The Technology of Offshore Drilling, Completion and Production

Compiled by

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Foreword

The collection of articles contained herein represents a unique effort by the international training company, ETA Offshore Seminars, Inc., to provide a comprehensive and up-to-date learning tool for the offshore petroleum industry. At a time when a severe shortage of trained rig personnel exists, the need for quick and efficient teaching devices is critical.

The multifaceted direction of this book is designed to accommodate not only the newcomers to the industry but also the veteran personnel. The articles cover both introductory aspects of offshore drilling, completion, and production and further delve into the technical details normally not found in beginner texts. The authors, who represent vital segments of the offshore industry, are leading experts in their fields.

The staff of ETA Offshore Seminars, Inc. gratefully acknowledges the dedication and hard work contributed by each of the authors in the preparation of the articles. The publication of a text of this nature is a tribute both to the contributors and to the industry for which it is written. The compilation of such a vast amount of knowledge and expertise under one cover is a tremendous accomplishment.

I would also like to acknowledge the efforts and long hours spent in the preparation of this volume by Ralph G. McTaggart, Bonnie S. Somyak and Susan Huey also the staff of ETA Offshore Seminars, Inc.

R. Stewart Hall
Chairman of the Board,
ETA Offshore Seminars, Inc.
Houston, Texas
1975

Introduction

The offshore drilling industry is involved in an unprecedented construction and drilling boom. Hundreds of millions of dollars are being spent to capture the much-needed energy supplies. The technology for drilling and producing in deeper waters and in more hostile environments is rapidly expanding. These factors have created an acute shortage of trained and qualified personnel to man the rigs now under construction.

Recognizing this need, ETA Offshore Seminars, Inc. (ETAOS) is attempting to alleviate the problem by presenting seminars aimed at training new men and updating experienced personnel on the theory, selection, and operation of offshore drilling, subsea completion, and production equipment.

The articles presented in this text are derivatives of the presentations made at the ETAOS international training seminars. The faculty of top experts from leading offshore disciplines that has presented numerous ETAOS seminars worldwide has authored the articles for this book.

The contents of the articles range from the very basic descriptions of equipment to comprehensive details of the latest technology in the industry. Illustrative drawings and photographs further supplement the text and allow for easier and more detailed comprehension. The tremendous amount of knowledge contained herein is equivalent to experience gained only through months or years of exposure in the offshore industry.

Contents

PART I

Offshore Technology

1

Offshore Mobile Drilling Units

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ETA Engineers, Inc.

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 semisubmersible, and the drillship. A typical evolution process is shown in Figure 1-1.

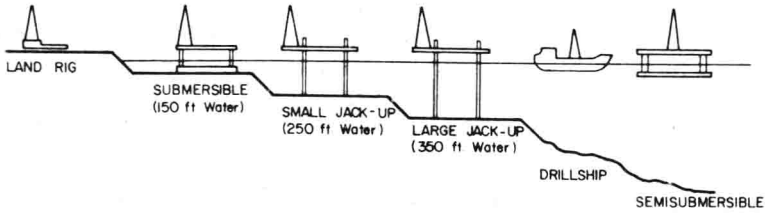

Fig. 1–1 *Typical evolution process for offshore mobile drilling units.*

To date, fixed structures have been installed in water depths up to 350 feet, but in this presentation we shall just discuss the movable structures.

Submersible Drilling Rigs

Figure 1-2 illustrates the evolution of the submersible drilling unit, sometimes called the swamp barge or posted barge. This type of unit is used in shallow waters such as rivers and bays, usually in waters up to 50 feet deep. One submersible, however, has been used in 175 foot water depths. The submersible has two hulls. The upper hull, sometimes referred to as the "Texas" deck, is used to house the crew quarters and equipment, and the drilling is performed through a slot on the stern with a cantilevered structure. The lower hull is the ballast area and is also the foundation used while drilling.

The submersible is floated to location like a conventional barge and is then ballasted to rest on the river bottom. The lower hulls are designed to withstand the weight of the total unit and the drilling load.

Stability while ballasting these units is a critical factor. In fact, the techniques developed were the foundation of semisubmersible ballasting schedules. As a point of interest, the first semisubmersibles were converted submersibles. Today, however, submersibles are fading from the scene simply because current water depth requirements have surpassed their capabilities. For example, in 1974 there were only about 25 submersibles in operation.

Jack-up Units

The first "jack-up" rig was the DeLong Rig No. 1, which was built in 1950 but was permanently installed as a platform in 1953. Figure 1-3 shows the evolution of the jack-up. The first "Mobile Jack-up" was the DeLong-McDermott No. 1, later to be known as The Offshore Company Rig No. 51.

This unit was followed by Glasscock Drilling Company's Mr. Gus (Figure 1-4) and by The Offshore Company Rig No. 52 (Figure 1-5). Each of these jack-up rigs had multiple piles or legs.

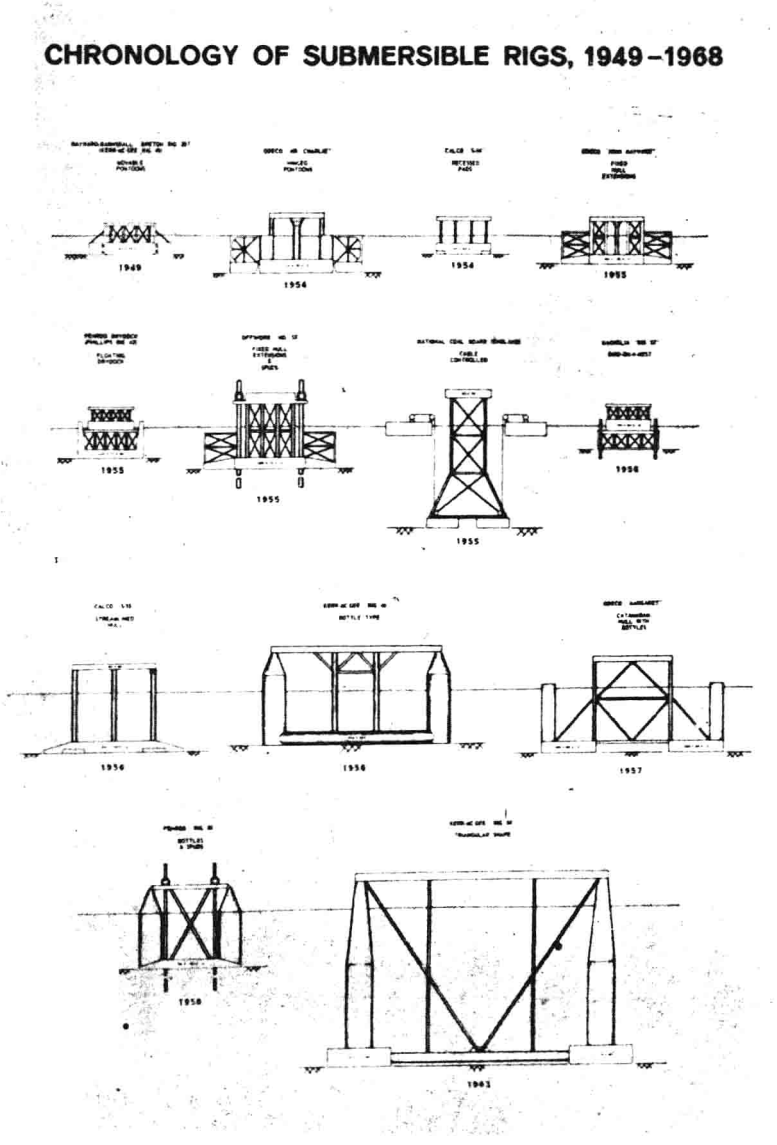

Fig. 1–2 *Submersible evolution.*

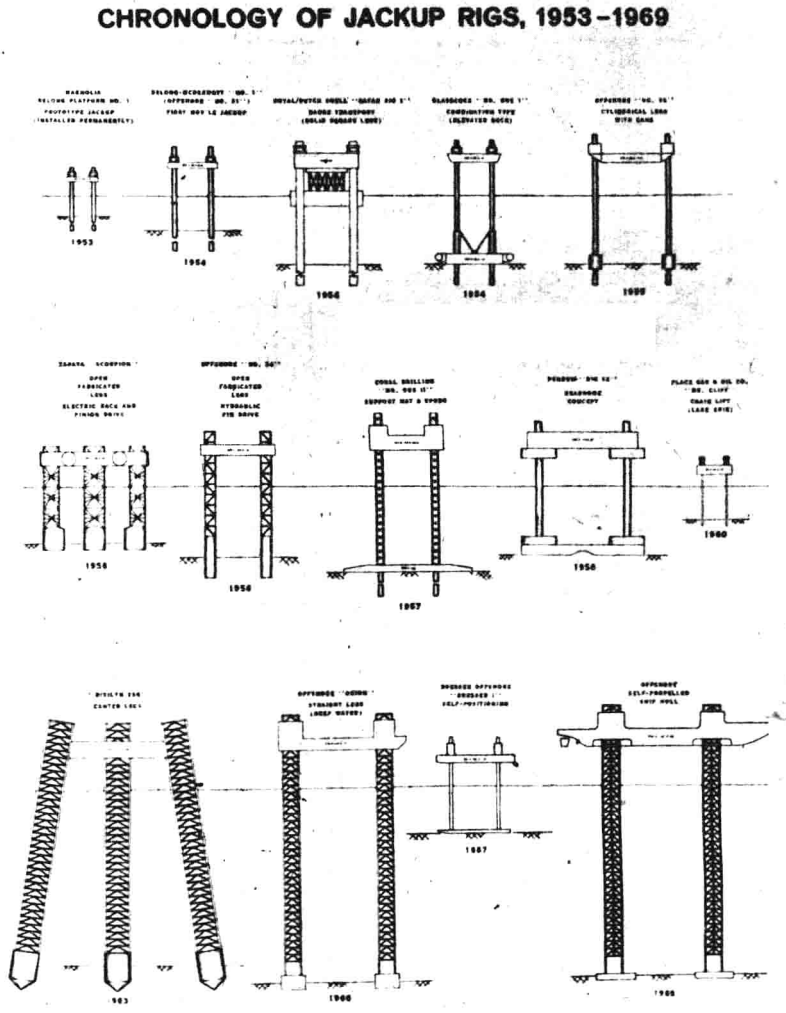

Fig. 1–3 *Jack-up evolution.*

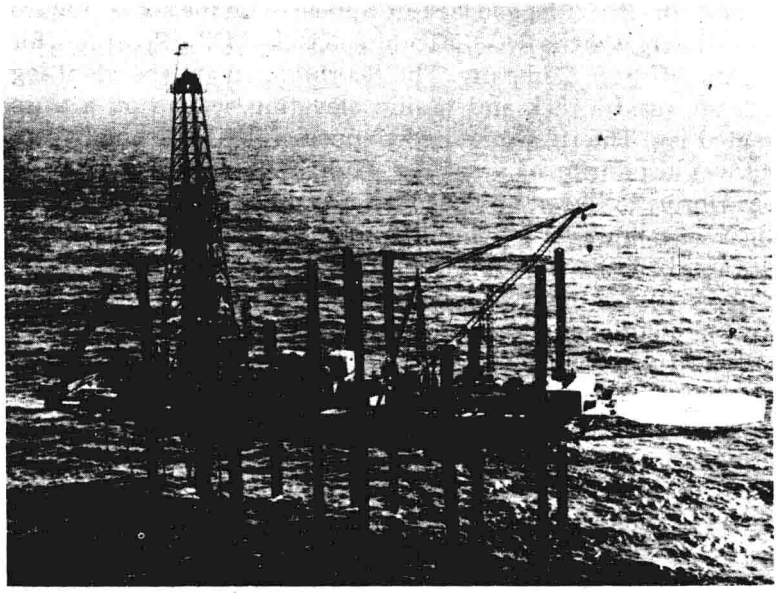

Fig. 1–4 *Glasscock's Mr. Gus I.*

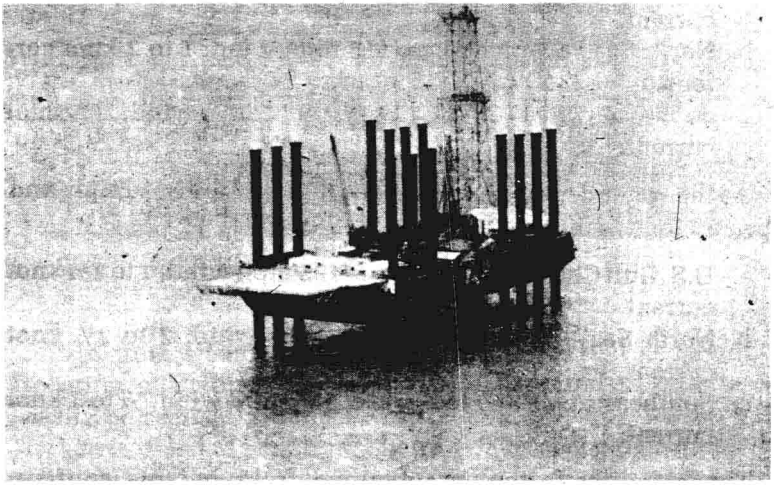

Fig. 1–5 *Offshore's rig 52.*

In 1955, the first 3-legged jack-up appeared on the scene (Figure 1-6). The rig was the R. G. LeTourneau jack-up, the Scorpion, for Zapata Offshore Company. The Scorpion, an independent leg jack-up, used a rack and pinion elevating system on a truss framed leg. The rig worked very successfully for several years but was lost during a move in the Gulf of Mexico. The Scorpion was closely followed by The Offshore Company Rig No. 54. For Rig No. 54, however, a hydraulic jacking system on a trussed leg was used. These jack-ups were followed by Mr. Gus II, a mat supported unit using a hydraulic jacking system, which was built by Bethlehem Steel Corporation.

The early breed of jack-ups was primarily designed to operate in the U.S. Gulf of Mexico area in water depths up to 200 feet. Wave heights in the range of 20 to 30 feet with winds up to 75 mph were considered as design criteria for these units. In most cases, in the event of a pending hurricane, the rigs were withdrawn to sheltered areas. Today's jack-ups, however, are being used in international waters in a range of environmental conditions that 10 years ago were considered to be unrealistic. For example, a rig designed for 250 feet of water will have to meet the following range of criteria:

a. U.S. Gulf Coast—55 foot wave, 125 mph wind, minimal current.
b. North Sea—75 foot wave, 115 mph wind, 1 to 2 knot current.
c. Southeast Asia—30 foot wave, 100 mph wind, minimal current.

As the water depth increases, the criteria rise accordingly and for 300 foot water depths the range becomes:

a. U.S. Gulf Coast—65 foot wave, 125 mph wind, 1 to 1½ knot current.
b. North Sea—90 foot wave, 125 mph wind, 2 to 2½ knot current.
c. Southeast Asia—50 foot wave, 115 mph wind, ½ to 1 knot current.

These figures, although obtained from reliable sources, should not be considered finite. Actual criteria must be deter-

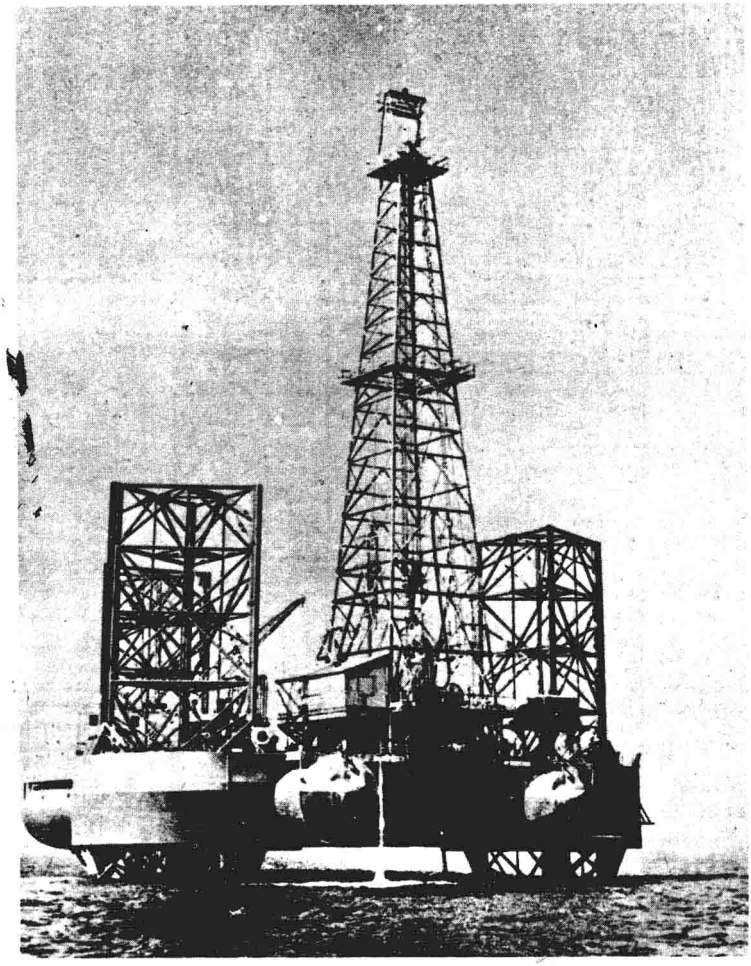

Fig. 1–6 *LeTourneau's Scorpion.*

mined from weather organizations in the actual geographical location of drilling. However, the differential in criteria can easily be seen.

A new breed of jack-ups (Figure 1-7) has been developed that will operate in water depths in excess of 400 fett, although in 1974 the maximum criteria unit was only operating in 350 feet of

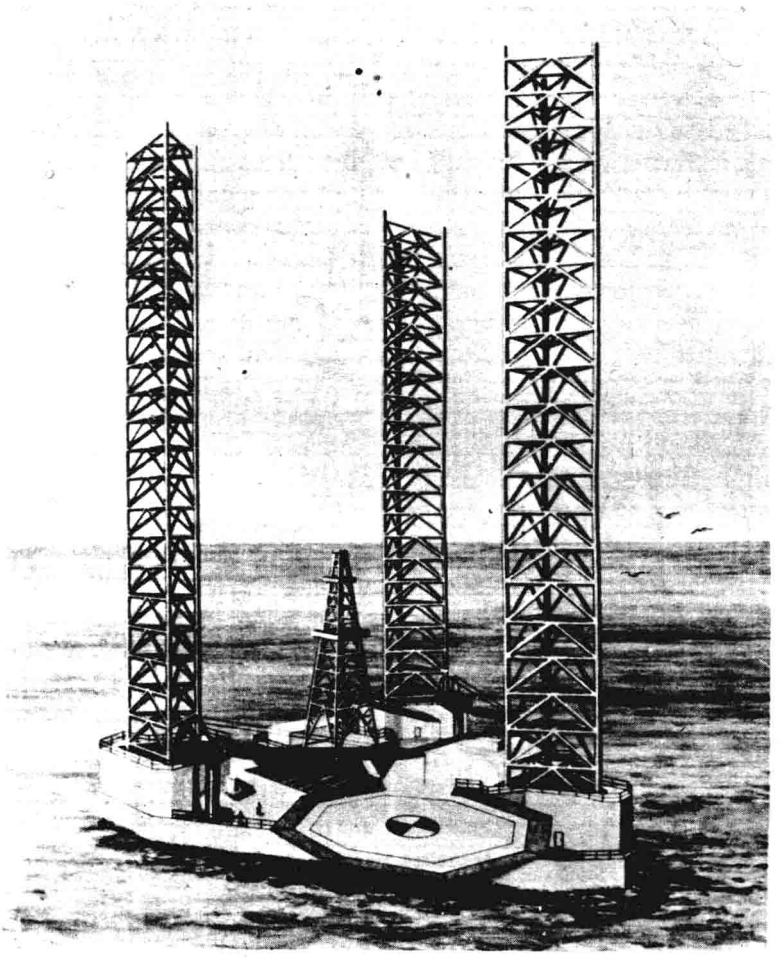

Fig. 1–7 *ETA's Europe Class Jack-up.*

water in the U.S. Gulf Coast, and in less than 300 feet in the North Sea.

Jack-up designs can generally be classified into two basic categories (Figure 1-8): independent leg jack-ups and mat supported jack-ups. Each unit has its particular value.

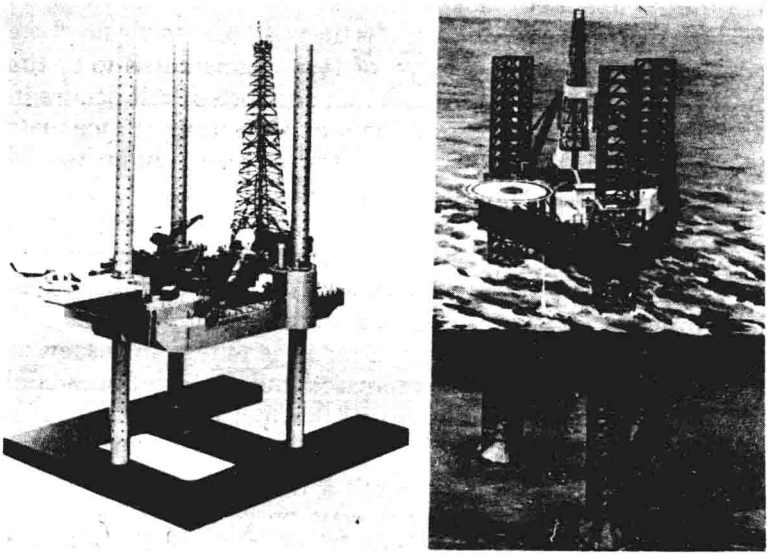

Fig. 1–8 *Mat supported and independent leg jack-ups.*

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 feet wide. Spud cans are subjected to bearing pressures of around 5,000 to 6,000 pounds per square foot, 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 to 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 feet. This compares with a penetration of perhaps 40 feet on an independent leg jack-up. As a result, the mat type unit requires less leg