CHEVRON USA, INC.
CONOCO, INC.
MINERALS MANAGEMENT SERVICE
MOBIL EXPLORATION & PRODUCTION SERVICES, INC.
NKK AMERICA, INC.

EXECUTIVE SUMMARY

A STUDY ON THE FEASIBILITY OF PRODUCTION, STORAGE AND LOADING SYSTEMS IN THE NORTH ALEUTIAN BASIN (OCS LEASE SALE 92)

SEPTEMBER 1985

BRIAN WATT ASSOCIATES, INC.
Consulting Engineers

284/BWA

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION

This report presents the results of a joint industry study to assess the feasibility and costs of alternative drilling and production systems for application in the OCS Lease Sale 92 area in the North Aleutian Basin Field, off the West Coast of Alaska. The study was conducted by Brian Watt Associates, Inc., (BWA) of Houston, Texas, who was the main contractor. Fabrication, installation, costs and schedules for the steel jackets and hybrid structures was evaluated by M & R Enterprises of New Orleans, Louisiana, who acted as sub-contractor to BWA. The study was carried out for the following original participants:

Chevron, U.S.A., Inc.
Conoco, Inc.
Minerals Management Service
Mobil Exploration and Production Services, Inc.
NKK America, Inc.

2.0 THE LEASE SALE AREA

The lease sale consists of approximately 9,000 square miles of offshore territory (Figure 1). The proposed lease sale area lies between the 55th and 57th parallels, and is in a remote region about 600 miles southwest of Anchorage. This region is characterized by severe seismic activity and structures must typically be designed to survive an earthquake of magnitude of 7 to 8 on the Richter Scale.

Extreme wave conditions have similar design magnitudes to those prevalent in the Gulf of Mexico. The area is characterized by drifting first year ice with occurrences and concentrations reducing from North to South. No ice grows in the area because of the relatively mild winters, coupled with cool summers. The area has water depths ranging from 50 to 300 ft with the majority of the lease sale area having depths of 200 to 300 ft. Because of the cool climate, visibility is reduced by fog for significant periods, particularly in summer.

3.0 OBJECTIVES OF THE STUDY

The objective of the study was to determine the feasibility of a number of alternative concepts in the ice, wave, and seismic environment of the North Aleutian Basin. For feasible systems the major member sizes and dimensions were determined and capital costs as well as construction/installation schedules were developed.

4.0 CONCEPTS CONSIDERED

The following concepts were considered:

- A piled jacket structure shown in Figure 2. Storage was assumed provided by floating storage and offloading (FSO) tanker. In addition, the costs associated with marine pipelines to shore were investigated.

- Two alternative gravity based systems were assessed. A hybrid steel/concrete system consisting of a steel jacket and concrete base storage caisson is shown in Figure 3. A concrete gravity platform typical of those used in the North Sea is shown in Figure 4. In both cases, loading was assumed via a remote loading buoy.

- A floating production, storage and offloading (FPSO) tanker based system, shown in Figure 5 was considered. The tanker and associated subsea templates, risers and pipelines were investigated.

The study included all pipelines connecting various templates, loading buoys, storage tankers, etc.

5.0 APPROACH FOR DEVELOPING FEASIBILITY

Appropriate design loads were developed for all seismic, ice and wave conditions. Two target water depths, 150 ft and 300 ft were selected for all fixed platforms and a single depth of 250 ft was used to assess feasibility of the floating systems.

Preliminary analysis of the fixed concepts indicated that seismic loads would dominate the design of both the major dimensions of the platform and the individual members. The platforms were designed to withstand the seismic loads and subsequently checked under wave and ice loads. Wave loads were found to have no effect on the global dimensions or the individual members. Ice loads were found to have no effect on the global design of the fixed platforms, but did control the design of members crossing the free water surface. In addition for both the piled steel jacket and hybrid concept, the conductors were protected by a system of tubular members designed to prevent unbroken ice from striking the conductors. The fixed platforms were designed primarily for inplace conditions, but a preliminary investigation was made of towing and installation requirements.

Floating systems are relatively insensitive to seismic conditions. The approach taken was to select a concept for an FPSO or FSO based on a ranking of alternative concepts, and 126,000 dwt size. Five alternative mooring systems were considered. The selected concept was the Turret Moored Flexible Riser System (TMFR) shown in Figure 5. A similar ranking procedure was used to assess a number of different options for the remote loading buoy. The selected concept was the CAM system shown in Figure 6. The motions of the tankers under the design seastate conditions and the required mooring system were determined.

The shuttle tanker size was assumed at 60,000 dwt. A statistical investigation of the efficiency of the loading system was conducted accounting for reduced visibility conditions, limitations of daylight and seastate conditions.

The sensitivity of all concepts to a number of variables, primarily water depth and production rate was established.

6.0 APPROACH FOR DETERMINING COSTS

Two fabrication sites were considered for cost determination:

- o Japan
- o U.S. West Coast

The material quantities were determined for the various concepts. Unit rates were applied for material and fabrication. The equipment spreads, costs, tow durations, etc., were determined for the various offshore operations and appropriate costs and schedules determined.

Facilities costs and schedules were determined based on previous experience with similar concepts. Two production rates were assumed 50,000 bopd and 100,000 bopd. The sensitivity of the costs to production rate was established.

Estimates were made for the construction schedules for a number of concepts, together with the required cash flow. Only capital costs of the production platforms, storage vessels, loading buoys, etc., were considered. No maintenance or operating costs were included and the costs associated with the shuttle tanker transport system required were also not included.

A number of field development scenarios were studied and appropriate costs provided.

7.0 COST SUMMARY

The estimated total costs for a number of platform types as a function of water depth and production rates are given in Table 1. Costs include the platforms and the drilling/production facilities only. Costs of shuttle tankers, pipelines, loading buoys are not included. Drilling costs are not included for the FPSO. Table 2 summarizes eight typical field development scenarios for comparison. Tables 3 to 5 show total capital costs for these scenarios, using different types of production platforms, crude storage and transport systems. A range of water depths and production rates have been considered. The participants are expected to conduct their own financial analyses using these costs provided and to suit their individual requirements. The reader is cautioned against a direct comparison of fixed platform and floating production system costs. The fixed platform includes a substantial provision for drilling rig and associated equipment capital costs not accounted for in floating systems.

In general, the initial capital costs are higher for fixed platforms but it must be borne in mind that the on-going operating costs such as leasing costs for semisubmersible drilling platforms may be much higher for floating systems.

8.0 GENERAL CONCLUSIONS OF THE STUDY

- To meet the objectives of this study each concept was considered in a general way. The objective was to determine feasibility of the concepts together with major dimensions weights, costs and schedules. The analysis and design applied in this study are compatible with that objective.

- The North Aleutian Basin has moderate ice conditions, wave conditions similar to design levels common in the Gulf of Mexico and severe seismic design criteria, which approach API Zone 5 design criteria. In addition the lease sale area has relatively high incidence of poor visibility.

- Seismic loads control most of the member sizes on fixed platforms and the major dimensions of all fixed platforms. Reductions in seismic conditions produce significant savings in both material and fabrication costs. Seismic loads have little effect on floating systems.

- Ice loading controls the design of braces crossing the ice region. These members must have increased wall thickness. The conductor systems in all steel platform applications must be protected from ice by a protective cage. In addition all floating systems require local ice strengthening. For all systems the global effects of ice did not control.

- Wave loads do not play an important role in local member or global design for fixed platforms. Wave conditions do influence the mooring design and operating characteristics of floating systems.

- The concepts designed here were all based on tried and proven technology. The jacket system is double battered with a launch truss and is similar to the thousands of jackets currently in use around the world. The concrete gravity system is similar to concepts already in use in the North Sea. The Hybrid system is a combined jacket and concrete base, with some innovation required for the connection between them. The floating production and storage systems are conventional converted tankers with moderate ice strengthening. The TMFR system and the CAM system for loading have not been proven in practice, but they are based on technology that has. Hence, to develop feasible systems for use in the ice, seismic and wave conditions of the North Aleutian Basin, requires no significant advances in current technology.

- Costs have been prepared for two fabrication sites:

  - Japan
  - U.S. West Coast

  The overall costs for constructing the platforms in Japan are lower than those on the U.S. West Coast. Refer to Section 7.0 above for the capital cost summaries and scenario comparisons. It is expected that participants will conduct their own financial analyses using the capital costs developed in this study to suit their individual requirements.

- Liquefaction under seismic conditions is a potential problem for the anticipated soil conditions and seismic conditions prevalent in the area. Piled jacket structures can be designed to function under anticipated seismic and soil conditions. Gravity based systems are severely affected by potential liquefaction. Placement of gravity systems must be examined on a case by case basis and a detailed study of liquefaction potential for each specific site should be undertaken prior to significant design of the platform. Floating systems are relatively unaffected by liquefaction, although the position and capacity of the mooring systems must be reevaluated after significant seismic activity.

	JAPAN		U.S. WEST COAST	
PLATFORM	50,000 BOPD	100,000 BOPD	50,000 BOPD	100,000 BOPD
Jacket, 300 ft depth	220.4	256.0	266.4	302.0 (1)
Jacket, 150 ft depth	297.9	333.5	343.6	379.2 (1), (2)
Hybrid Platform, 300 ft depth	324.8	414.7	-	483.2 (3)
Hybrid Platform, 150 ft depth	287.5	373.3	-	433.1 (3)
Concrete Platform, 300 ft depth	319.2	392.5	-	458.7 (3), (4)
Concrete Platform, 150 ft depth	293.4	359.5	-	416.7 (3), (4)
FPSO, 250 ft depth	163.4	178.6	-	- (5)

Notes:
(1) Includes costs of topside facilities, conductors, and risers, but no storage vessel, offloading buoy, pipelines or shuttle tankers.
(2) Multiple Jackets considered only.
(3) As (1) above but includes integral crude storage in base caisson.
(4) - indicates not costed.
(5) Includes production facilities, storage and offloading hardware but no drilling facilities or shuttle tankers.

TABLE 1 SUMMARY OF PLATFORM COSTS ($MM)

SCENARIO		PLATFORM WATER DEPTH (FT)	MARINE PIPELINE (MILES)	FPSO + TEMPLATE	FSO	LOADING BUOY	SHUTTLE TANKERS
Piled	1	300	170	-	-	-	-
Steel	2	300	1	-	X	X	X
Jacket	3	150	40	-	-	-	-
Hybrid	4	300	1	-	-	X	X
Platform	5	150	1	-	-	X	X
Concrete	6	300	1	-	-	X	X
Gravity	7	150	1	-	-	X	X
FPSO	8	250	6	X	-	-	X

x = Included in scenario. Shuttle tankers are excluded from costs.

TABLE 2 SUMMARY OF TYPICAL SCENARIOS CONSIDERED

	COSTS ($MM)					
Scenario	Platform	Pipelines	FPSO + Template	FSO	Loading Buoy	Total
1	220.4	115.0	-	-	-	335.4
2	220.4	11.0	-	98.0	-	329.4
3	297.9	20.0	-	-	-	317.9
4	324.8	23.0	-	-	6.7	354.5
5	287.5	23.0	-	-	6.2	316.7
6	319.2	23.0	-	-	6.7	348.9
7	293.4	23.0	-	-	6.2	322.6
8	-	21.1	163.4*	-	-	184.5

* FPSO system includes no drilling costs.

TABLE 3 ESTIMATED COSTS OF SCENARIOS 1 - 8 FOR 50,000 BOPD PRODUCTION FABRICATION IN JAPAN

	COSTS ($MM)					
Scenario	Platform	Pipelines	FPSO + Template	FSO	Loading Buoy	Total
1	256.0	143.0	-	-	-	399.0
2	256.0	12.0	-	98.8	-	366.8
3	333.5	29.0	-	-	-	362.5
4	414.7	23.0	-	-	7.2	444.9
5	373.3	23.0	-	-	6.5	402.8
6	392.5	23.0	-	-	7.2	422.7
7	359.5	23.0	-	-	6.5	389.0
8	-	21.1	178.6*	-	-	199.7

* FPSO system includes no drilling costs.
All floating system fabrication in Japan.

TABLE 4 ESTIMATED COSTS OF SCENARIOS 1 - 8 FOR 100,000 BOPD PRODUCTION FABRICATION IN JAPAN

	COSTS ($MM)					
Scenario	Platform	Pipelines	FPSO + Template	FSO	Loading Buoy	Total
1	302.0	143.0	-	-	-	445.0
2	302.0	12.0	-	98.8	-	412.8
3	343.6	29.0	-	-	-	372.6
4	483.2	23.0	-	-	7.2	513.4
5	433.1	23.0	-	-	6.5	462.6
6	458.7	23.0	-	-	7.2	488.9
7	416.7	23.0	-	-	6.5	446.2
8	-	21.1	178.6	-	-	199.7

* No drilling costs included for FPSO.
All floating system fabrication in Japan.

TABLE 5 ESTIMATED COSTS OF SCENARIOS 1 - 8 FOR 100,000 BOPD PRODUCTION FABRICATION IN U.S. WEST COAST

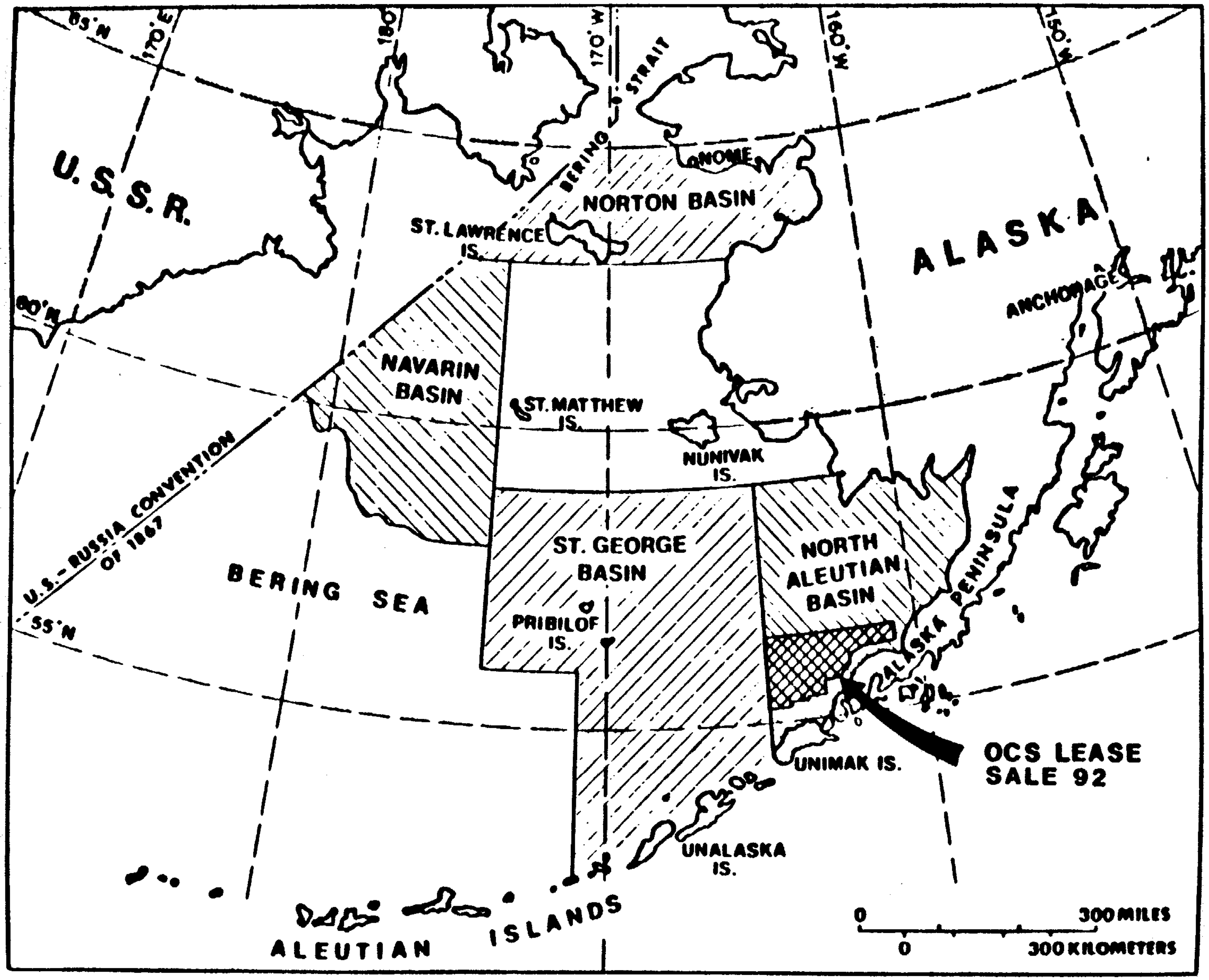


FIGURE 1 NORTH ALEUTIAN LEASE SALE SITE

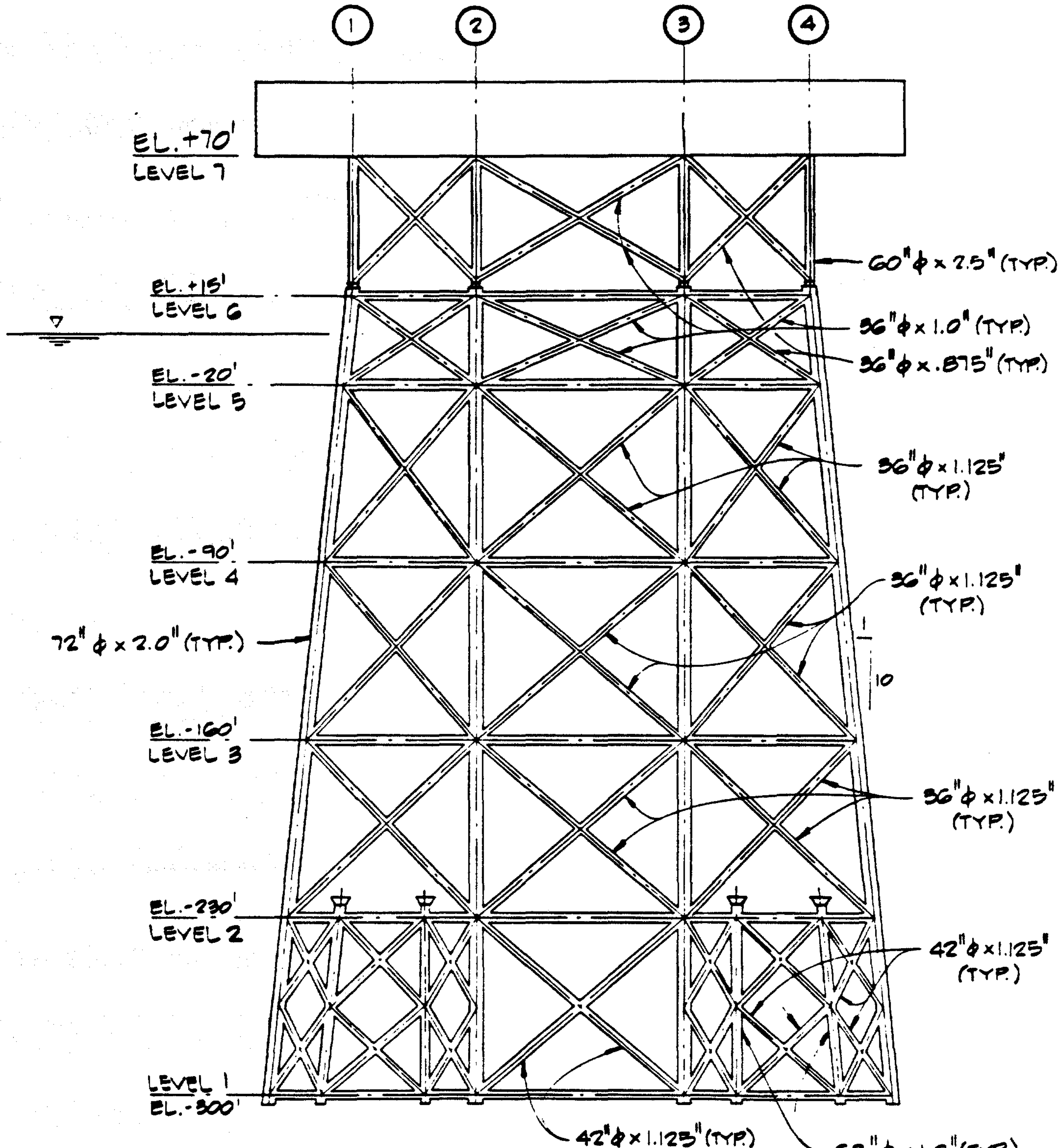


FIGURE 2 PILED JACKET CONCEPT

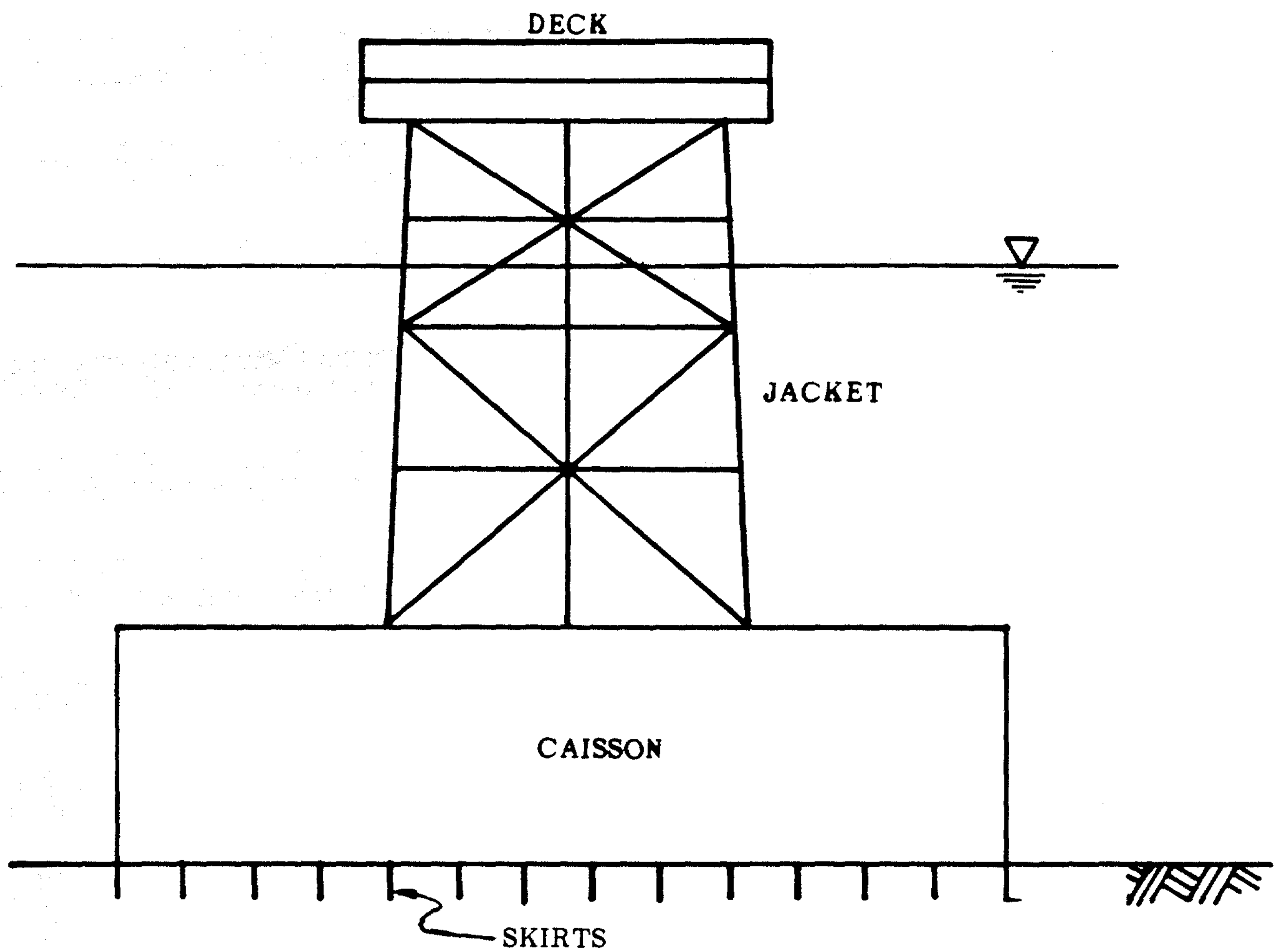
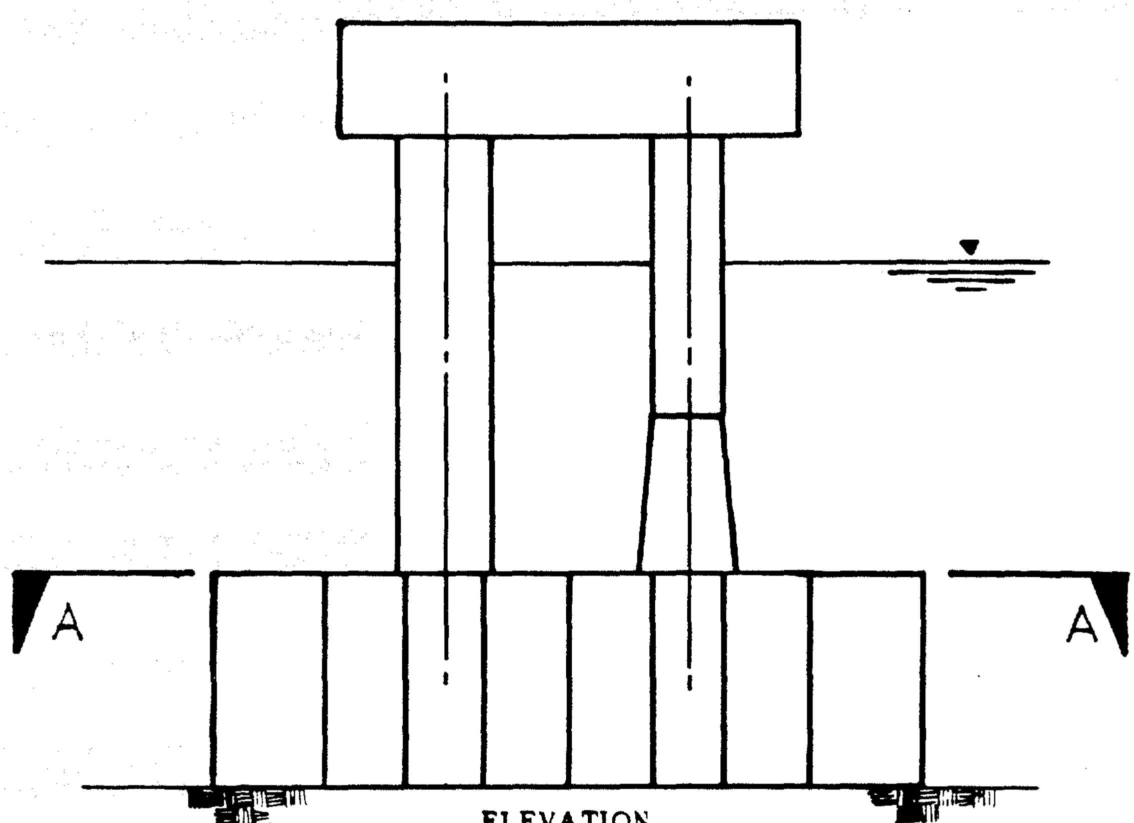
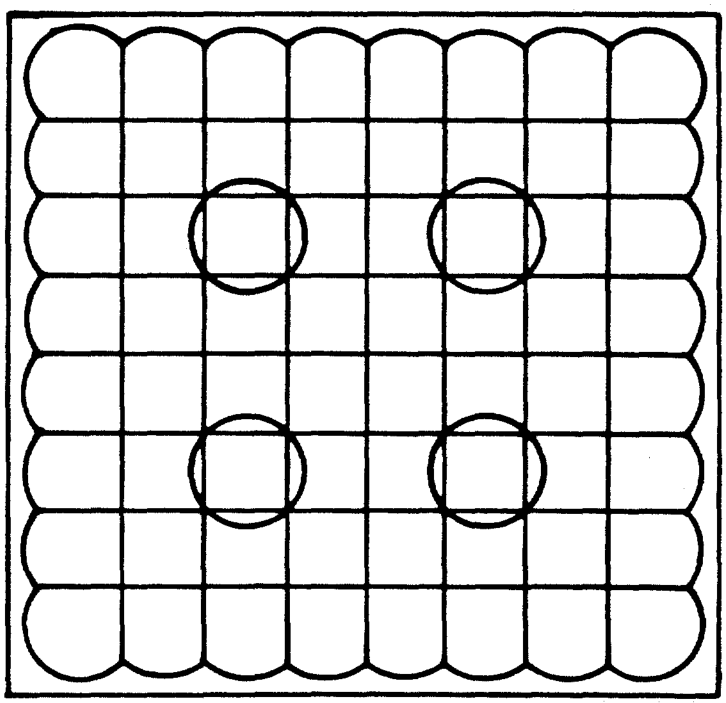


FIGURE 3 HYBRID PLATFORM



ELEVATION



SECTION "A-A"

FIGURE 4 CONCRETE GRAVITY PLATFORM

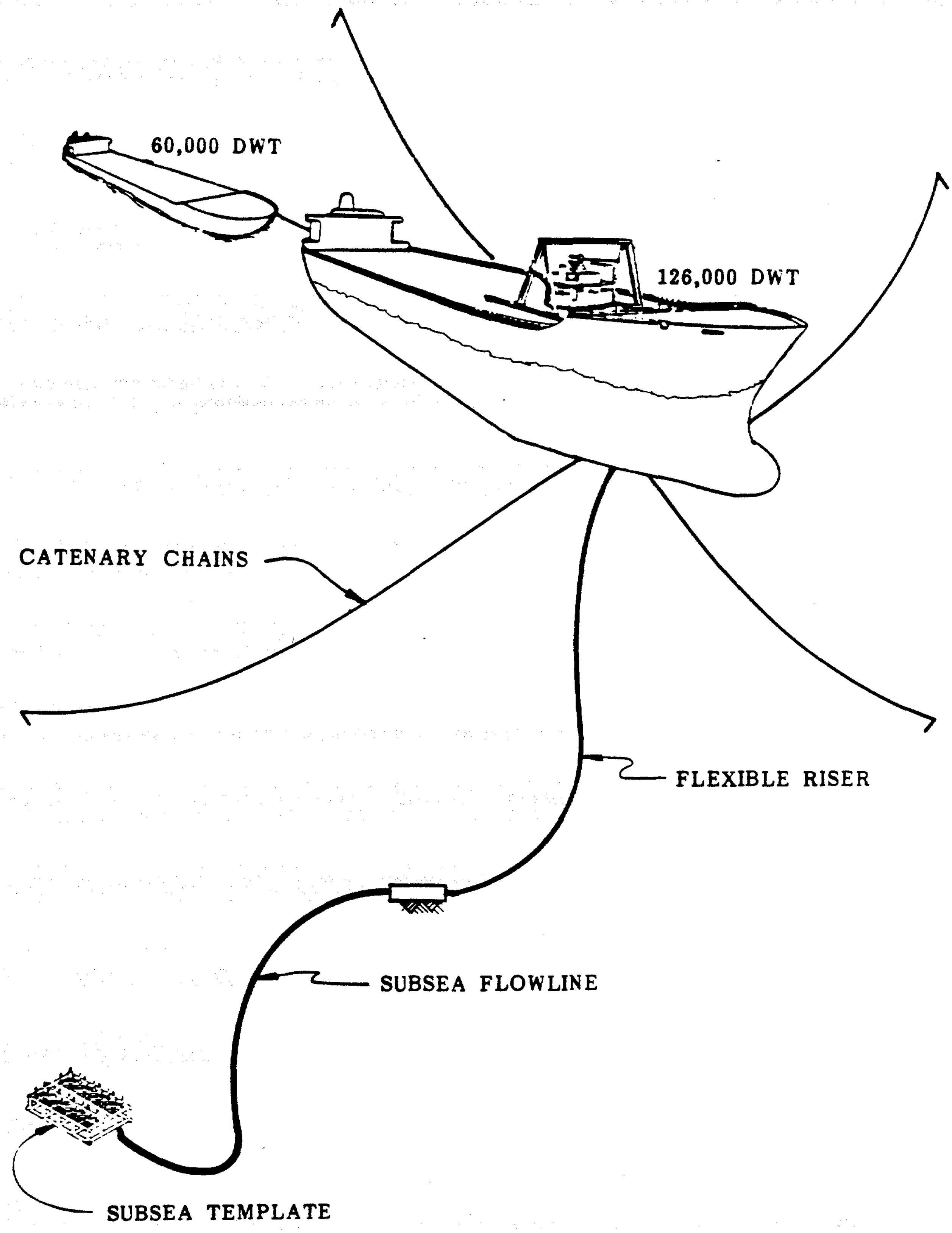


FIGURE 5 FLOATING SYSTEMS

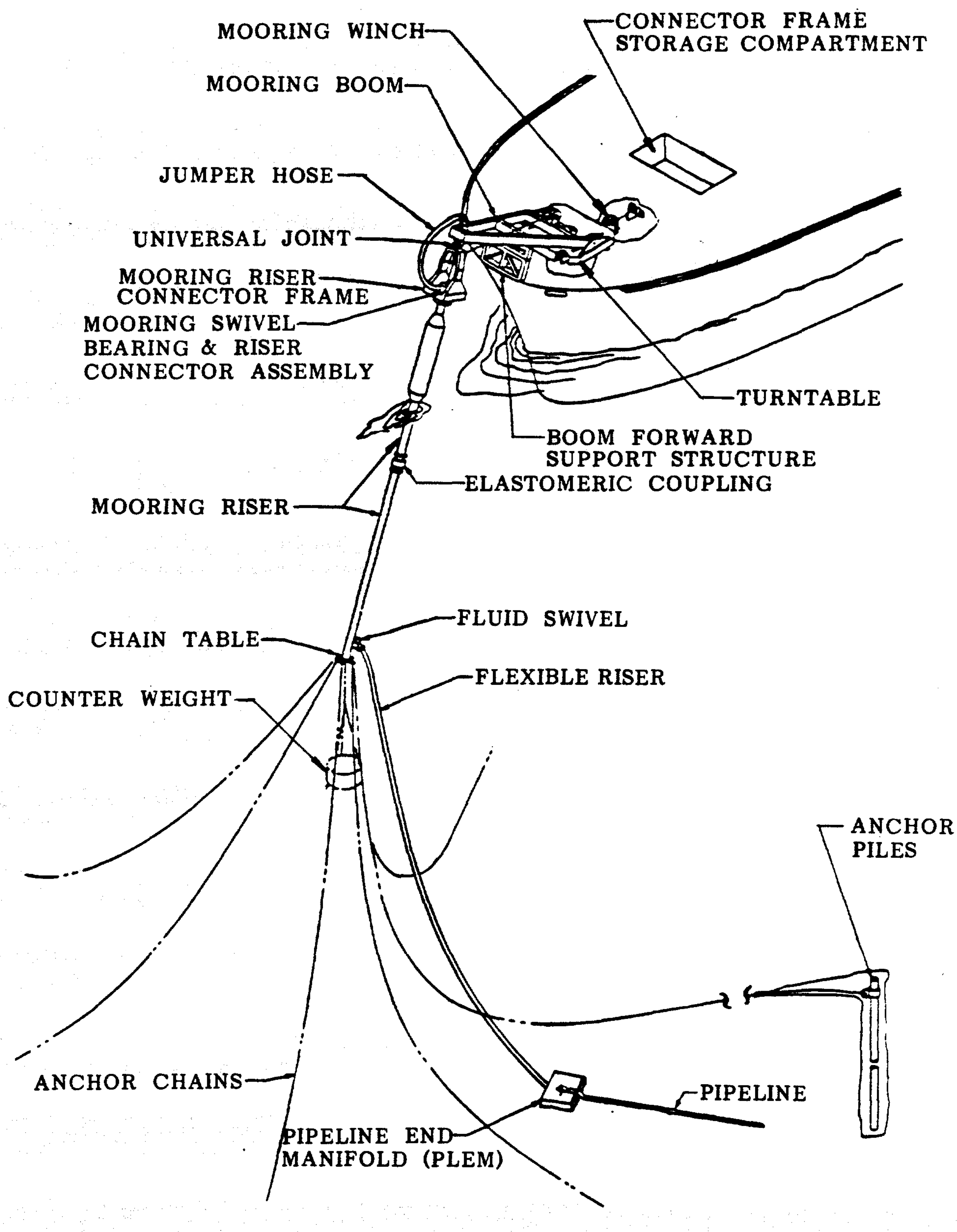


FIGURE 6 COUNTERWEIGHT ANCHOR MOORING (CAM) SYSTEM FOR REMOTE LOADING