additionally, it eases the work of the rig crew.

In the course of this report the rating of each rig component is stressed out as they have to complement each other during drilling or handling pipe with regard to power and type of operation. This co-ordination of ratings is very important to the manufacturer as he has to plan the design of the respective components which have to match in order to guarantee a smooth operating of the total drilling complex.

Great care has to be bestowed on the assembly of the parts and equipment in order to pass the test and the final check up of the components for safety and reliability by the respective Association for technical inspection of the country.

The rig-up and test includes, among other checks :

1) Rig-up and test in the yard, assembling the mast, substructure, engine extension and mounting all drilling machinery thereon; running the same; setting up the pumps and connecting the drive; installing all mud manifolding, positioning mud tanks and hook-up manifolding, complete pressure testing of mud system; and complete rig test prior to disassembly for shipment preparation.

2) Furnish, assemble and install where required one lot of water, fuel, oil and air piping for the rig.

3) Furnish, assemble and install where required one lot of blowout preventer piping.

4) Dynamic brake and hoist cooling, where applicable, consists of cooling tower with three pumps.
Pumps are manifolded to tower and water tank.

5) One lot labour and material to wire and connect all AC equipment.

6) Thorough inspection of the derrick or mast, including crown block and travelling block, according to API regulations and/or instructions established by local technical inspection authorities.

The study includes up to date tables and figures to illustrate modern rig equipment and accessories. Dimensions, ratings and layouts of components are described very accurately and references are given for further follow-up. The report is compiled from a great many up to date papers, professional literature and sources provided by the drilling industry. The author wishes to express his thanks to corporations, companies, individuals and publishers for the courtesy and permission to reproduce some of the information they have developed. Many thanks also to the University of Austin, Texas for the literature provided which has greatly aided in the research and writing.

1. Scope and Summary of the Report

The study has been initiated by UNIDO, Vienna. It should deliver a major contribution to the plans and projects of different governments to urge the manufacturing of drilling rigs and components.

Furthermore, existing local branches of industries should be encouraged to focus on the diversified products employed by a drilling rig to enlarge their capacities and facilities for this new market. Engineering bureaux, R&D departments and governmental institutions should be prepared to concentrate on the design and development of rig components and on employment of existing local facilities with regard to fabrication and manufacturing.

This report is supposed to provide the necessary information to promote and to support the engagement in this branch of industry. It should assist the institutions, project groups and advisers involved to establish and speed up the required analyses, R&D work, implementation of programs and the manufacturing by qualified suppliers.

The study is addressed to :

1.1. Ministry of Industry (Oil, Gas, Water, Minerals).

1.2. Ministry of Natural Resources (Oil, Gas, Water, Minerals).

1.3. Ministry of Finance.

1.4. Ministry of Industrial Planning.

1.5. Ministry of Energy.

1.6. Governmental Boards or Advisory Committees established for energy development projects, irrigation planning, R&D of exploration work, promotion of metal finishing enterprises, national heavy industry.

1.7. Engineering Departments of national oil and gas companies, drilling companies, prime metal working and manufacturing companies.

1.8. National metal manufacturers associations.

1.9. Engineering departments of prime compressor, pumps and engines manufacturing or assembling companies.

1.10. Electric cable and wire line producers.

1.11. Instruments, appliances and gauges manufacturing industries.

1.12. Engineering Departments of steel construction companies.

1.13. Tanks and container building or assembling enterprises.

1.14. Prime Electric motors manufacturers.

The report aims to direct the attention of all the above mentioned governmental institutions, manufacturers and producers to the manufacture of drilling rigs and components.

Furthermore, it gives suggestions to the respective authorities with regard to implementing, developing and producing the necessary equipment. Recommendations have been elaborated to advise what, how and when it should be accomplished.

In order to realise parts of this important project within a reasonable period of time the following general steps are recommended to be taken by the respective governments :

- to establish an advisory committee (technical/financial)
- to promote R&D projects
- to promote development programs
- to encourage the domestic industry providing incentives for investments.
- to obtain studies (technical and economical) from universities on technical and economical feasibility of planned projects.
- to establish professional training programs.
- to conduct surveys and employ consultants.

In order to enforce the required actions which have to be taken to achieve the overall objective, the assistance of the government through its ministries is an absolute necessity. It has to be emphasised that the support of the ministries and governmental institutions to promote development programs and R&D projects is an essential part in obtaining the desired results.

Credit also has to be given to the assistance of UNIDO which may contribute considerable experience to realize the whole project.

A team of experts - including financial, technical and technological specialists - should be available to assist the government or the appointed advisory committee to evaluate R&D projects, development programs, studies, etc. for short term or long range planning for schemes already initiated.

Furthermore, the UNIDO team should conduct a techno-economical survey throughout the country concerned under the supervision of government or appointed officials and make recommendations together with key members of the advisory committee.

The team should analyse and qualify the existing capacities, technical standards and possible capabilities of national or domestic manufacturers with regard to the eventual production of the equipment. By the same token a financial report can be established to estimate costs, funds, needed investments, etc. for the implementation of new product lines within certain domestic industries.

Finally, the UNIDO group should perform as a continuous adviser after the survey has been finished to evaluate, analyse and summarise the results of the study.

After submitting the results of the analysis to the government or the advisory committee, the UNIDO team should assist now in establishing R&D projects and development programs. During this phase of industrial planning UNIDO should be referred to as a consultant and project adviser until the first manufacturing of a prototype of a specific product line. The UNIDO experts team may be considered as in a "staff position" to the government or advisory committee during the whole time of the duration of a certain project or different projects running parallel. In case of any difficulties or obstacles of the program the team should be consulted to assist in solving the problem, provided that it is in the interest of the government.

Additionally, UNIDO can furnish the government body with consultants to meet special requirements or, if needed, to advise on a specific R&D project.

The co-ordination of different R&D projects, the management of development programs, and the supervision of pilot tests may be delegated to the UNIDO experts group or to professional representatives appointed by UNIDO.

2. Rigs for Offshore Exploratory Drilling

Offshore mobile drilling units as we know them today are sophisticated pieces of machinery. However, this was not always the case. The original units were simply land rigs taken into shallow waters and placed on a structure for drilling. The same drilling techniques that had been developed on land were used on the first offshore rigs. These techniques worked for some time, but the need to drill in deeper waters created a new type of engineer - the offshore structural design engineer. And along with the new engineering concepts came the new breed of drilling rigs which we see today.

Following drilling trends, we find that there are four basic types of offshore mobile drilling units :

the submersible; the jack-up; the semi-submersible; and the drillship.

2.1. Comparative View of Mobile Rig Configurations

The environment in which each type of mobile drilling rig functions best is determined by its performance in various water depths and combinations of sea states and weather. Mobilization, positioning, station keeping, and support requirements are important considerations. Jack-ups and drillships often operate in the same water depths. Heavy submersibles do not compete with other types of rigs in shallow waters.

Jackups have largely replaced submersibles. A jackup rig: (1) provides a fixed drilling platform, (2) its initial cost is less than others, (3) it can work soft bottom areas of deltas if equipped with mats to support the legs, (4) it can be designed to withstand hurricane-type storms, (5) it is the best tool available for water depths of less than 300 feet.

It has several disadvantages: (1) it is difficult to tow, (2) legs must be laid down or removed for long moves, (3) jacking mechanisms have moving parts, (4) going on or off location is hazardous - jacking to raise or lower the platform deck, (5) accidents underway have produced poor safety record.

Drillships have a number of advantages. Among them are: (1) proven deep water capability, (2) the capacity to transport much larger loadings of drilling supplies, (3) faster travel times to remote loactions, (4) no need for tugs, as they are self-propelled, (5) lower costs to operating company - maintenance and insurance, day rates, (6) adaptable to dynamic positioning systems and turret mooring. The disadvantages of the drillship appear to be its limited capacity to operate in wind or wave conditions which produce excessive platform motion.

Drillships typically range in length from 200 to 450 feet. Several larger drillships are under construction. Their cargo carrying capacity and general mobility make them especially useful for drilling in remote areas where shore based supply cannot be easily maintained.

With modifications drillships expect to operate in water depths of 3000 feet. Engineering studies for the Mohole project and the core drilling successes of the Eureka, the Glomar Challenger, and a predecessor, Cuss 1, have proved the capability of drillships for operation in deep water. Limitations are found in the lack of suitable risers to support drilling mud circulation - wellhead to drilling floor.

Shipshapes include offshore drilling platforms that (1) are self-propelled and have the appearance of conventional seagoing ships, and (2) drilling barges, also seagoing, but not equipped with any system of propulsion.

The drilling barge should be distinguished from the platform-tender commonly used with the small fixed platform. One of its notable features is its control by a bargemaster rather than a captain. On drillships, a captain, his officers, and able-bodied seamen are in charge of all ship operations involving seamanship. On location the salaries, quarters, and food catering cost continue. Drilling barges avoid these costs.

A semisubmersible: (1) provides a relatively stable drilling platform, (2) it functions under more severe sea and weather conditions than the others, (3) its capabilities for water depth are excellent - rated for water depths of 2000 feet, (4) it has good safety record.

Semisubmersibles have: (1) limited capacity for cargo transportation, (2) require moresupport vessels - supply, anchor handling, tugs, (3) must use marine risers not needed by jackups.

Drilling barges have the advantages of (1) lower cost than other floaters, (2) smaller crew and quarters needs. Their disadvantages are: (1) low towing speeds, and (2) dependence on tugs and other work boats.

Semisubmersible drilling rigs came into use as it became clear that floating drilling platforms instead of bottom supported must be use in deeper waters. A few submersibles were converted to semisubmersibles. Newer semisubmersibles resemble their predecessors in appearance but improved streamlining and design changes in the buoyancy and flotation chambers have increased towing speeds from 3-4 knots to 9-10 knots. A few semisubmersibles are self-propelled. At its drilling location it is lowered to its working position by flooding ballast chambers with seawater. The vessel is positioned to achieve the best wave, current, and wind relationships and moored and anchored.

If the semisubmersible is self-propelled, it will have a shipmaster who will supervise its propulsion, towing, mooring, and anchoring. Most semisubmersibles have a nominal operating water depth of 600 feet. A few are capable of modification to drill in water depths up to 1000 feet. Under construction and testing are a number of semisubmersibles with nominal depth ratings of 2000 feet.

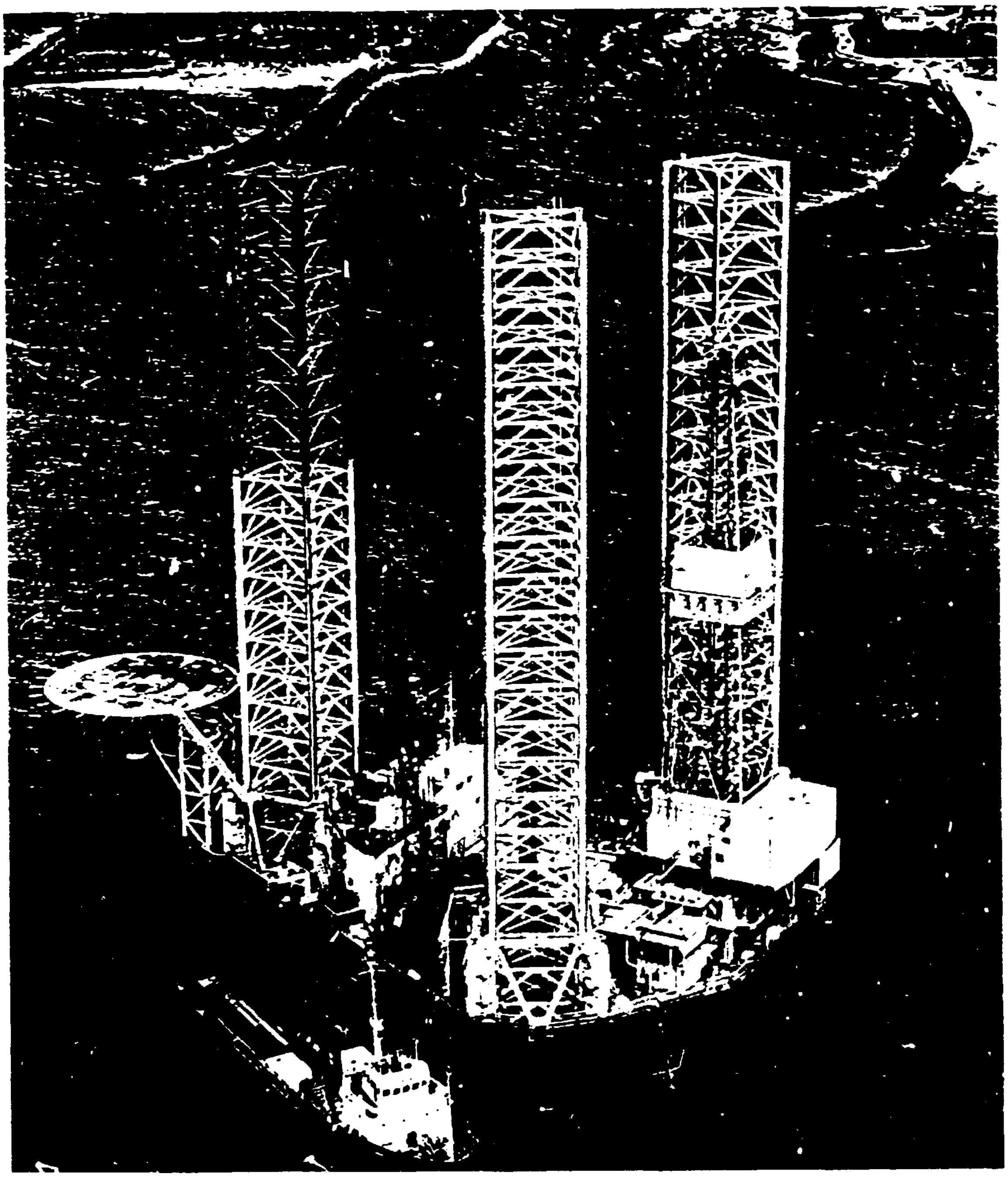


Figure 6.
The Jack-up Rig.

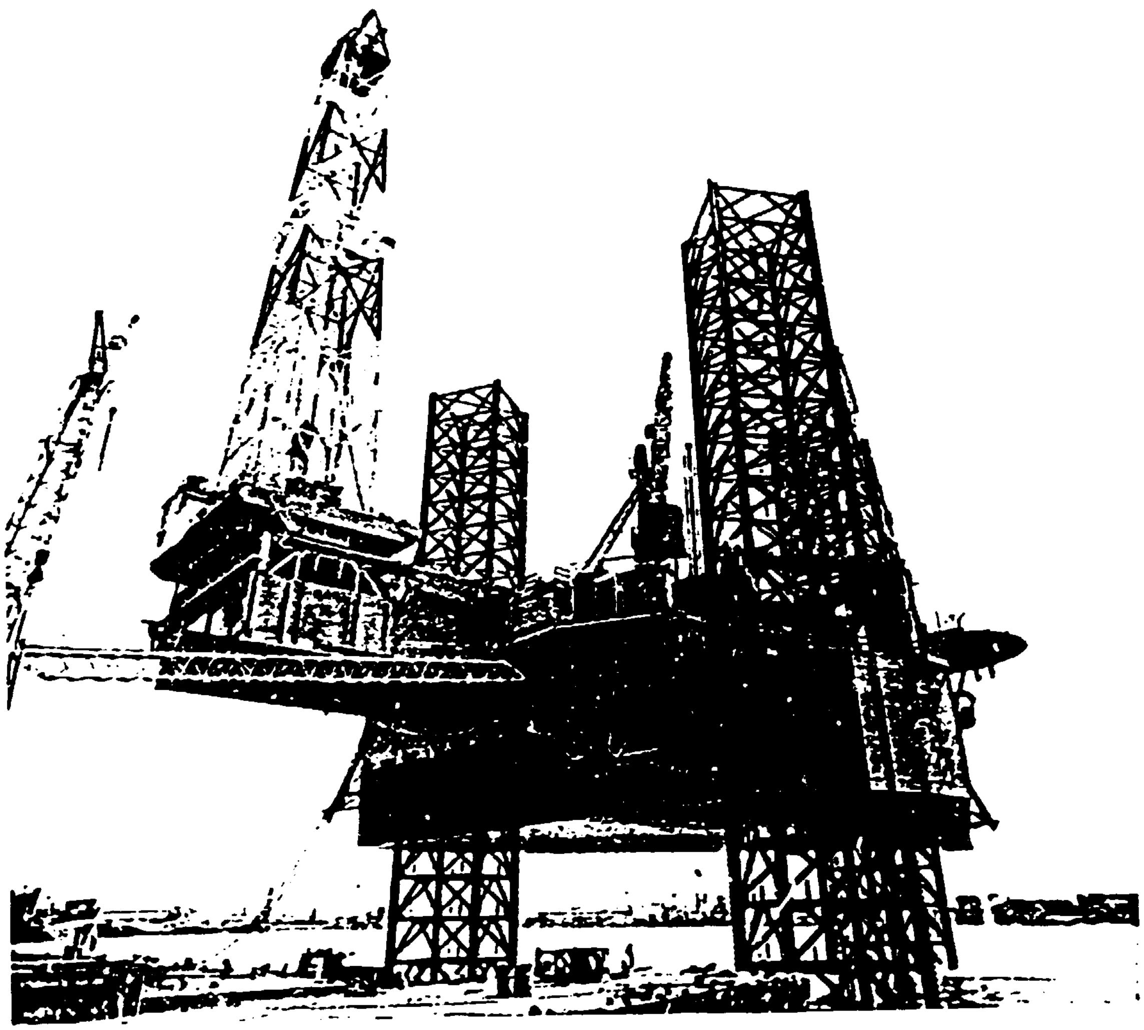
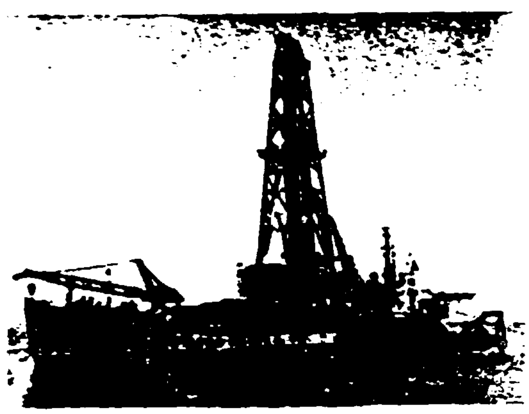


Figure 7.
The Jack-up Rig.



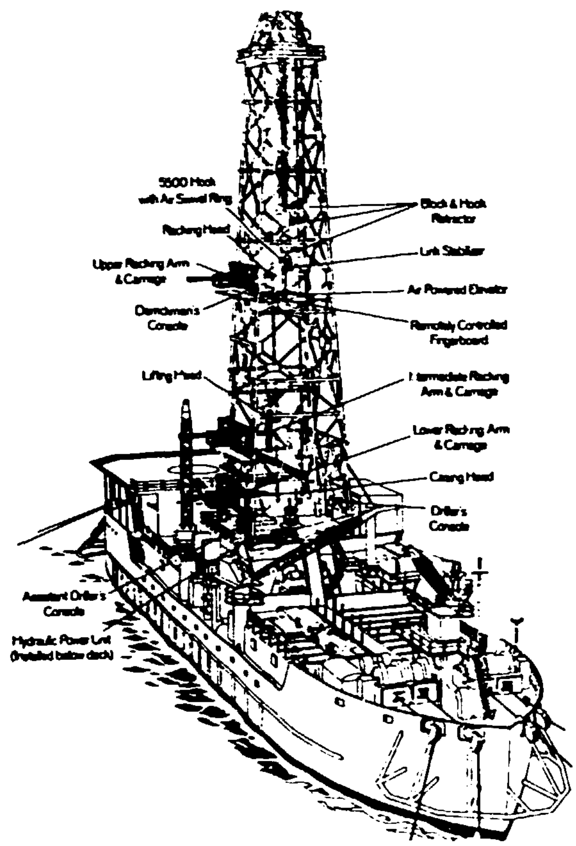
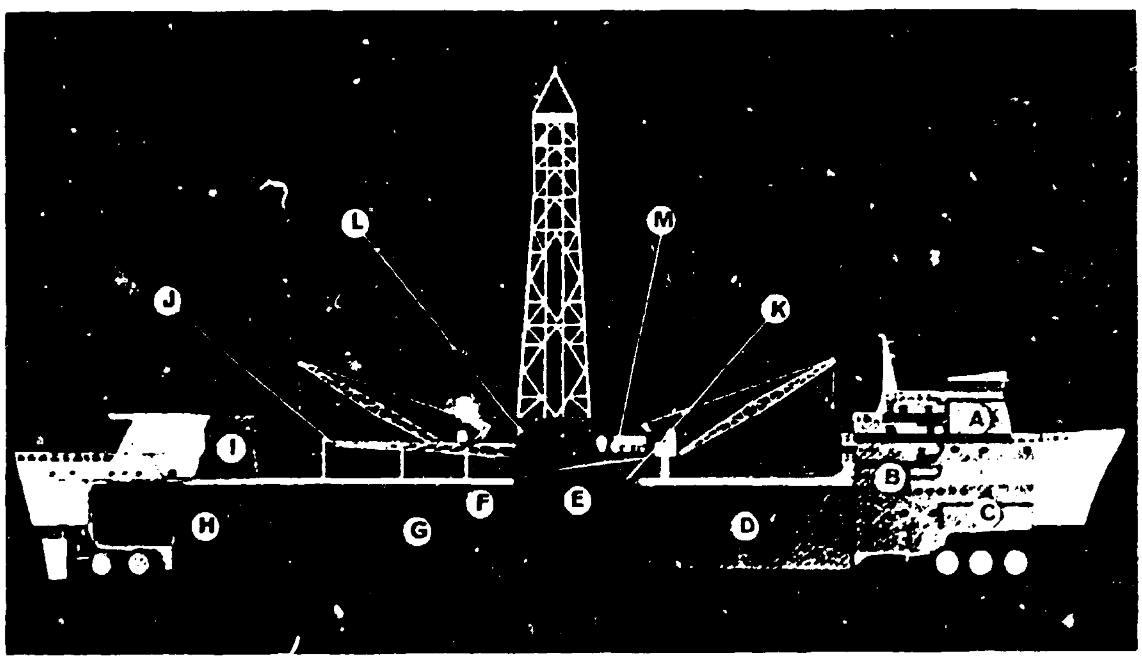


Figure 8.
The Drill Ship.



—Main parts of the drillship include stabilizing tanks (A,I); living quarters (B); positioning machinery (C,H); pipe storage (D); drilling equipment (E); diving gear (F); mud additive storage, active and reserve tanks and mixing-conditioning devices (G); power plant and utility equipment (H); automatic pipe handling system (J); BOP storage and workshop (K); driller's control cubicle (L); and logging unit (M).

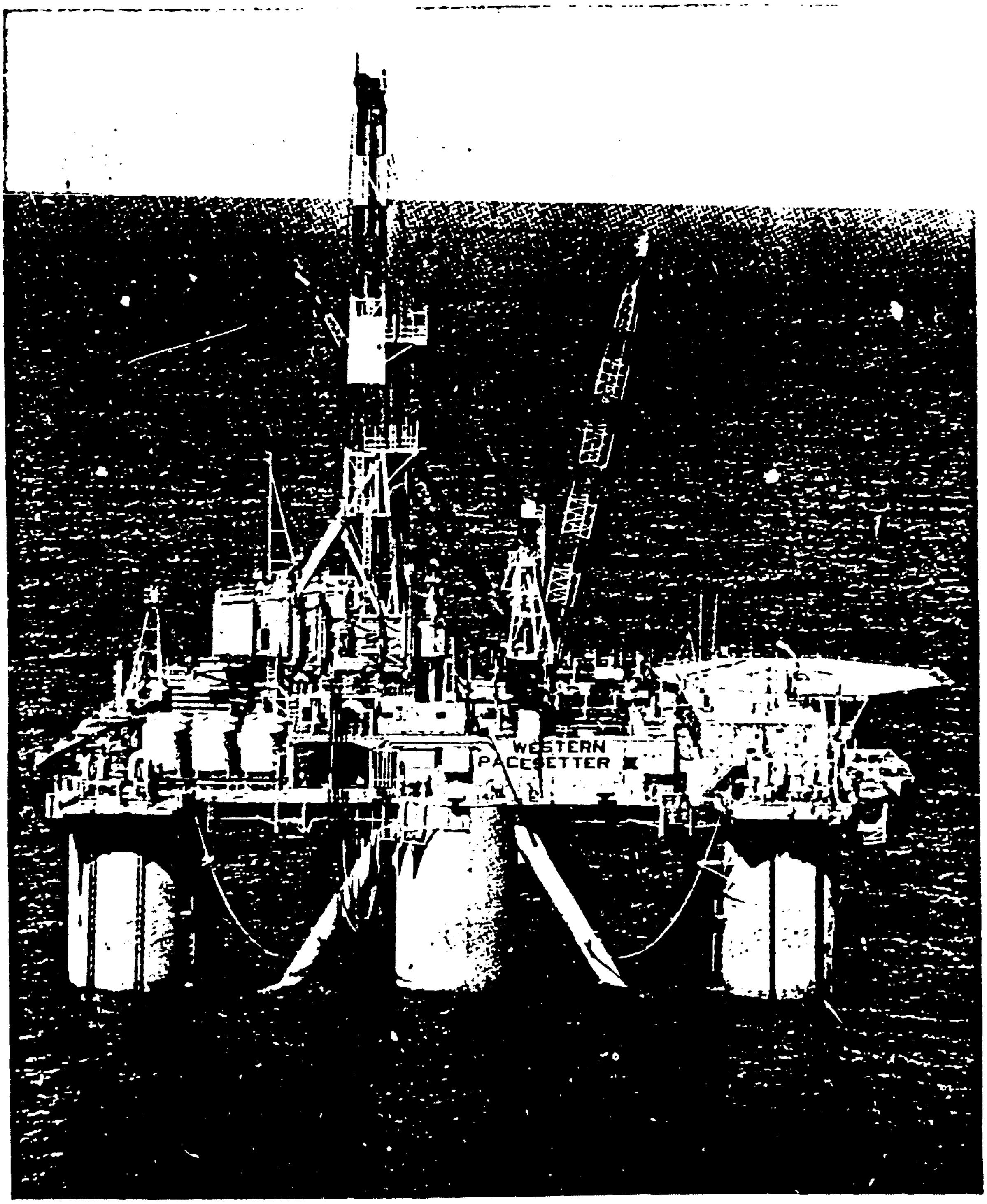


Figure 9.
The Semi-submersible.

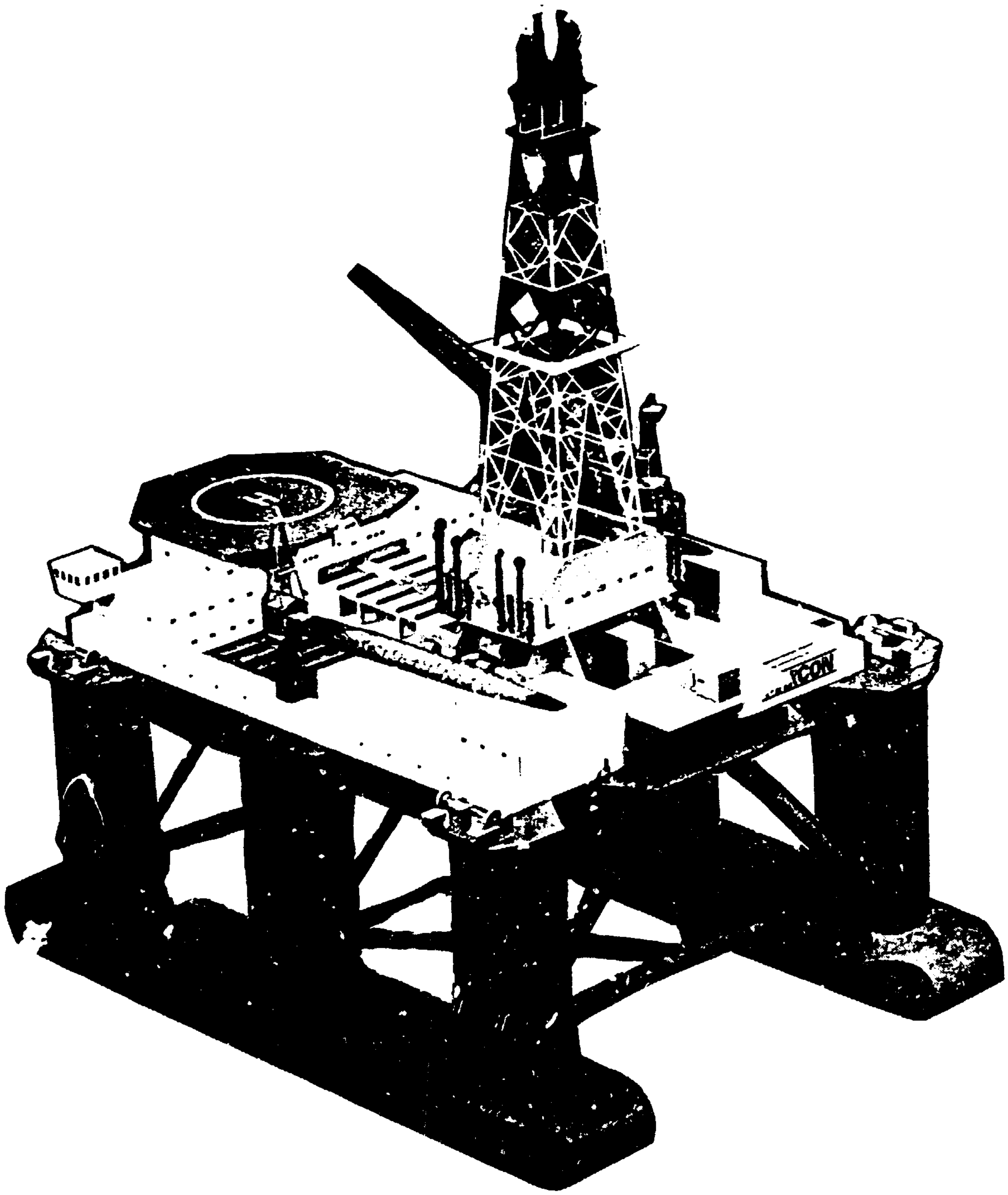


Figure 10.
Semi-submersible.

2.2. Technical Comments on the Different Structures

2.2.1. The Jack-up Unit

Jack-up designs can generally be classified into two basic categories :

independent leg jack-ups and mat supported jack-ups.

Each unit has its particular value.

The independent leg jack-up will operate anywhere currently available, but it is normally used in areas of firm soil, coral, or uneven sea bed. The independent leg unit depends on a platform (spud can) at the base of each leg for support. These spud cans are either circular, square, or polygonal, and are usually small. The largest spud can being used to date is about 56 ft. wide. Spud cans are subjected to bearing pressures of around 5,000 to 6,000 lbs. per sq.ft., although in the North Sea this can be as much as 10,000 psf. Allowable bearing pressures must be known before a jack-up can be put on location.

The mat supported jack-up is designed for areas of low soil shear value where bearing pressures must be kept low. The mat is connected to all of the legs. With such a large area in contact with the soil, bearing pressures of 500-600 psf usually exist.

An advantage of the mat type jack-up is that minimum penetration of the sea bed takes place, perhaps 5 or 6 ft. This compares with a penetration of perhaps 40 ft. on an independent leg jack-up. As a result, the mat type unit requires less leg than the independent jack-up for the same water depth. One disadvantage of the mat type unit is the need for a fairly level sea bed. A maximum sea bed slope of 1-1/2° is considered to be the limit. Another problem with the mat supported unit occurs in areas where there is coral or large rock formations. Since mats are designed for uniform bearing, the uneven bottom would probably cause a structural failure.

Jack-ups can be either self-propelled, propulsion assisted, or nonpropelled. The majority of jack-up rigs are nonpropelled. The self propelled unit, although very flexible, requires a specially trained crew of seamen as well as a drilling team.

Jack-ups have been built with as many as 14 legs and as few as 3 legs. As the water depth increases and the environmental criteria become more severe, we find that to use more than 4 legs is not only expensive but impractical. The prime forces on a jack-up are generated from the waves and currents, hence the less exposure to the waves and currents the fewer the forces being developed on the unit. From this standpoint the optimum jack-up is the monopod, or single leg unit.

Problems other than wave forces, however, must be overcome with the monopod type unit. But in areas such as the North Sea with very rough seas there is a need for the monopod jack-up. Thus, research is now being done in this area. A monopod production platform is already being built for use in the North Sea.

When evaluating which type of jack-up to use, it is necessary to consider the following :

- water depth and environmental criteria.
- type and density of the sea bed.
- drilling depth requirement.
- necessity to move during hurricane season.
- capability to operate with minimum support.
- how often it is necessary to move.
- time lost preparing to move.
- operational and towing limitations of the unit.

2.2.2. The Semi-submersible Unit

The semi-submersible evolved from the submersible and many of today's semisubmersibles are designed to operate either resting on the sea bed or totally afloat. The semi-submersible, or column stabilized, units differ radically in appearance from traditional vessels. The platform is supported by columns connected to large underwater displacement hulls, or is mounted on large vertical cassions, or is supported by some combination of the two. The basic purpose of the general design is to reduce wave forces by locating the major buoyancy members beneath the surface or beneath the wave action. In terms of drilling displacements these types of units are much larger than most ship or barge units and range from 8,000 to 17,600 long tons. There are about 140 semi-submersibles in service.

Today's semi-submersibles are designed for operation in water depths up to 3000 ft. and are therefore subjected to severe sea states and high winds. The general configuration of a semisubmersible consists of two longitudinal lower hulls which are used as ballast compartments to achieve the necessary drilling draft. These lower hulls are also the primary hulls while the rig is under tow. By virtue of its size and location, the semi-submersible offers low towage resistance while providing tremendous stability.

There are other designs of semi-submersibles such as the triangular design used on the Sedco series, four longitudinal hulls used on the Odeco series, and the French-designed Pentagone rig with 5 pontoons. The Pentagone unit is possibly the most successful of the multi-hull types, offering a unique symmetry and uniformity of stability characteristics. This unit does not offer the towing capabilities of twin hull units, but it does provide good drilling characteristics.

Semi-submersibles permit drilling to be carried out in very deep waters and they are held on location either by a conventional mooring system or by dynamic positioning. The conventional mooring system usually consists of 8 anchors placed in a spread pattern and connected to the hull by chain or wire rope, sometimes even a combination of both. The dynamic positioning method is an evolution of the ship sonar system whereby a signal is sent out from the floating vessel to transducers set out on the ocean floor. Dynamic positioning becomes a greater necessity as the water depth increases and is generally considered necessary in water depths beyond 1,000 ft. However, a semi-submersible has recently been contracted for 1,500 ft. water depths using the anchor and chain method. Much of the necessary chain will be carried on support vessels.

Because of the submerged mass of the semisubmersibles, rolling and pitching is of a low magnitude. The motion that causes problems for the semi-submersible is heave or the vertical motion. Because of forces on the drill string when the vessel is heaving, the semi-submersible with a low heave response is considered to be the most suitable. According to mathematical formula, the smaller the waterplane area, the lower the heave response. This is achieved in the semi-submersible by submerging the lower hulls and floating at the column or caisson level. With the loss of waterplane area to reduce heave response, a reduction in stability follows. Therefore, the designer must reach a compromise between acceptable heave response and adequate stability. There are, of course, other methods of reducing heave induced forces on drill string.

Many of the new breed of semisubmersibles are being designed to operate in specific areas of the world such as the North Sea where the criteria are very severe. These vessels require a very large consumables capacity, a low heave response, and good stability.

Another consideration in the design and operation of the semi-submersible is propulsion. There are several opinions on this matter, each based on valid reasoning. Propulsion is a large initial expense which can be recovered in a reasonable period of time if mobility is required.

In selecting a semisubmersible, it is therefore necessary to consider the following criteria :

- water depth.
- drilling depth requirement.
- environmental criteria.
- motion characteristics.
- consumables capacity.
- mobility.

2.2.3. The Drillship

The last type of mobile drilling unit to be discussed is the drillship. As the name implies, it is simply a shipshape vessel used for drilling purposes. Earlier drillships were converted vessels - either barges, ore carriers, tankers, or supply vessels. However, although conversions are still being done, there are several new drillships being designed purely for drilling, such as the Glomar Challenger or the Offshore Discoverer. Drillships are the most mobile of all drilling units, but they are the least productive. The very configuration that permits mobility results in very bad drilling capabilities.

Drillships are being used extensively in the U.S. Gulf Coast to bridge the gap between the jack-up and the semisubmersible. As discussed earlier, heave is the major problem when using a floating vessel. The drillship, because of its surface contact with the sea, develops very large heave response compared to the semisubmersible. It is possible, by means of stabilizing tanks and other methods, to reduce roll on drillships but heave cannot be reduced. A subsequent increase in 'rig downtime' or 'lost' time occurs. Because of this there is a bigger demand for the use of compensation devices.

Mooring for drillships is very similar to the methods previously discussed for semisubmersibles. However, there is one additional system that has been developed on a drillship - the 'Turret' system. This system has been used successfully on the Offshore Company's Discoverer II and III and will be installed in Offshore's Super Discoverer.

Briefly then, drillships are versatile tools but should only be considered for use in areas of small wave heights and low wind velocities.

Barge units differ from ship units only in that they are not self-propelled and must be towed from location to location. They too, are frequently converted traditional barges or ships but may be designed and constructed for this specific service. There are currently about 30 barge units in use, which vary in displacement from 900 to 10,600 long tons.

2.3. Vessel Design

Naval architects, marine engineers, and drilling people have all laboured long to improve vessel layout for better operating efficiency and safety. Actual arrangements are as varied as the number of vessels operating. However, certain basic component arrangements seem to have become common to most rigs. The centre drill well is located with the centre of gravity of the vessel to minimize the effect of rotational motion. The derrick or mast is located over the drill well with the pipe racks adjacent either fore or aft. The rig pumps, the generator, and all noise generating equipment are usually located in the same section of the vessel as the pipe racks. Crew quarters, galley, recreation areas and office space are then located in the opposite direction from the centre drill well in order to minimize disturbance caused by the operation of equipment.

Most vessels are equipped with two separate administrative centres, one considered the vessel or marine centre and the other the drilling control centre.

The drilling control centre provides offices for the drilling superintendent, tool pushers, and drilling engineers.

The helicopter landing deck is usually located on top of the quarters and administrative offices. This keeps the helicopters away from the pipe rack area where cranes and other material handling activities would present flying hazards.

2.4. Storage and Cargo Handling Equipment

As mentioned previously, semisubmersible units are more limited for storage capacity than most ship and barge units. Actually, some of the barge units can handle more than 8,000 long tons of materials and supplies. Even the smaller ship or barge units have more capacity than most of the larger semisubmersibles.

In the ship or barge units, storage is provided near the water line, often even below the water line. Hence, storage weight can easily be countered by ballast.

In the case of the semisubmersible, however, storage is necessarily at considerable height above the water line. While ballast can offset the added weight as far as buoyancy is concerned, it alone cannot be used to control stability. Most vessels are equipped with at least two deck cranes for onloading, offloading, and handling equipment and material on board. At least one of the cranes is usually in the 45-50 ton class and the other somewhat smaller. Both cranes are usually positioned to handle loads over the side and each is within the range of the other. One crane is always positioned near the derrick and can handle loads for the moonpool area. The other generally is located at the far end of the pipe rack area. Overhead cranes are also provided in the moonpool area for handling the blowout preventer stack and other subsea gear.

2.5. Vessel Support Facilities

Electrical systems (generators and distribution systems), fuel systems, water systems, ballast systems, and sanitation systems are common to all types of vessels. Water distillation units are provided on the vessels to supplement water storage capacity. Mooring winches and conventional mooring-control systems are used on most vessels, but few have either added to or replaced the conventional mooring equipment with dynamic positioning equipment.

3. Offshore Drilling / Production Platforms

Introduction

Exploration drilling is the final step in determining whether a petroleum reservoir holds enough oil or gas reserves to justify field development. A series of dry holes will likely result in cessation of all activity and termination of leases. Marginal quantities of reserves will delay development. If the reservoir potential jusitifies development, a program of development will be formulated. This program will include the designing and construction of all drilling/production platforms, storage facilities, loading systems, pipelines, compressors, and every installation used between the reservoir and the initial purchasers of crude oil or natural gas. A time lag of two to five years may exist between the completion of exploration drilling and delivery of the first barrel of crude oil.

It is common practice for several companies to share both exploration and development costs. Capital requirements generally exceed the amount of money that a single company is willing to invest.

3.1. Platform History

The first specifically designed steel structure was installed in the Gulf of Mexico in 1947 in a water depth of 20 feet. In almost three decades since this beginning the industry has installed over 3000 fixed platforms in water depths ranging to 400 feet. Platforms for use in the North Sea will be installed in 460-foot depths. A Santa Barbara Channel platform will stand in water depth of 850 feet.

Approximately 2000 of the 3000 drilling/production platforms of the world are located in the Gulf of Mexico. The improved techniques of fabrication and erection gained in the Gulf structures have influenced platform construction worldwide. Several American firms operate in the Singapore area designing, constructing, and erecting platforms. The industry safety record for fixed platforms has been excellent. A few incidents have been much publicised because of their spectacular nature, but the overall record is excellent. The magnitude of offshore operations in the Gulf has generally been unrecognised by the public because of their good record.

3.2. Water Depth

Shallow depths permit the use of smaller and less expensive structures. Early drilling was done from posted platforms in water depths of 20-30 feet. Small fixed platforms with minimum equipment were built as a part of the platform-tender rig combination, usually in water depths of 60 feet or less. The tender was an LST of WW II surplus or similar type and equipped for supply and auxiliary services. After a well was completed (sometimes four wells from a single platform), the tender was moved to the next location.

At water depths of 50-300 feet two factors favoured the use of more complex structures. First, less sheltered locations produced mooring and anchoring problems associated with damage to the platform caused by motions of the tender. And, secondly, the costs of separators, storage pipelines, and loading equipment required that a large number of wells be drilled from a central location.

The need for construction of platforms in water depths greater than 500 ft. will be closely related to production technology gains. Current drilling capability can be extended toward 3000 ft. water depths but the construction of deep water production platforms will be contingent upon capability of subsea production systems.

3.3. Environmental Factors

Fixed platforms must be designed to withstand environmental forces. In the Gulf of Mexico the forces of winds, waves, and currents control design considerations. The history of hurricanes over a one-hundred year period is one basis for design. Ice in the Cook Inlet dictates both design and structural materials used. Earthquakes in the Pacific affect the construction characteristics of fixed platforms from California to Alaska.

Soil and bottom conditions affect foundation structures. Generally soft bottoms are common in the Gulf of Mexico and these require deep pile penetration and cluster piles around each footing of the platform. Boulders on the floor of the North Sea have led to the development of gravity-type structures less dependent upon driven piles. Other areas of the world have other problems, and each area must be surveyed before the platform is designed.

One estimate of elapsed time between the decision to build and the completion of a standard platform follows :-

Design	8 months
Construction	1 year
Erection	3-4 months.

The effects on structural materials of continuous stresses produced by waves, winds and currents is of concern to both operating companies and governments. More complete studies are proposed.

3.4. Basic Steel Structures

The jacket platform is basically an evolution of the many posted platforms of early offshore drilling. Steel construction provides the required strength. Steel permits designs with good wave transparency. Template construction enables the drilling of multiple wells with rigs which can be skidded on deck. Sleeves welded to legs of the platform provide for attachment of skirt piles to form the foundation Steel platforms in the Gulf are four- or eight- pile structures. One North Sea platform is a 32-pile structure.

A caisson-type platform was needed in the Cook Inlet because of ice. A caisson is a water-tight compartment used in underwater construction. For the caisson-type platform one or more large cylindrical chambers formed the legs of the platform. Drilling operations were inside the legs, protected from destruction or abrasion from surface ice which forms in protected waters of arctic areas.

3.5. Platform Characteristics

Drilling slots will vary in number. These slots will be arranged in rows forming a rectangular pattern. Examples are : two rows of four slots, four rows of six slots, and up to 48 slots. Rigs are skidded from slot to slot until the drilling phase is completed. Facilities for services such as drilling fluids control, well logging, cementing, drill-stem testing, and completions will require deck space. Quarters and food services for personnel are provided.

When production is the principal platform activity, provisions will exist for workover equipment and well service, separators, compressors, and other production equipment. Even with multiple decks, space requirements are critical. Modules containing the essential units of a production operation are designed for compact arrangement and optimum utilization of space. Modular units are constructed with weight and dimensions that can be handled by derrick barges and cranes during erection.

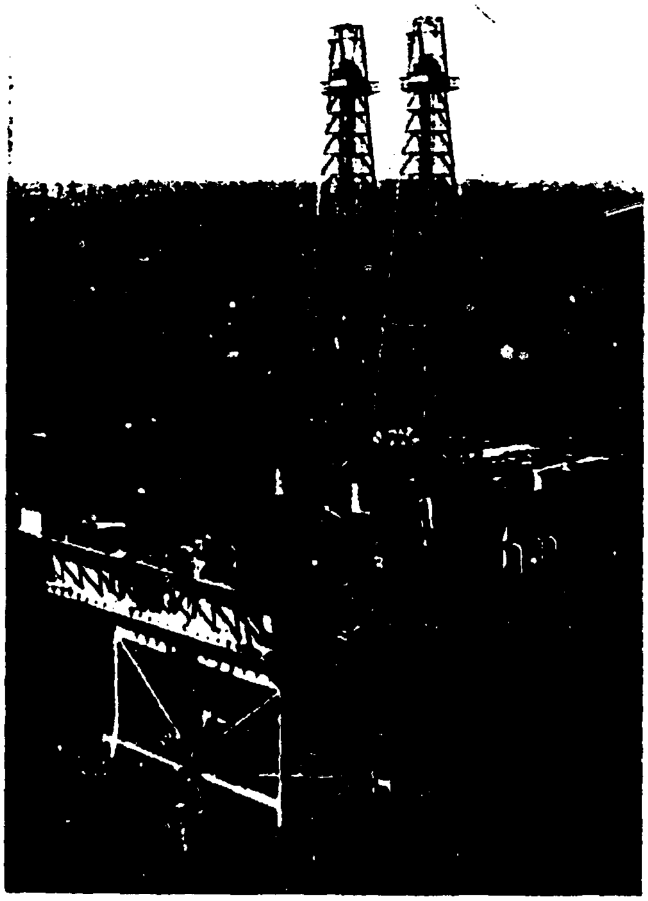


Figure 11. Offshore Drilling Platform.

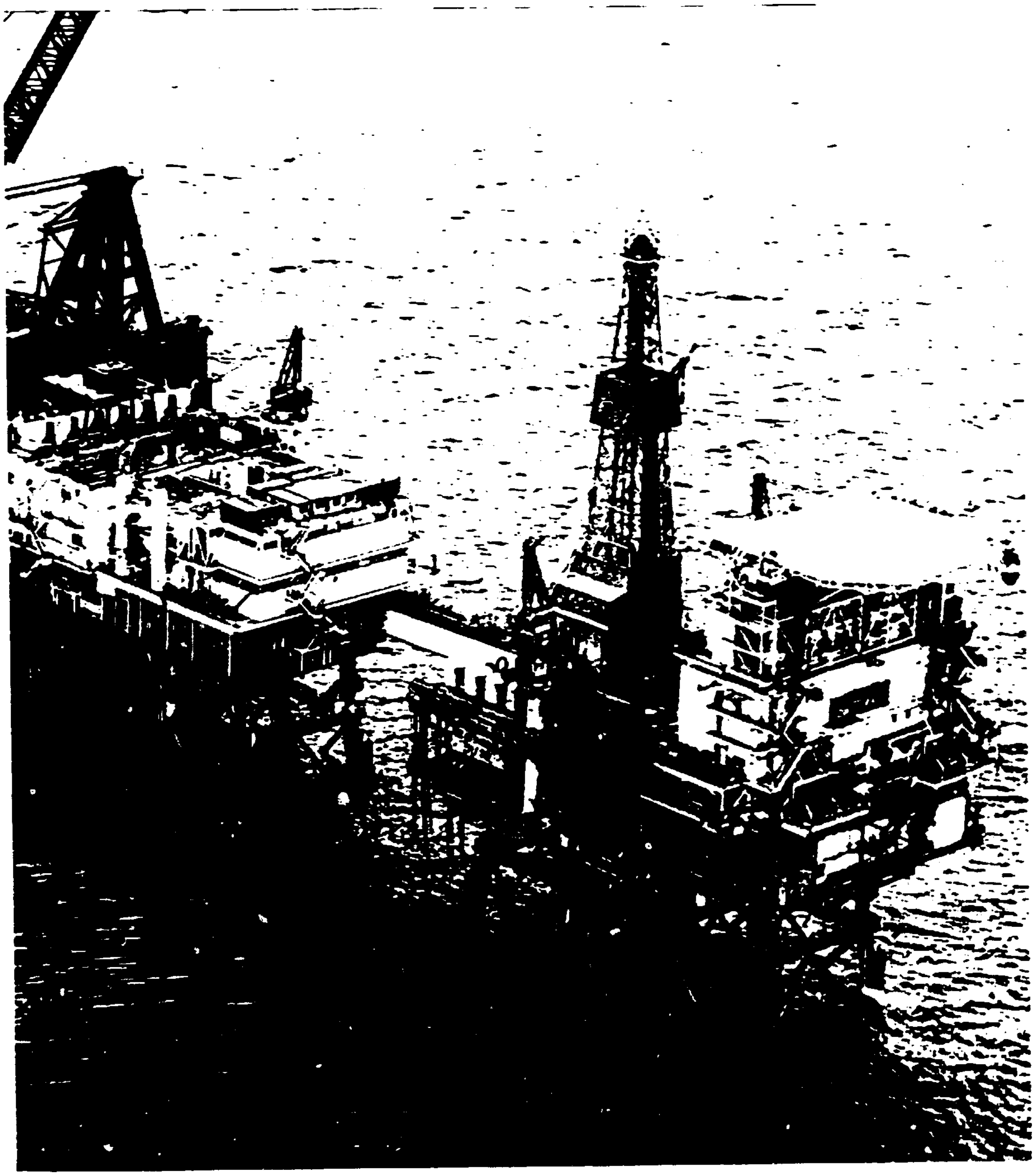


Figure 12.
Drilling and Production Platform in the North Sea
(Beatrice Field).

3.6. Construction Considerations

Platform jackets are usually constructed in shipyards or large fabrication plants adjacent to navigable waters. Early steel jackets were moved by barge positioned with the assistance of derrick barges. Some steel jackets currently use their own structural members for flotation and are towed to their location.

Derrick barges, tugs and supply workboats make up the auxiliary craft at the erection site.

3.7. Production Drilling from Fixed Platforms

Movable drilling rigs are mounted on a grid somewhat resembling a checker board. Slots are spaced laterally to allow for the installation of the Christmas trees when the wells are completed. Multiple drilling slots are used by skidding the rig from one drilling slot to the next. Of platforms currently under construction most are 12-slot; the second most common is the 24-slot platform.

Many platforms have derricks which can be used for two or more wells by skidding the crown block, the rotary, and drawworks. For severe weather locations drilling slots have access to the seafloor through the piles which support the platform.

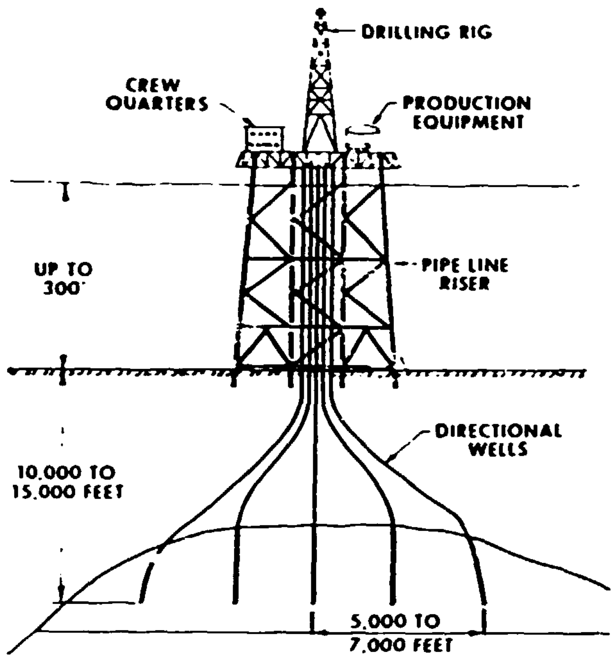
BOP stacks are located below the drilling floor as in deep well drilling offshore.

3.8. Workover

Offshore production has the same problems that are encountered ashore. Paraffin, sand, repair or replacement of subsurface equipment require the same corrective measures that are used on land.

Skid mounted well workover masts and tools are part of the permanent equipment of may multiwell platforms.

Special well workover equipment which can be handled with deck cranes is used on smaller platforms.



Directional drilling techniques.

Figure 13.

3.9. Concrete (Gravity) Structures

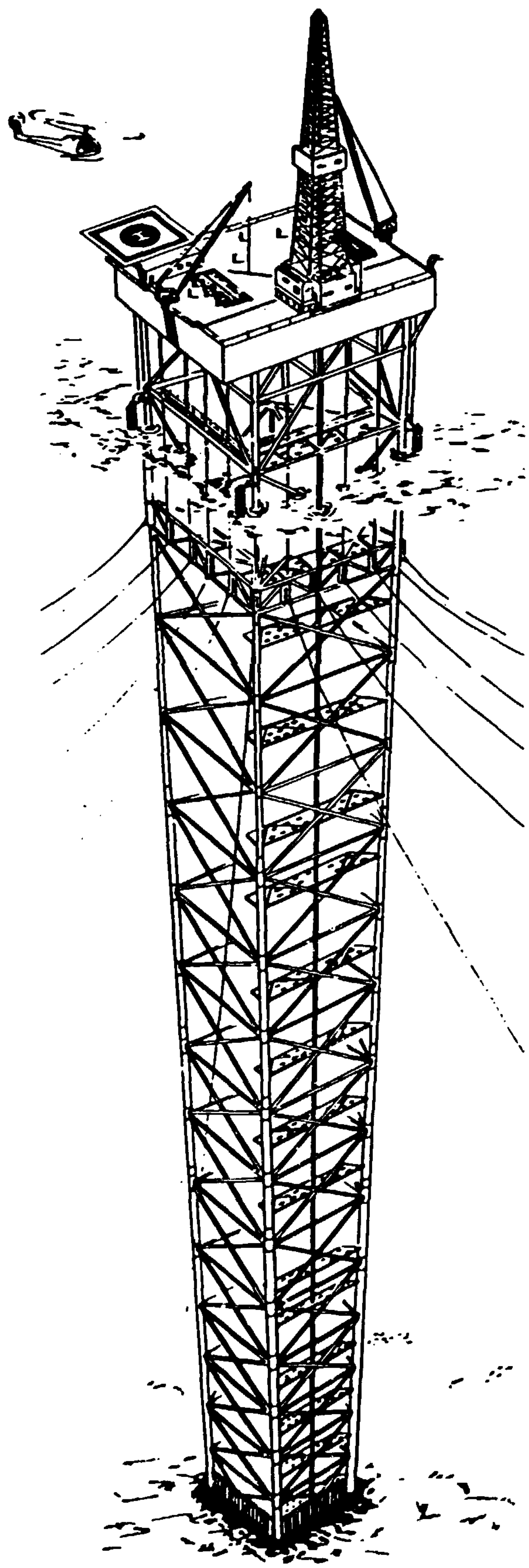
Concrete gravity structures have been built for use in the North Sea. Their enormous bulk affords protection from storms and sea states common to that area. The size of structure supported by the ocean floor is adaptable to bottom conditions. Spaces between the structure and the sea floor can be filled with a grout which provides a very good degree of resistance to erosion by currents. Rock is built up around the perimeter of the base to provide protection. The huge vertical concrete legs contain cells with storage capacity of from 800,000 to one million barrels of crude. The gross weight of the structure is over 300,000 tons, approximately ten times the weight of a steel structure.

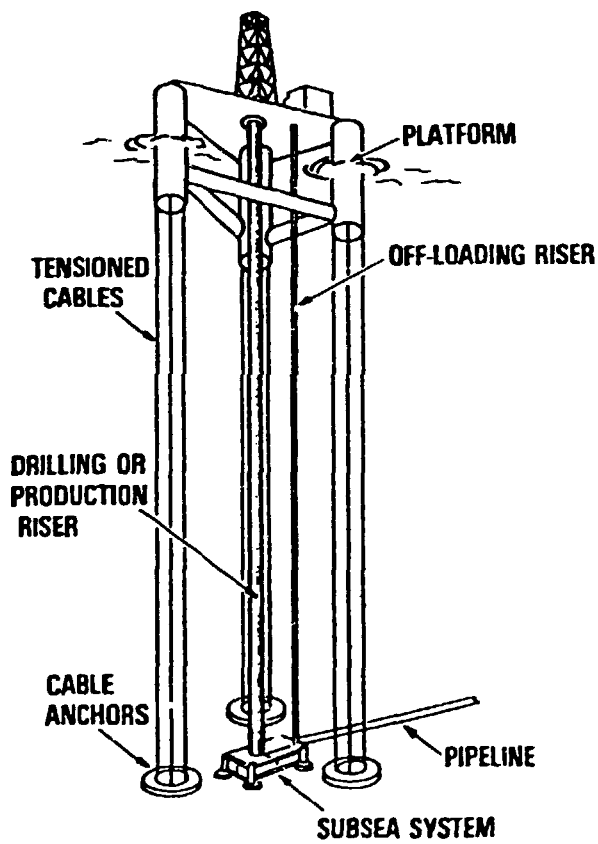
The concrete legs are built first, then the decks are completed with the drilling and production modules. The entire structure is towed to its site and put on bottom. During towing the structure is 40% submerged. A vertical dimension of 680 ft. from base to top of the drilling mast gives an idea of its size.

Cost figures range from $140 million to $200 million. Its water depth capabilities based upon present use is in water depths of 385-474 ft.

3.10 Proposed Platforms

Two experimental platforms are being tested; they are 1) a slim tower-type supported by guy wires, and 2) a tension-leg platform.





Proposed platforms

Above is a diagram of a tension leg platform.

On the left is a diagram of a completed 1500 foot guyed tower.

Figure 14.

4. Manufacturing of Offshore Rig Structures and Modules

4.1. General Comments

The report provides general comments on offshore structures only as a detailed description of the equipment involved would be beyond the scope of the initial objective and too voluminous within this stage of publication. The report aims to direct the attention of the reader to the offshore industry where many different industrial branches could establish themselves and gain the necessary improvement of technologies and expertise to take part in this extremely vital business.

Considering the dimensions and sizes of the recent offshore flotilla of semisubmersibles or jack-ups and the gigantic steel constructions of recent platforms being installed in the North Sea and other areas, one gets an idea of how much engineering, design and construction work is involved in such a single project. It is obvious that the recent steel constructions of offshore installations are based on the evolution of much smaller and less sophisticated structures of 10 or 15 years ago. Significant improvement of technologies and engineering design work made the rapid development of offshore structures possible. Remarkable contribution to that rapid progress was made by the modernisation of ship yards, application of sophisticated computer methods and expansion of existing facilities.

To build and assemble the huge steel structures usually three to five shipyards are employed to accomplish the total project. It is not unusual that 40 to 50 contractors are employed for the design, fabrication, assembly, pipe layouts, electric cable layouts, transportation and the launching of a platform. Considering a semisubmersible, different branches are working on the floating body and on the deck structure. The floater has to be built and assembled in different sections and the finished components will be transported to one location for the final assembly. Meanwhile contractors are busy completing the different modules of the deck structure. To move and to assemble the different modules requires some sophisticated and large capacity lifting equipment and transport facilities which the shipyards and assembly plants have available.

Some platforms of today consist of about 20-25 modules including the flare tower and heli-deck. The time for construction of a semisubmersible of modern design amounts to 2 or 2-1/2 years. Platform work, considering the new constructions installed in the North Sea, may total up to 3 to 3-1/2 years. Very large barges are used to float out the assembled structures or large modules.

Besides the building of semisubmersibles, jack-ups, drilling ships and drilling platforms, shipyards are busy assembling large structures of subsea installations, production systems, floating and submerged systems, templates, subsea storage installations, and mooring systems. All of these modules and systems have to be considered as offshore equipment and offshore installations when planning to penetrate this extremely lucrative market.

Maintenance and repair work of offshore installations represents another big portion of the offshore business with a tremendous potential. Contracts are generally let on a yearly basis - but specialist work such as scaffolding or generator maintenance is often let out on an ad hoc basis as the need arises. Oil majors operating a large number of rigs or platforms prefer large multi-discipline contractors who can offer a wide range of expertise covering all the main fields of maintenance work, such as painting, instrumentation, fabrication, process engineering and so on. The major maintenance and repair operators in return generally aim at farming out work to a range of small, specialist contractors each of which would concentrate on one particular area. For newcomers to the offshore scene, the post-construction phase might be very likely their first opportunity to break into the offshore market.

4.2. Principal Particulars about the Construction Work of a Semisubmersible

The primary design advantage of the semisubmersible has to be seen in placing the buoyancy chambers below the surface of the water. This minimises the response to the wave forces, hence stabilizing the motion of the working floor and drill string.

Drawings, records and all kinds of supporting documents about the respective design may be obtained under licence. That saves, from the beginning, taking care of principal design work which would normally be involved. If a new design or an alteration of an existing design is required the need of a combined design and drawing office appears which would employ approximately 50 people. The design work will be split up between steel work, outfitting, mechanical systems and electrical systems. This assumes of course that the design department does not have a mix of contracts going through, but that the entire group has to be devoted to the project.

The planning and progressing group should have a manpower of 12 to 15 people.

The actual labour force may include the following :

approximately -

200	coded welders
100-130	steel workers (like fitters or plating workers)
50-70	pipe fitting workers
50-70	electricians

Assuming the availability of the above mentioned labour force and a suitable shipyard for the construction, the semisubmersible could be built and completed in 2 to 2-1/2 years.

If the construction is assembled using a building dock, a lifting crane capacity of about 500 tons is required. The most important aspect of cranage is that a floor area is available which would correspond to a lift crane capacity of around 200 tons in pre-fabrication areas to allow the full benefit of block erection.

A maximum lifting height of 120-150 ft. is normally sufficient. The greater capacity in the pre-fabrication area the better for handling and lifting. A quayside over 100m with a minimum dredge depth of 10-15m. has to be available.

The weight of a semisubmersible, assuming average dimensions and size, amounts to 8-12.5 thousand tons. The heavy duty type goes up to 16000 tons.

The steel quality of the structure may be generally described as high tensile strength, low carbon, thru thickness quality steel. (SAE 2512, 2515, DIN 40MnCrN18). The welding procedures and equipment have to be capable of dealing with this high tensile strength steel and have to meet the standards and specifications of ASMI and ANSI.

The whole semisubmersible construction is split up in the manufacturing modules :

- Deck structure with full production process facilities.
- Internal (three, four, six) leg structure.
- Displacement hulls (buoyancy chambers)
- Bracing members.

4.3. Principal Particulars about the Construction Work of a Platform

The platform which has been used as an example is supported by a 12-leg steel jacket secured to the ocean floor by 12 main piles and 8 skirt piles - two at each of the four corners. The platform shows three main decks which are 180 by 120 ft. The design has been obtained by licence and was modified to customer needs by an independent engineering firm. The steel for the structure was detailed by the assembly contractor and then drawings and templates were sent to the steel mill. The steel mill rolled about 3.1 metric tons of steel for the jacket, 215 metric tons for the cap trusses and 3.2 metric tons for the piles. The steel plate was made at different steelworks. The plate was then sent to the mill to be rolled, the plant selection depended on the pipe diameter, wall thickness and whether it was seamless. The pipe for this particular platform varied from 4-1/2" diameter, 0.237" wall thickness to 55" diameter, 2" wall thickness. After rolling the pipe was sent to two plants for cutting and edge preparation. One plant took care of the columns and the other prepared braces, etc. The cutting was done according to the drawings and templates which were mentioned before.

Finally, the finished structural members came to the yard for assembly. This yard was originally designed for shipbuilding but is now used exclusively for fabricating offshore structures. The major phases of assembly are the column assembly, the conductor guide assembly, panel assembly, tilt up and final assembly.

Jacket assembly began with the column assembly, whi is the shop sub-assembly of the leg components into sections a'ɔut 115 ft. long, followed by welding in the yard of three of these sections end-to-end to make a full 343 ft. length leg. The next step was to assemble the panel in the horizontal position. Each panel consisted of three legs connected by horizontal and diagonal braces. A total of four panels were assembled, each measuring 343 ft. in length and having a width of 90 ft. at the top, 158 ft. at the bottom. Each panel weighed about 620 tons.

Each panel was tilted up (rotated 90 degrees) by two 400-ton Goliath cranes. Each crane spans about 580 ft. and has a vertical clearance of about 230 ft. These cranes are operated in tandem and are controlled by a single operator. Because of the large capacity of the cranes, this platform was the first of its size to be erected by tilting up one panel with only two cranes. The tilt up stresses were minimized by attaching slings to the centre leg and the outer leg of the panel. The most critical point in the lift occurred when thepanel was first raised. This was when the stresses in the jacket members were greatest. The tensions in the lifting lines were carefully monitored during this operation. The measured tensions were compared to cable tensions calculated to limit panel stresses to allowable values. The panels were successfully tilted up without overstressing.

The panels were then moved by the cranes from the assembly area to an area near the wharf where the jacket would be loaded onto the barge. The first two panels were set on skid beams, which were coated with paraffin and greased to reduce frictional resistance. After being set in place, the panels were vertically aligned.

After the first two panels were aligned, they were connected together by preassembled conductor guide framing and other horizontal and diagonal braces. At each of six horizontal elevations, guides were installed that would direct the wells from the deck into the ocean floor. These had to be positioned so the conductors would be aligned vertically when inserted through the guides. After the four panels were aligned and connected together, the platform was 145 ft. wide at the top and 213 ft. wide at the bottom.

Several modifications were required for both the barge and the jacket before it could be towed across the sea. Six-foot bilge keels were fastened to the bottom of the barge to reduce rolling. Additional stiffening for shear strength was needed for the jacket conductor guide framing.

The other parts of the structure - the cap trusses and piles - were assembled before. The steel mill produced 60 ft. pile lengths without a circumferential weld. A single length weighed about 20 tons. The mill describes their proprietary pipe forming process: "A 3000-ton press shapes the plate into a U. Then a 55000-ton machine changes the U to an O. After welding, the pipe is expanded to correct any deviations in roundness and straightness. Size measurements are accurately and rapidly taken by automatic size-measuring devices."

The following main sections can be distinguished :

- topside facilities.
- deck structure or structures (main deck, cellar deck).
- production jacket including mud mats and buoyancy tanks, used jacket legs.

The construction work of the main sections as outlined in the comments on the two examples of offshore structures has to be complemented by a great deal of fitting and finishing work.

The deck structure has to provide for the working areas, storage place, crane facilities, rig location, accommodation of the crew, offices, power plants, helideck, - just to mention the most important facilities. Considering all the mounting and fitting work which has to be accomplished to finish the above mentioned sections with pipes, wires, cables, installations, etc., this enables someone to visualize the enormous amount of working crews operating on one and the same offshore structure and the importance of co-ordination work which has to be planned, supervised and carried out.

The following table lists most of the products and services used by the offshore industry.

Table 1.

Accommodation Units	Acoustic Systems
Actuators	Air Compressors
Air Conditioning Systems	Air Handling Systems
Air Sampling Systems	Alarm Systems
Alternators	Anchors
Antennes	Anti-corrosion Products
Anti-corrosion Services	Anti-scour Services
Barges	Batteries
Beacons	Bearings
Blasting Equipment	Boilers
Bulk Storage Systems	Buoyancy Materials
Buoys	
Cable Laying	Cables - Mooring and Towing.
Cables - Power and Signal	Cables - Specials and Underwater Vehicles
Catering Equipment	Cathodic Protection
Chains	Civil Engineering Contractors
Coastal Engineering	Communications Systems
Compressed Air Dryers	Compressors
Connectors - Electrical	Connectors - Hydraulic
Connectors - Pneumatic	Consulting Services
Containerized Modular Systems	Control Equipment
Control Services	Coolers
Corrosion Inhibitors	Corrosion protection
Cranes	Crane Load Moment/Overload Indicators
Crane Services	Crane Vessels
Data Processing	Data Processors
Decompression Chambers	Depth Sensors and Recorders
Design and Evaluation of Structures	Desalters
Diesel Engines	Distillation Plant
Dredgers	Dredging Equipment
Dredging Services	
Electrical Distribution Systems	Electrical Equipment
Electronic Research	Emergency Equipment
Engineering Services	Epoxy Chocking-, Socketing-, & Repair Compounds
Erosion Protection Systems	Explosion Suppression Systems
Fasteners	Fenders
Filters and Strainers	Fire Detection Systems
Fire Fighting Equipment	Fire Resisting Glass
First Aid Equipment	Fittings
Flameproof Electrical Equipment	Flare Systems
Foundation Engineering	

Table 1. (continued)

Gas Storage Facilities	Gas Treatment Systems
Generators - Electric	Glass
Heat Exchangers	Heating Systems
Heavy Lift Transportation	Helicopter Services
Hoisting and Lifting Equipment	Hoses and Fittings
Hydraulic Systems	Hydraulic Pneumatic Tensioning Systems
Inspection Platforms	Inspection Services
Installation of Offshore Structures	Installation of Underwater Structures
Instrumentation	Instrumentation Valves and Fittings
Insulation - Electrical	
Jackets	Jacking Services
Jack-up Systems	
Level Measurement Equipment	Life Safety Equipment
Lighting	Living Quarters
Load Cells	Loading-arms
Load-outs	
Maintenance Services Offshore	Meteorological Data Services
Metering Equipment	Model Tests
Module Positioning	Mooring Systems
Motors - Electric	Motors - Hydraulic
Navigational Aids	Non-destructive Testing
Oil Storage Tanks	
Paints and Coatings	Penetrometers, Static Cone.
Pile Driving Equipment	Pipe Laying
Pipes	Pipes - Steel
Piping Systems	Platforms
Pneumatic Systems	Pollution Control Equipment
Pontoon Services	Position Fixing Systems
Powerpacks - Hydraulic	Propulsion Systems
Protective Clothing	Pumps - Centrifugal
Pumps - Other	
Radar	Remote Control Systems
Refrigerating Systems	Rigskids
Ropes - Natural Fibre	Rope - Synthetic Fibre
Rope - Wire	Rope - Fittings
Rubber Products	Rubber Lining/Coating
Safe Load Indicators for Cranes	Salvage
	Salvage Vessels
Scaffolding Equipment	Scrapertraps
Scrubbers	Seismic Survey
Semi-submersibles	Sewage Treatment Systems
Shackles	Shipbuilding Engineering
Shiprepair	Shiprepairs/Conversions
Skidding Devices	Skidding Technics
Sonar Equipment	Sonar Survey
Steel Constructions	Steel - Plates

Table 1. (continued)

Steelwire Ropes	Stonedumping Barges
Submersibles	Subsea Systems
Supply Boats	Supply Boat Services
Switch Gear	Systems Design
Testing Services	Tools - Hand
Tools - Power	Towage
Transmission Systems	Transportation
Tugs	Tug Services
Underwater Inspection Systems	Underwater Storage Systems
V-Belts	Valves
Ventilation Systems	Vibrators - Hydraulic
Walls, Windows and Doors	Warehousing
Welding Equipment	Welding Services
Welding Completion Services	Winches
Wire Rope Slings	Wire Rope Testers
Wireline Equipment	Wireline Services.

Quality and inspection control is established according to high standards and commissioning of semifinished components and sections on a rigid time frame integrated within the respective working processes or after certain stages of manufacturing. Much less to mention is the extremely severe control standards of welding seams which include checking the condition of welding equipment and welders' qualifications.

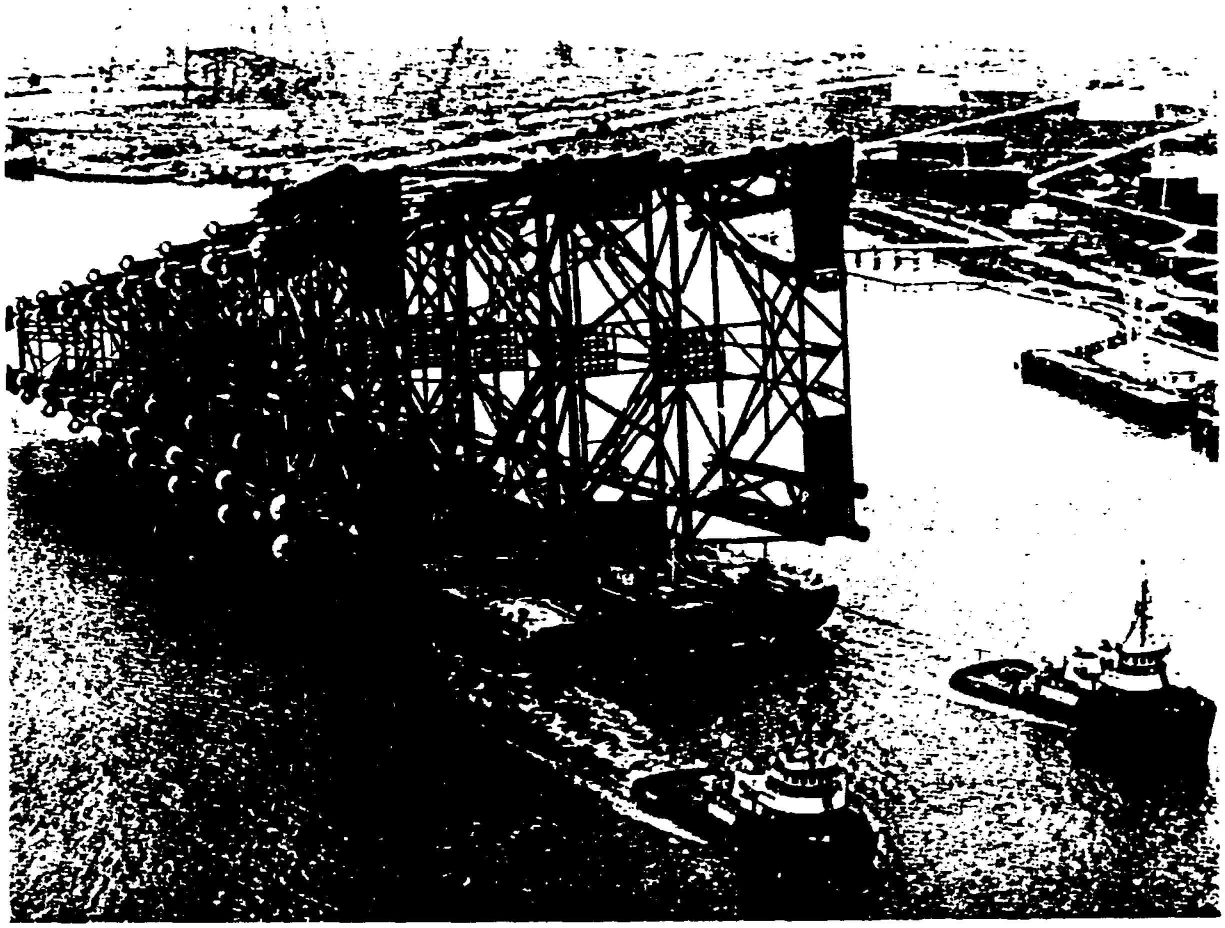


Figure 15.

The figure illustrates a jacket built recently for an offshore oil and gas platform. The height of the assembled platform is 750 ft. and the total weight of the assembled platform, including the one piece, three-level deck, exceeds 17,000 tons.

Large scale design, fabrication, assembly, transportation and final launching of the platform have to be considered when involved in such a construction;and engineering, project management, procurement and contract maintenance are some capabilities which have to be produced.

The oil and gas platform shows the equivalent of a 75-storey high building. The specifications called for an 8-pile drilling and production structure to rest in 651 ft. of water. The project was organised in two separate yards. Components of the platform were fabricated in sections and then transported for the final assembly at the second location. The massive jacket was 671 ft. in length. The jacket has been transported to the offshore site by barge and was assembled in only three months of offshore construction time. It took 2-1/2 years to build the total structure.

4.4. General Recommendations on the Project entering the Offshore Business

It is obvious that an offshore drilling or production structure appears at first sight as a very complex and diversified venture. A great deal of technical expertise and experience are the basic requirements for a successful accomplishment of the project. Focussing on offshore equipment, the basic requirements have to be considered :

- availability of port facilities like docks, piers, ship canal, etc.

- availability of shipyard facilities like large capacity lifting facilities, railway link, dry docks, large open yard space for assembly, large indoor facilities like warehouses, workshops for pre-fabrication, welding, cutting, etc, repair and conversion facilities.

- availability of qualified welders, fitters, crane operators, machinists, etc.

- large steel mill capacities.

- capacity of the domestic shipbuilding industry for large barges, tugs, hulls for drillships.

- check on standards of welding technologies and welding equipment (complete range of automatic welding machines including power sources such as transformers, rectifiers, generators etc., arc-air, torch and hyperbaric welding techniques).

- check on domestic engineering and design firms.

- check on standards of quality control and inspection of welding techniques and welding seams.

- availability of laboratory and test facilities.

The check list outlined above shows the most important factors which have to be considered when going into the offshore manufacturing business. There are still more basic requirements, but they are related virtually to specialized outfits and fitting work and should not be discussed any further. As already mentioned, there is quite a large variety of offshore structures on the market already such as drilling, production, storage, loading terminals and subsea systems, which differ very much in design and show different operational features. Due to this variety several detailed studies or reports are necessary to explain the different modules sufficiently and exactly.

4.5. Recommended Actions to Start Manufacturing Offshore Rig Structure Components

4.5.1.

Assuming a domestic light metal working and repair facility exists, the first approach to start manufacturing offshore equipment should be directed to a profile plate cutting shop handling steel plate approximately 12.5m by 2.5m and up to 350mm thick. The capacity of the shop should enlarge gradually to all kinds of cutting and edge preparation work for columns and braces of pipe as well. The shop will be supplied by the steel mill or another outside source (import). The shop needs to be equipped with up to date flame cut plate devices and the necessary auxiliary outfit to supply pre-fabricated steel items to the respective offshore customer. This workshop may develop after two to three years of operation to a capable repair and maintenance facility with additional machinery, such as a large horizontal borer, two to three lathes, one or two milling machines, two drill presses, etc. to accept more work for offshore components. Cranage should be available up to 25 metric tons for larger size of equipment to be handled.

4.5.2.

Another alternative to launch the fabrication of offshore equipment components might be the set up of a welding and simple assembly facility close to the dockyard. Any kind of existing workshop on the waterfront can easily be modified to fit the purpose. A drilling template may be the first offshore component to start with. The following figure shows a 24-slot drilling template and guide-piles ready for installation.

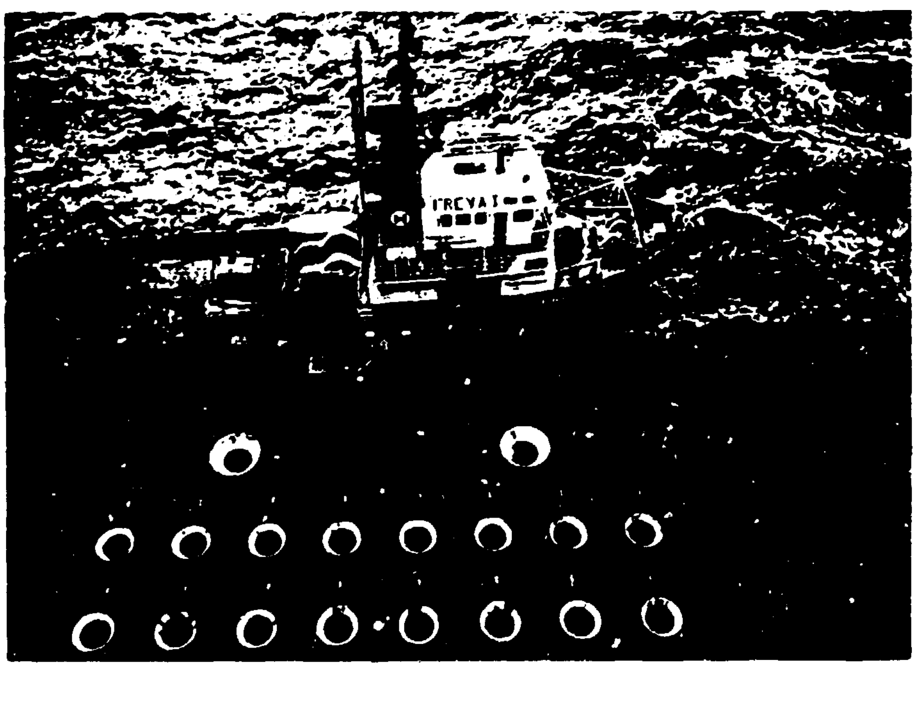


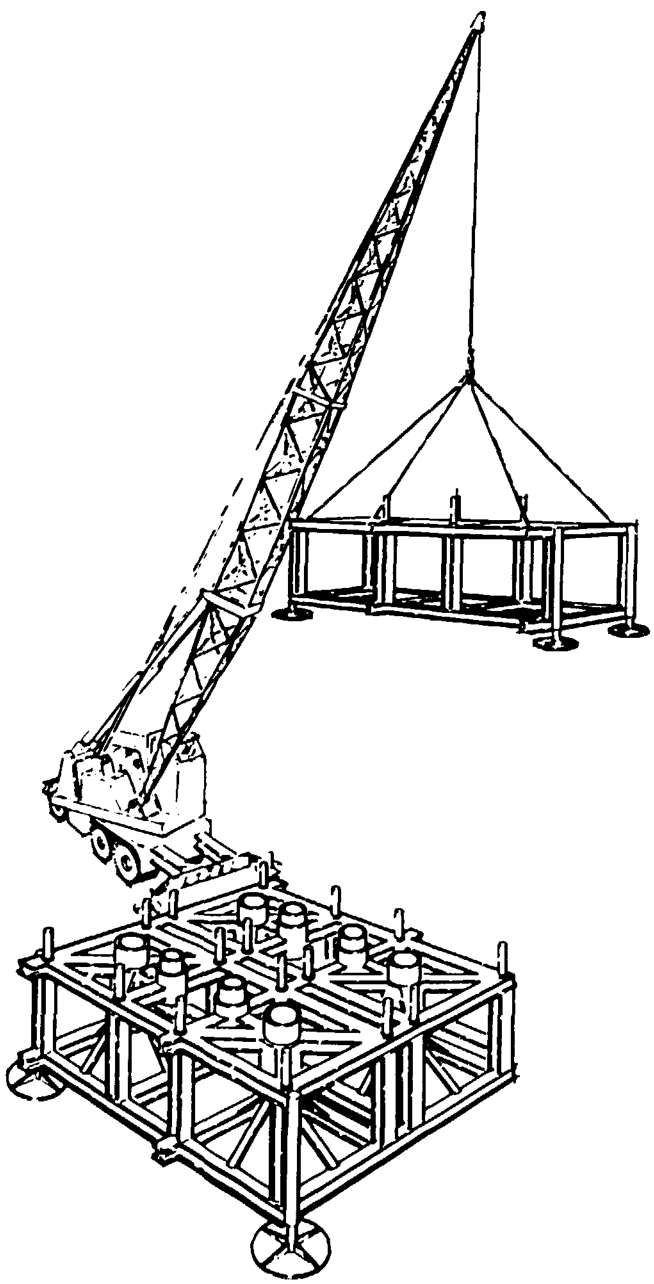
Figure 16.

Assembling and testing of template modules

The template structure will be transported from the point of manufacture to the assembly yard. The use of different modules adds flexibility to the design. As an example, the number of wells to be drilled can be varied by changing the number of modules. In addition, the valves and manifolding on the riser base module can be pre-assembled and added to the template with a minimum of on-site fabrication.

Other variations may be added, such as a module which provides for the attachment of flowlines from satellite wells or pipe lines to a single buoy mooring system.

The modules are beam or tubular constructed. The assembly of the modules is accomplished by pinning and welding them together to form a rigid template framework.



Testing of the interconnecting pipe between modules and the riser manifold base is performed prior to moving the assembled template structure to its field location.

All wells are drilled from a common rig location using standard techniques. Satellite wells can be tied into the template if field economics require satellites.

After the assembly of the modules the template will be installed on the ocean floor.

The sketch shows the first step of assembling and testing a group of two-well modules to form a complete template system.

Figure 17.

The shop needs an overhead crane, load capacity 10-15 metric tons, two or three automatic welding machines, flame cutting equipment, and common workshop hand tools to begin with. About 10 to 20 skilled welders and fitters may be required to operate the facility. Fabricating templates requires conventional but accurate welding techniques and simple assembly work. Other components on which to focus for manufacture by this kind of shop may be mud mats for drilling or production platforms and buoyancy tanks for jacket legs. These two components require probably a larger lifting capacity already and more advanced assembly techniques. The shop may also be capable, after a certain time of operation, to send out welding crews and fitter crews to offshore installations in order to assume all kinds of piping layouts or piping repairs on the location.

In the process of successfully executing such smaller projects, the shop accumulates know how and technology leading to licence agreements with the world's number one offshore manufacturing firms.

4.5.3.

Assuming any kind of domestic companies who look back on a long tradition of marine engineering and construction can adopt offshore equipment and systems to their product lines immediately. Companies specialized in the design and construction of vessels, dredges, passenger ships, etc. can start immediately with the repair and overhauling of drilling ships. This requires of course all necessary port facilities at hand. The company may extend the repair and overhaul work immediately, of course, to include derrick and pipe lay barges, support vessels, floating storages, anchor-handling tugs, pipe supply vessels and in the long run semi-submersibles, all depending on the capacity of the respective facilities.

4.5.4.

Taking a short look at the main fields of technology involved in offshore systems, we might end up with the following :

- steel construction
- piping
- machinery
- hydraulics
- electro-technics
- electronics
- naval architecture
- ship building.

The first two items mentioned seem to be the most likely technical systems on which to concentrate. All product groups included in those systems should be considered as the first components to be manufactured by the domestic industry.

A survey has to be carried out to distinguish suitable locations of possible repair and maintenance facilities and manufacturing centres. The results of the study should lead to deciding on priority development programs :

- module construction (fit-out and hook-up).
- heavy offshore fabrication and repair and maintenance.
- ship repair.
- offshore hook-up.
- subsea systems.

4.5.5.

Another approach to establish within the offshore industry may be the qualification for service contracts. This requires skilful, well-trained crews of welders, fitters, coaters, mechanics and divers who carry out service work on the platform or floater using and handling customers' equipment. This first step may develop into a back-up facility onshore which stores spare parts and consumables for the service crews. Further development may lead to spare part manufacturing and to repair facilities with their own yard and machinery.

4.5.6.

The setting up of a shot blasting and coating workshop may be initiated by itself or together with an assembly plant of module construction. The shop should also provide service crews to meet the customer requirements offshore on location.

To sum up the given suggestions, the following statements can be derived :

- A decision is made as to what offshore structures and systems should be concentrated on first.
- A survey has to be accomplished about the present facilities and infrastructure with regard to offshore work.
- Suitable facilities will be selected for :
  - small repair - maintenance - and overhaul work
  - initial production and fabrication of selected offshore components
  - prefabrication of steel elements and components
  - assembly shops for module construction.
- Service contracts, licences for manufacturing of components will be obtained by the Government.

- Promotion of engineering firms and R&D facilities.
- Training programs for professionals and engineers will be established.
- Technical assistance and economical studies will be obtained through UNIDO.

The suggestions and alternatives presented in this study are based on assumptions and estimations of respective available capacities and technologies.

Further detailed investigations have to be conducted to judge on the efficiency and capability of the national industry. Based on the results of such surveys, another study should be initiated and promoted to describe in more detail offshore systems and installations and to recommend more specifically the components which should be considered for immediate manufacturing.

As can be concluded out of the presented comments, the variety of offshore systems and constructions requires careful planning and co-ordinating of development programs, training programs and activities to progress continuously in the various technological fields.

The presented suggestions cover basic alternatives and proposals only as the overall objective of the report has been assigned initially to drilling rigs and rig components themselves.

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