Heavy Movable Structures, Inc.

SIXTH BIENNIAL SYMPOSIUM

October 30 - November 1, 1996

Doubletree Resort Surfside
Clearwater Beach, Florida

Ford Island Bridge, Pearl Harbor, Hawaii

by

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Quade & Douglas, Inc.

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Introduction

The Ford Island Bridge is a unique 4,672-foot-long bridge that combines fixed trestle spans with two movable transition spans and a 930-foot-long floating draw section to provide a 650-foot-wide channel for US Navy aircraft carriers leaving the Pearl Harbor Naval Base, Oahu, Hawaii. Currently under construction by the joint venture of Dillingham-Manson for the U.S. Navy, the bridge is scheduled for completion in 1997. The design was prepared by Parsons Brinckerhoff Quade & Douglas, Inc. with a number of subconsultants including Moffatt & Nichol Engineers, Santa Ana, California, who were responsible for the fixed spans; Makai Ocean Engineering Inc., Honolulu, Hawaii, who provided a dynamic analysis of the floating draw span; and Edward K. Noda Associates, Inc. Honolulu, who developed the wind, wave and tide data that played a central role in designing the draw span. Parsons Brinckerhoff managed the project from our Honolulu office, and in addition to overall project management, provided civil, architectural, geotechnical, mechanical and electrical design as well as all aspects of the design of the movable portions including the transition spans, draw span, machinery and controls.

As this was a design-build project, the contractor and several subcontractors played a strong role in the development of the design concept as well as the final design. Concrete Technology Corporation of Tacoma, Washington, suppliers of the pontoons for the draw spans, and Bob Stevens of Manson Construction in particular were key participants in the development of this unique design. The design was developed over a one-year period and included monthly meetings of all concerned, and as the meetings were held in Parsons Brinckerhoff's Honolulu office, attendance was always excellent.

Description

An overall layout of the project is shown in Figure 1. It should be noted that in addition to the 650-foot-wide channel provided by the draw span, there is a fixed small boat channel that provides a 100-foot-wide opening for smaller craft using Pearl Harbor. Toward the east end of the bridge there is a sentry house and turnaround to control access to Ford Island, which is to be developed by the Navy for housing and other purposes.

The bridge roadway is 40 feet wide, to allow for two-way traffic and to provide shoulders for bicycles and a breakdown area. On the north side of the roadway there is a 4-foot-wide sidewalk for pedestrians. The control house for the draw span is located just above the small boat channel, as this is the high point on the bridge. At either side of the draw spans, traffic lights and roadway and barrier gates are provided, following normal movable bridge criteria.

Movable Bridge

Figure 2 shows an overall arrangement of the movable section of the bridge. This includes a 120-foot-long transition span, the 930-foot-long floating draw span, (Figure 3), a 250-foot-long transition span, (Figure 4), and operating machinery (Figure 5). The bridge is intended to operate infrequently, perhaps four times a year, and the design allows for 25 minutes for opening or closing the span, from the time the traffic is stopped to the time the channel is open.

The normal sequence of operation is as follows:

1. Stop traffic using traffic lights
2. Lower traffic gates, lowering oncoming gates first
3. Lower barrier gates
4. Raise transition spans
5. Retract draw span

The transition spans are hinged to allow for a 4.6-foot maximum tide range, as well as the ability to pivot up when the draw span is withdrawn. Simple spring loaded plates are used at the roadway and sidewalk joints to provide a smooth transition for cars, bicyclists and pedestrians. The west transition span allows for expansion while the east transition is pinned.

As shown in Figure 5, the draw span is operated using 2-inch-diameter wire ropes and hydraulically powered winches. Two winches (Figure 6) are provided with a countertorque system so that one rope is retarding the draw span movement while the other rope is advancing the span. This allows the draw span to always be under control and is based on systems used to position barges.

To retract the draw span the sequence is:

1. Tension ropes from their slack position. (When the bridge is in the closed position the ropes are slack to allow for tidal movement.)

2. Increase tension in the retract rope and decrease tension in the extend rope so that the draw span begins to accelerate.

3. The draw span reaches a normal operating speed of approximately 70 feet per minute.

4. As the draw span reaches the nearly closed pontoon, the tension in the extend rope will decrease and the tension in the retract rope will increase so that there is a net retarding force to decelerate the pontoon.

5. Once the pontoon reaches the nearly retracted position, it will creep into the fully retracted position. Once in the fully retracted position, the rope tensions will equalize to hold the draw span, and then the winch brakes will be set. The brakes are only for holding the winches, as all dynamic braking is hydraulic. As considerable energy can be used to slow the span, the hydraulics for the winches are provided with an oil to air heat exchanger system that is operated by a temperature switch.

The lateral movement of the draw span is controlled by a high density polyethylene rub strip attached to the draw span edges and stainless steel fender panels attached to the piers that guide the pontoon.

The two transition spans are raised hydraulically, each in 8 minutes. Both spans use a half-filled grid deck with a 2-inch overfill and are designed for a future overlay. A pendulum type switch is attached to the end of the transition span to control any out of level movement of the span. This type of device is commonly used in mobile equipment to keep it in level position.

The cylinders (Figure 7) were designed for 2000-psi pressure, using full dead load and 20% impact in accordance with the AASHTO Standard Specifications for Movable Highway Bridges. The hydraulic power unit that operates the east transition span also operates the winches.

Each hydraulic unit is housed in a building mounted directly on the pier adjacent to the lift span cylinders. The west hydraulic power unit uses two 40-hp motors while the east hydraulic power unit uses two 75-hp motors. The bridge can be operated with only one hydraulic pump but only at half normal speed. The size of the east hydraulic power unit motors was controlled by the transition span operation, and smaller motors could have been used for the draw span operation.

In order to allow for some lateral translation of the draw span relative to the fixed spans due to wind, wave and currents, each transition span is articulated on rocker type bearings with a centering guide at the center of each end of the span. This is similar to the type of alignment device used on a vertical lift span with the added feature that the span needs to pivot.

As Hawaii is in a seismic zone, it was necessary to consider seismic effects in the transition span/draw span interface. Seismic motions normal to the bridge centerline are transferred to the draw span by the piers that guide the draw span and this was their controlling design case. However, there was no reasonable way to transfer seismic motion along the bridge centerline between a 930-foot-long floating draw span and the transition span. Therefore, the design incorporated a breakaway feature in the transition span pivot bearing that minimizes potential damage and can be readily repaired.

The control system uses hard wired relays for most of the interlocking, except that programmable logic controllers are used for the hydraulic functions. This was a decision made by the Contractor who will be responsible for maintaining the bridge for four years after it is constructed.

There is a 24-hour notification prior to a bridge operation. This gives the operators ample opportunity to check out the controls and machinery in advance. The bridge operation is controlled from the control house. There is a second operator stationed at the winches to observe the bridge operation and to plug and unplug the draw spans prior to opening and after closing, respectively. The plug-in connection is required for the roadway lighting on the draw span as well as a leak detector system in each pontoon cell and the navigation lights on the draw span. The leak detectors are wired back to the sentry house, which is manned 24 hours a day.

The control system uses a microwave link across the navigation channel with two carrier frequencies, one for controls and one for video, as there are video cameras on both sides of the channel to assist the operator when operating the bridge.

As this was a design-build project, the design process was very dynamic, particularly prior to submitting the bid when only preliminary engineering was completed, as it was necessary to define every feature so that the joint venture's estimators could price the bid accurately. During the final design we worked closely with a number of the subcontractors to develop design details and that close working relationship has continued through the construction. On this project the design-build process has proven to be a very effective way of accomplishing a complex undertaking.

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Figure 1
Ford Island Bridge

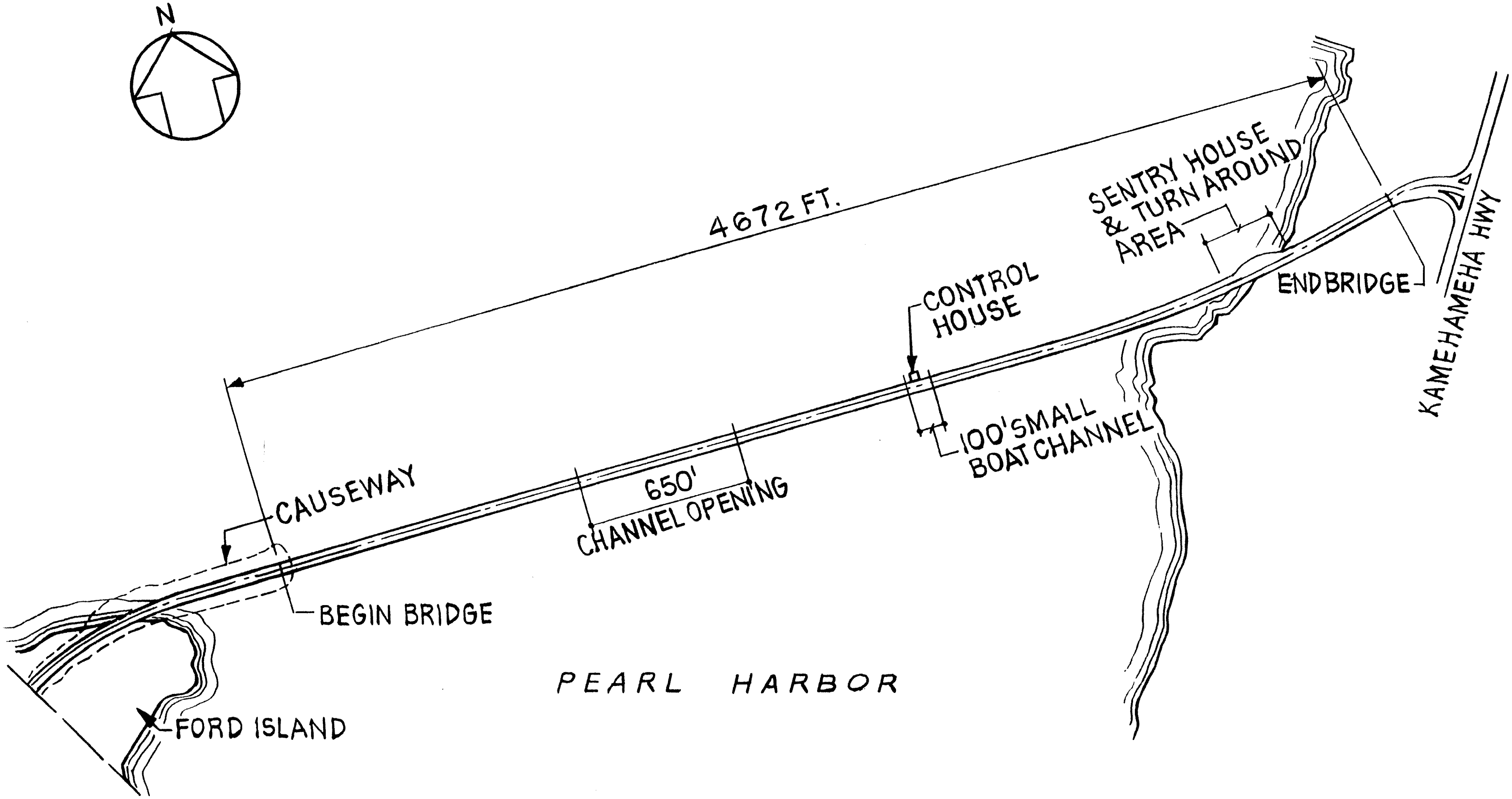

Figure 2
Transition & Draw Spans

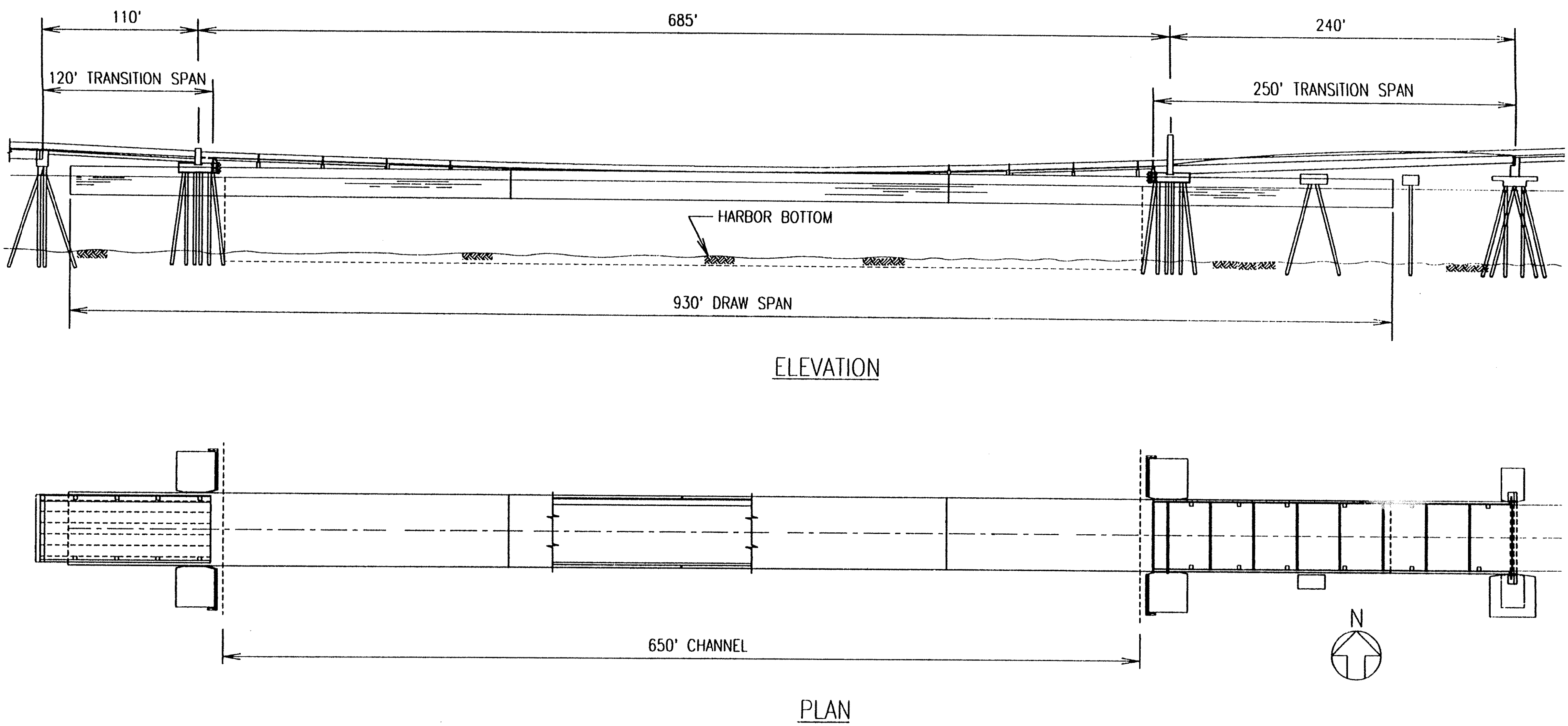

Figure 3
Pontoon Section

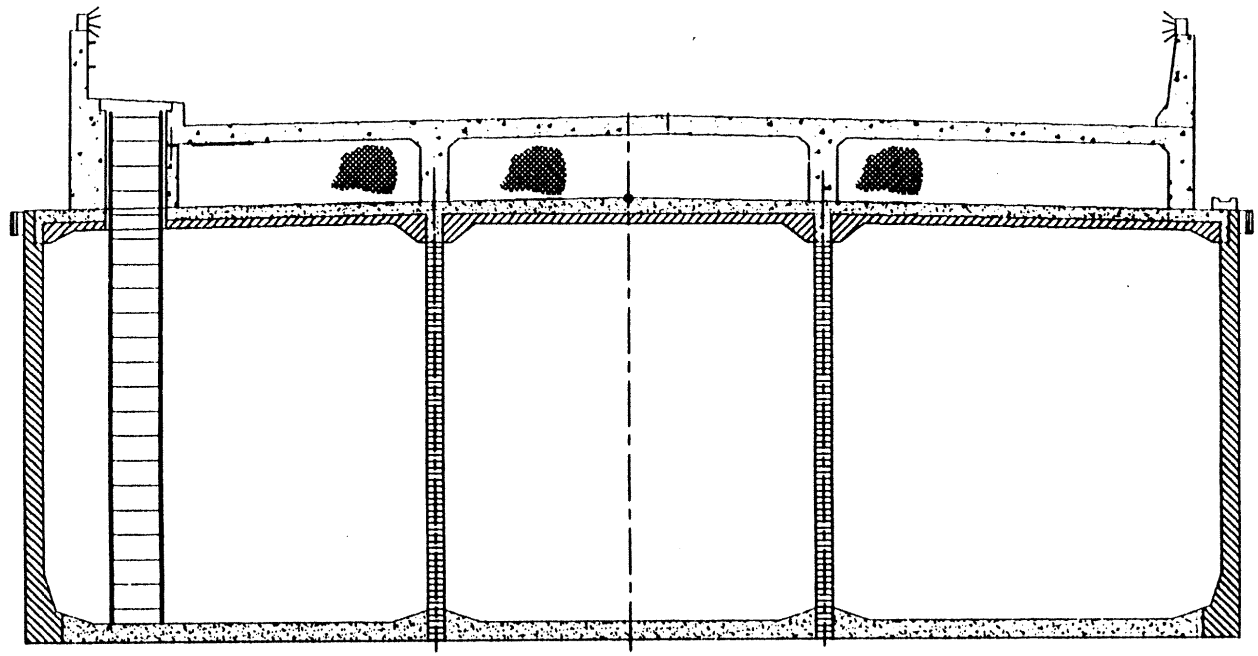

Figure 4

Typical Cross Section Transition Span

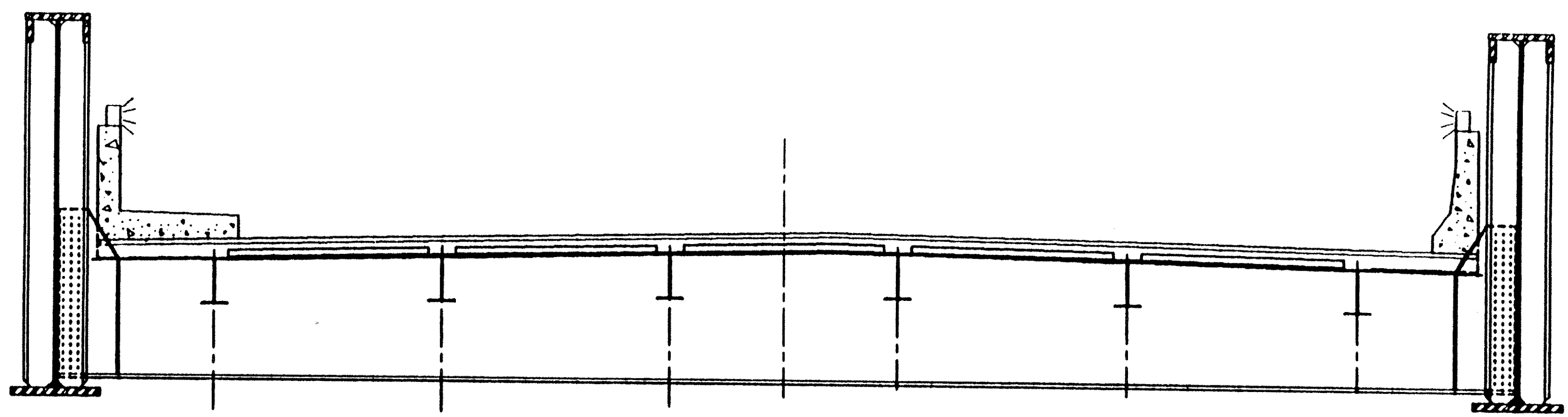

Figure 5
Machinery

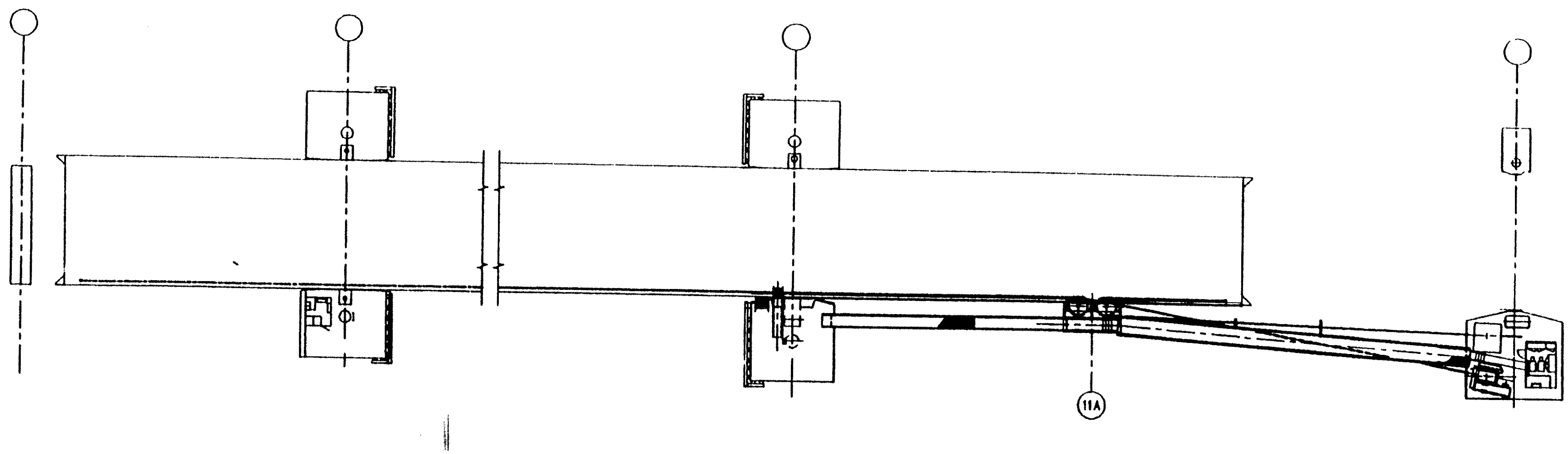

Figure 6
Winches

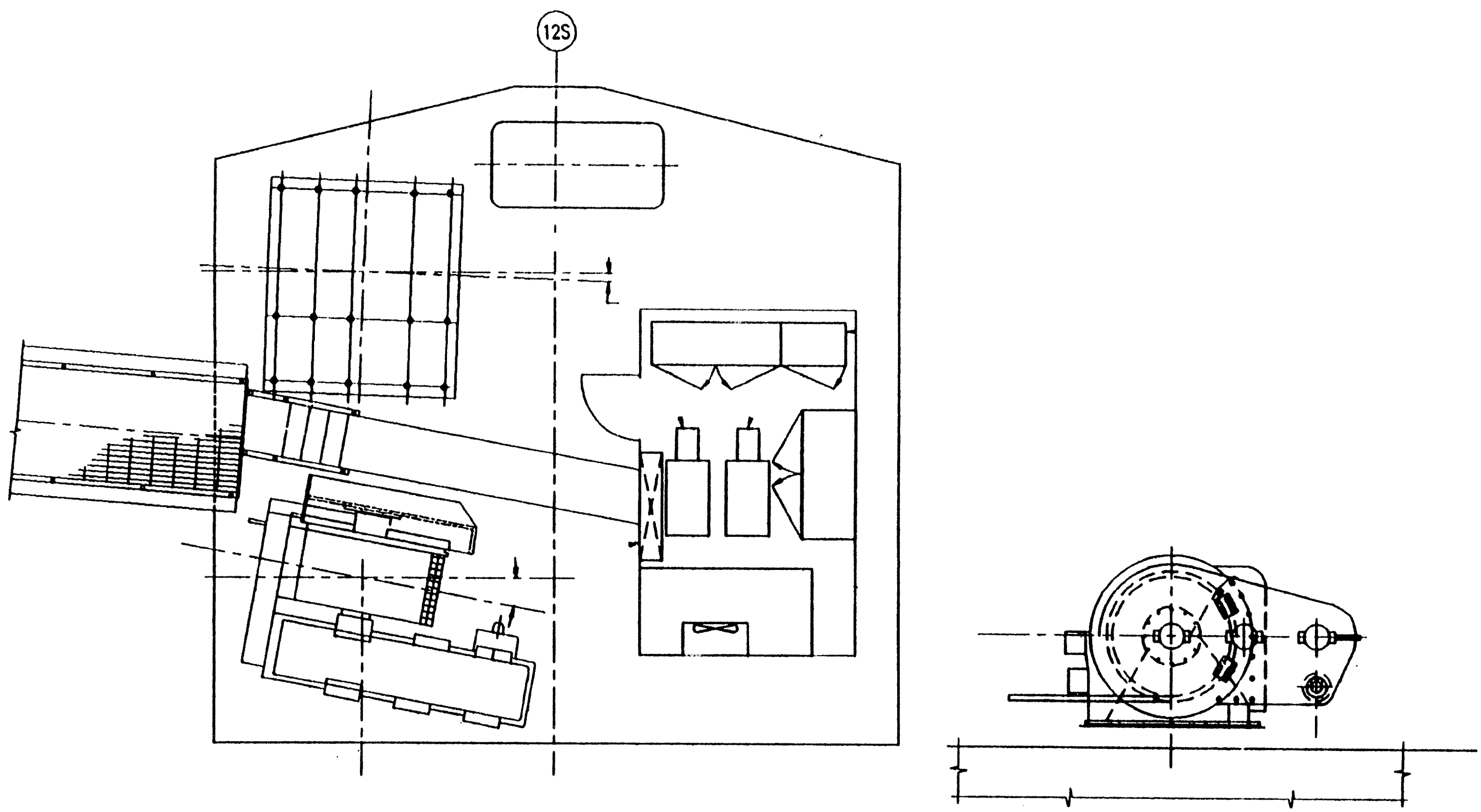

Figure 7

Lift Cylinder