HEAVY MOVABLE STRUCTURES, INC.

NINTH BIENNIAL SYMPOSIUM
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OCTOBER 22 - 25, 2002

AN OVERVIEW OF WASHINGTON STATE'S FLOATING CONCRETE PONTOON BRIDGES

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OWNERSHIP/PUBLIC USE
and MANAGEMENT

An overview of Washington States Floating Concrete Pontoon Bridges.

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Introduction

There are four floating concrete pontoon bridges in the State of Washington. Three are located in King County (the Seattle area) and provide access across Lake Washington. Lake Washington is 20 miles long from north to south and up to 4 miles wide. It is up to 200 feet deep in places and the bottom is soft mud up to 200 feet deep. The fourth bridge is located in Kitsap County and provides access across Hood Canal connecting the Kitsap peninsula and the Olympic peninsula. Hood Canal is approximately 330 feet deep under the bridge and is subject to tides of minus four to plus thirteen feet. Given the length of the crossings and the depth of water in these locations, floating concrete pontoon bridges were selected.

Lacey V Murrow Bridge

The Lacey V Murrow Bridge (90/25S) is a floating concrete pontoon bridge. It was first opened to traffic in 1940. It consists of 20 concrete pontoons, which were floated into place, bolted together and anchored to the bed of Lake Washington between Mercer Island and the Mount Baker section of Seattle. Each pontoon typically consists of 48 watertight cells, and the pontoons at the east and west ends of the bridge consist of 32 watertight cells. The floating portion of the bridge is 6,603 feet long. It originally had a 220-foot draw span located in the vicinity of Mercer Island. This draw span could be retracted into a tuning fork shaped opening called "the bulge". This bulge obliged motorists to negotiate a sharp curve at high speed and the bridge became notorious for sometimes-fatal accidents. This section was removed in September of 1981 after completion of the east channel bridge provided sufficient vertical clearance for vessels of over 45 feet high and made maintaining the draw span with its high incidence of vehicular accidents unnecessary.

On November 25, 1990 the bridge was undergoing renovation when a severe storm caused almost half of the bridge to sink due to an excess accumulation of water within the pontoons. This renovation work included the use of hydro-demolishers, which were used to remove concrete to allow the roadway to be widened. Holes were also cut into the sides of the pontoons to allow installation of new interior hatches. Fortunately no one was injured or killed when the bridge sank. The bridge was removed from the National Register of Historic Places when it sank. It was rebuilt in 1992 at which time it was converted from two-way traffic to east bound traffic only. The bridge is anchored to the lake bottom with steel anchor cables and concrete anchors. It is equipped with an anchor tensioning system consisting of permanently installed hydraulic jacks, which allow adjustment of the anchor cables. Adjustment of the anchor cable tension is performed routinely on all of the Lake Washington floating bridges because the lake level is lowered two feet each winter by releasing water from the Ballard locks to allow for spring flooding. The anchor cables are protected from corrosion by an impressed current cathodic protection system.

The bridge has a 14.76 KV distribution system consisting of submersible transformers and fuses connected by medium voltage cable and load break elbows. This system provides power to the pontoon lights and receptacles, the navigation lights, the motorist aid telephones, the cathodic protection system, the bridge intercom system and the remote monitoring system. The remote monitoring system monitors water sensors in each cell, transformer thermal sensors, transformer cell smoke detectors, pontoon lighting status and navigation light status. The water sensors, smoke detectors and transformer thermal sensors will send alarms to the maintenance facility on Mercer Island as well as the WSDOT Traffic System Management Center in Seattle. The pontoon lighting and navigation lighting can be controlled remotely from the control panel in the maintenance facility on Mercer Island. The bridge is also equipped with a network of 3 inch PVC suction pipes which allow water to be removed using trailer mounted, diesel powered pumps.

Homer Hadley Bridge

The Third Lake Washington or Homer Hadley Bridge (90/25N) is a floating concrete pontoon bridge, which was opened to traffic in 1989. It consists of 18 concrete pontoons, but it does not have a draw span. Each pontoon typically consists of 60 watertight cells, and the pontoons at the east and west ends of the bridge consist of 45 watertight cells. The floating portion of the bridge is 5,811 feet long. It is anchored parallel to and just north of the Lacey V Murrow Bridge. It originally carried east and westbound traffic of Interstate 90 during the renovation and the subsequent sinking and replacement of the Lacey V Murrow Bridge. It now carries westbound traffic and reversible HOV lane traffic. When portions of the Lacey V Murrow Bridge sank, a number of the anchor cables for the Homer Hadley Bridge were damaged. A fleet of tugboats were tied to the south side of the Homer Hadley Bridge for several weeks to maintain the bridge alignment until the anchor cables could be replaced.

The bridge has a 14.76 KV distribution system consisting of submersible transformers and fuses connected by medium voltage cable and load break elbows. This system provides power to the pontoon lights and receptacles, the navigation lights, the motorist aid telephones, the cathodic protection system, the bridge intercom system and the remote monitoring system. The remote monitoring system monitors water sensors in each cell, transformer thermal sensors, transformer cell smoke detectors, pontoon lighting status and navigation light status. The water sensors, smoke detectors and transformer thermal sensors will send alarms to the maintenance facility on Mercer Island as well as the WSDOT Traffic System Management Center in Seattle. The pontoon lighting and navigation lighting can be controlled remotely from the control panel in the maintenance facility on Mercer Island. The bridge is also equipped with a network of 3 inch PVC suction pipes which allow water to be removed using trailer mounted, diesel powered pumps.

The Hood Canal Bridge

The William A Bugge Bridge, more commonly called the Hood Canal Bridge (104/5.1 and 104/5.2) is a floating concrete pontoon bridge, which was built across the 330-foot deep Hood Canal in 1961. The floating portion of the bridge is 7,450 feet long. The bridge carries one lane of traffic in each direction. Unlike the Lake Washington floating bridges this bridge has an elevated roadway deck. This allows maintenance access to the entire bridge without having to deal with traffic. It is important to note that in addition to wind and wave action this bridge is subject to tide changes of minus four to plus thirteen feet. On February 13, 1979 the west draw span broke away and the west half of the bridge sank in a severe windstorm with gusts in excess of 120 miles per hour. Fortunately there were no injuries when this happened. A new, stronger west half with greatly improved waterproof hatch design was built and opened to traffic in 1982.

The bridge has two retractable draw spans, when opened together they provide a 600-foot opening for marine traffic. This bridge is one of busiest both for recreational boaters and Navy ships and nuclear submarines. The east half of the bridge has a tuning fork shaped opening into which the draw span is retracted. The west half originally had the same tuning fork shaped opening but when it was rebuilt it was equipped with a series of three hydraulic lift decks. These lift decks raise a portion of the roadway approximately nine feet to allow the draw span to be retracted beneath it. The west half of the bridge is designated bridge number104/5.1. It consists of 11 floating concrete pontoons, which are anchored by steel cables and concrete anchors to the bottom of the Hood Canal and a single draw pontoon. In the draw pontoon area the flanking pontoons on the north and south side of the draw span are connected by three submerged cross struts. These struts provide structural integrity to the draw span area and provide a path for routing electrical cables. The east half of the bridge is designated bridge number 104/5.2. It consists of eight floating concrete pontoons, which are anchored to the bottom of Hood Canal and a single draw pontoon. The anchor cables are protected from corrosion by an impressed current cathodic protection system. There is also a permanently installed hydraulic anchor cable adjustment system. There is a control tower on each half of the bridge with duplicate control desks. The bridge control system consists of a combination of relay based controls and a Square D PLC system which communicates between the two halves of the bridge over a microwave system or by way of a submarine telephone line.

To open the bridge advance warning lights and red traffic lights are turned on. When traffic stops a traffic gate on the east half and two traffic gates on the west half are lowered. The west half also has a swing barrier mounted in the median barrier, which is swung open to provide a physical barrier. On the east half of the bridge this physical barrier is provided by the draw span when it retracts. The two longitudinal locks which hold the east and west half draw spans together are operated hydraulically to unlock the two draw spans. In this same area there are two span alignment pyramids. The end locks on each corner of the draw span are withdrawn by a rack and pinion operated by an electric motor and a gear reducer on the west side and by a motor and gear reducer operating a cam on the east side. The east end lock bar receiver is slotted to allow bridge expansion. The west bridge lift decks are raised by hydraulic cylinders until they are clear of the draw span. Each of the three decks has an HPU skid powered by two 75 horsepower motors. The two draw spans are each retracted by four motors operating gear reducers and pinions, which act of the rack, which is mounted along the north, and south faces of the draw pontoons. On the east half the motors are 40 horsepower DC operated by motor generator sets. They are equipped with electric solenoid operated brakes. On the west half the motors are 75 horsepower wound rotor motors operated by Square D thyrister drives. They are equipped with thrustor brakes. Draw span alignment is maintained by vertical and horizontal guide rollers. On the west half the horizontal and vertical guide rollers are combined in a roller set at 45 degrees.

Each half of the bridge is powered by an independent 12.47 KV electrical service with a backup diesel generator and an automatic transfer switch.

In the near future this bridge deck will be widened to provide a shoulder on each side of the roadway. Plans are currently being developed by Parsons, Brinkerhoff, Quade and Douglas to completely replace the east half of the bridge and to renovate the mechanical and electrical components of the west half. Provisions have been made in these plans for future widening of the road deck to provide two eight foot shoulders in addition to the existing two lanes of traffic.

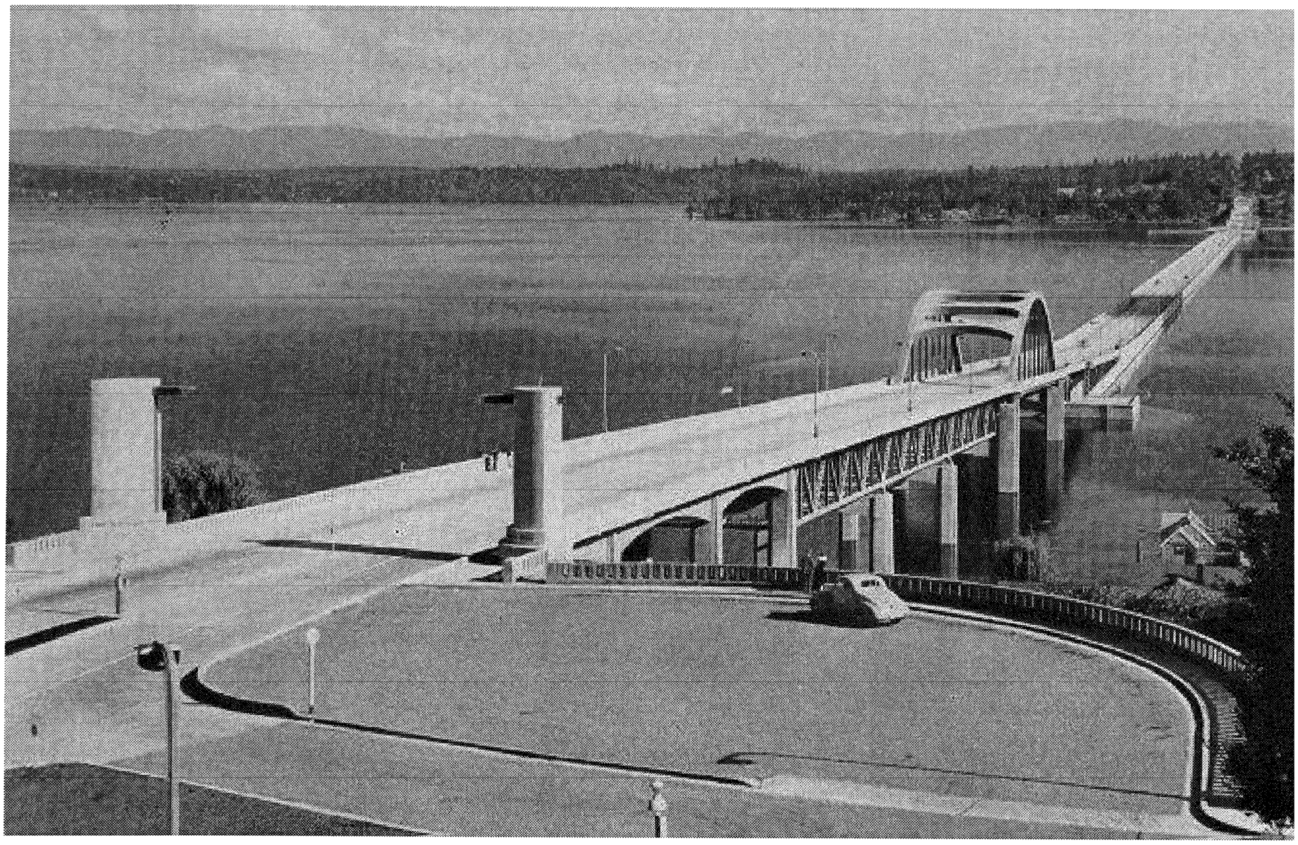
Evergreen Point Bridge

The Albert D Rosellini or Evergreen Point Bridge (520/8) is a floating concrete pontoon bridge across Lake Washington about 3 miles north of the Lacey V Murrow Bridge and Homer Hadley Bridge. It was opened to traffic on August 23, 1963. It carries two east bound and two west bound lanes of State Route 520 traffic. It consists of 35 separate pontoons, which are anchored to the bed of Lake Washington. It has two retractable 100 foot draw spans, which provide a 200-foot opening. Unlike the Hood Canal Bridge access for maintenance is through hatches at the roadway level or from the aprons at the draw spans. This bridge receives fewer marine opening requests than any of our other bridges and it is one of our most heavily traveled roadways. As a result we schedule monthly maintenance openings in the night during off peak traffic times in order to perform operator training and essential maintenance. The floating portion of the bridge is 7,578 feet long. The anchor cables are equipped with permanently installed hydraulic jacks to facilitate cable tension adjustment. Cable tension is adjusted annually to account for the seasonal lowering of the lake level to allow for spring flooding. Unlike the Hood Canal Bridge, the Lacey V Murrow Bridge and the Homer Hadley Bridge there is no cathodic protection installed on this bridge. The original design consisted of lift spans which were raised by electric motors operating chains and counter weights to allow the draw spans to be retracted beneath them. Replacement chains were installed in 1986. The new chains were of slightly different pitch which resulted in cracking of the welds in the chain segments. This raised concern that a failure of the chains could result in the counterweight puncturing the bottom of the pontoon and sinking the bridge. In 1994 a major electrical and mechanical renovation occurred and the counterweight system was replaced with hydraulic lift cylinders.

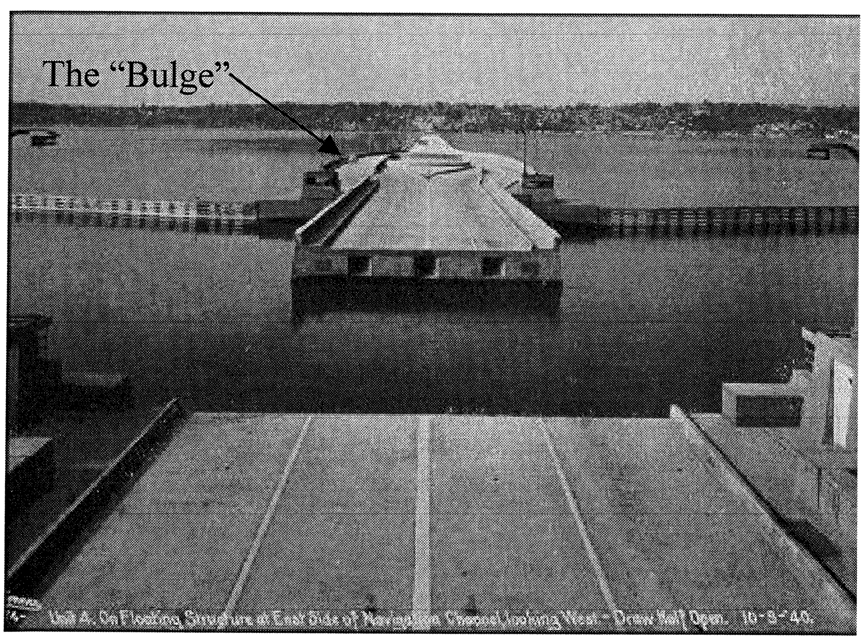
On January 20, 1993, the Inauguration day storm occurred. Sustained winds of 70 mph and gusts to 92 mph caused significant structural damage including damage to anchor cables and an anchor cable seal, numerous transverse cracks and cracks in the grout at pontoon joints, which allowed water leakage, and the shearing of bolts for the hooks on the center locks. On March 3, 1999 a storm with winds of 45 to 50 mph caused severe damage to the vertical and horizontal guide rollers and again sheared off the bolts which hold the center lock. Spare guide rollers and center lock hooks were installed by WSDOT maintenance. In order to overcome leaking caused by the cracking, sealant was injected into the cracks and post tensioning was installed through the interior of the pontoons in 1999.

There is a control tower on the west half of the bridge. A Square D Programmable Logic Controller is used to control the operation of the bridge. The bridge is also equipped with a redundant manual control system, which allows manual operation of the bridge in the event of a malfunction of the PLC. To open the bridge, traffic is stopped by turning on the advance warning lights and traffic lights. Oncoming and then Offgoing traffic gates are lowered and traffic barriers, which are mounted in the median barriers are swung out and secured. The lift decks are raised approximately eight feet by hydraulic cylinders. Unlike the Hood Canal Bridge each half of the Evergreen Point Bridge has a single lift deck. There are two cylinders in each corner of the lift deck to provide redundancy. There are two hydraulic power units on each half of the bridge with two 40 horsepower motors and pumps on each unit. One unit provides power to the two sets of cylinders on the north side of the bridge and the other provides power to the cylinders on the south side of the bridge. Control of the lift deck level is provided by a Rexroth digital loop circuit and temposonic position sensors mounted inside each of the cylinders, which automatically keeps the lift deck level. The endlocks are then withdrawn by motor operated jack screws and the center locks are unlocked by hydraulically extending the three center lock hooks located in to east draw pontoon and hydraulically lifting a lock bar located in the west draw pontoon. The two draw spans are then retracted beneath the raised lift decks to create a 200-foot opening. Each draw span is operated by four 15 HP DC motors operating gear reducers, pinions and racks which are mounted along the north and south faces of the draw pontoons. Each motor is equipped with electric solenoid type brakes and are controlled by Saftronic DC drives. Draw span alignment is maintained by vertical and horizontal guide rollers.

The west half of the bridge is power by a 4160 volt distribution system and the east half is powered by a 12.47 KV distribution system. Each half is equipped with a 150 KVA backup generator and an automatic transfer switch. In addition to the power distribution and bridge control system the bridge is equipped with a leak detection system, a public address system and a fire alarm system.



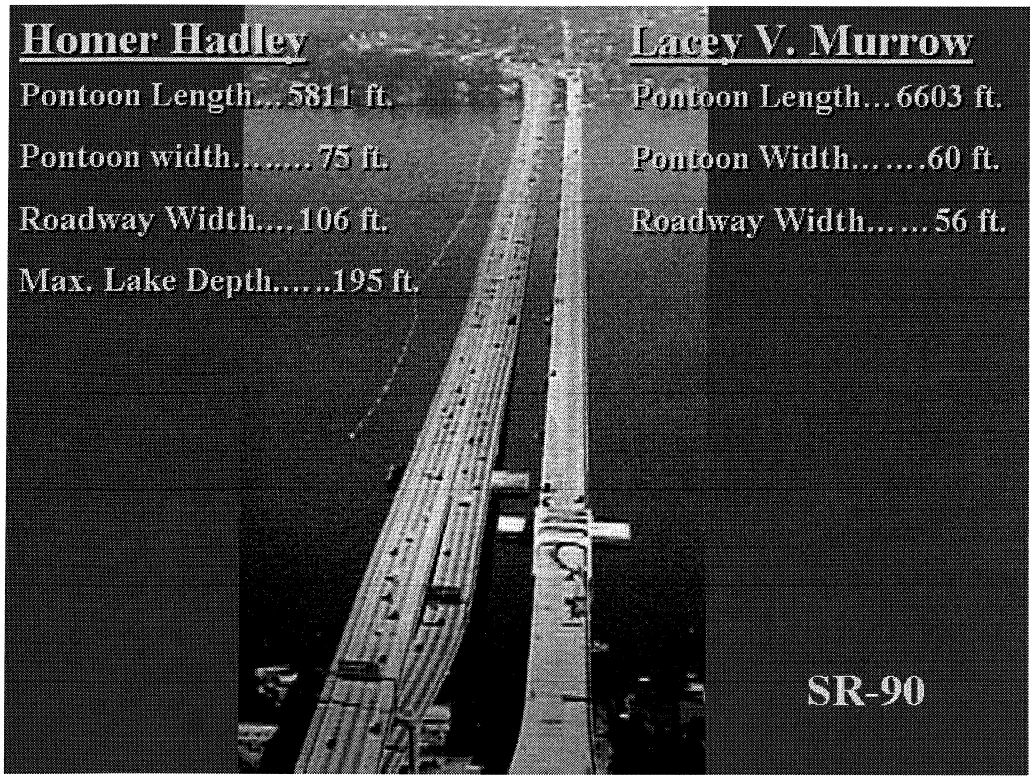
Photograph 1: Original Lacey V. Murrow Bridge. 1940.



Photograph 2: Original Lacey V. Murrow draw spans. 1940.

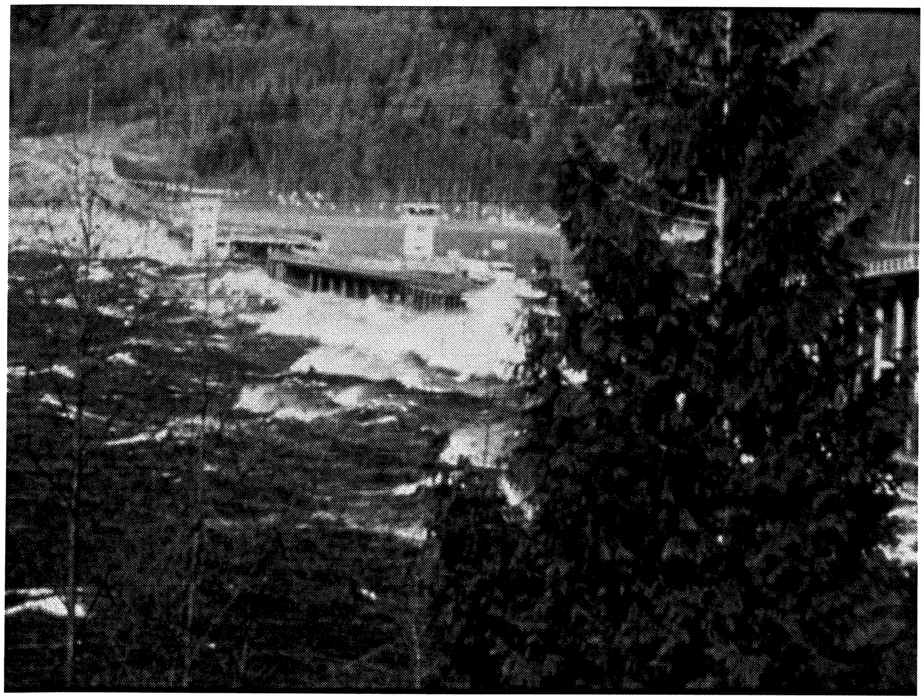
Photgraph 3: Original Lacey V. Murrow Bridge sinking after a severe storm. 1990.

Photograph 4: Tugboats holding the new Homer Hadley Bridge in place after anchor cables were damaged by the sinking Lacey V. Murrow Bridge.

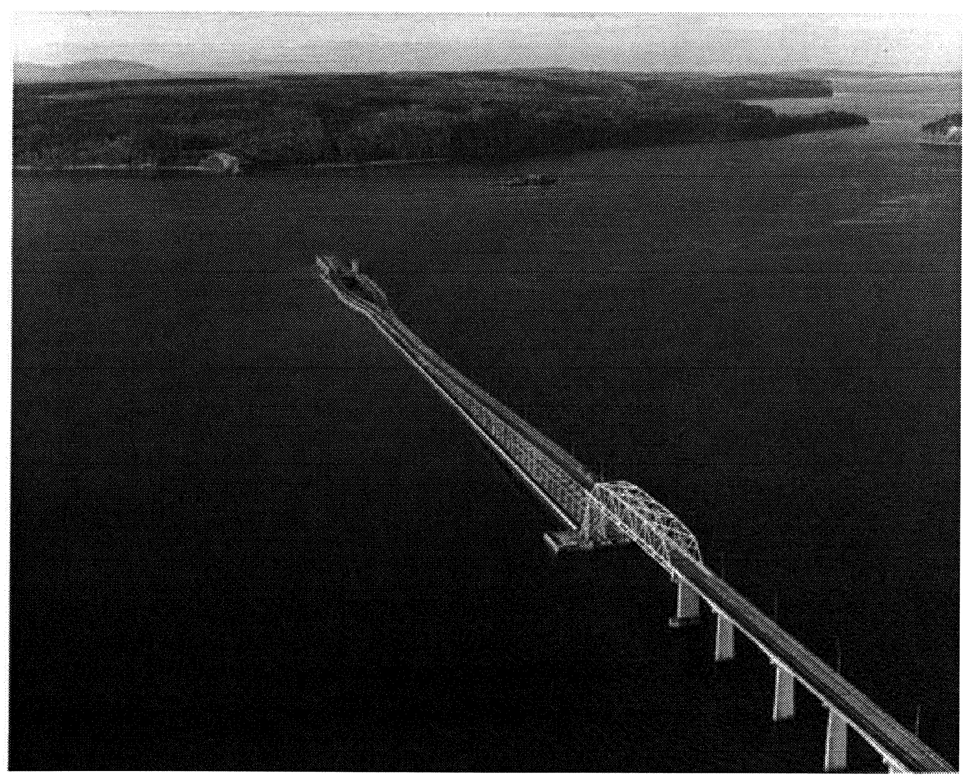


Photograph 5: Rebuilt Lacey V. Murrow Bridge and the new Homer Hadley Bridge.

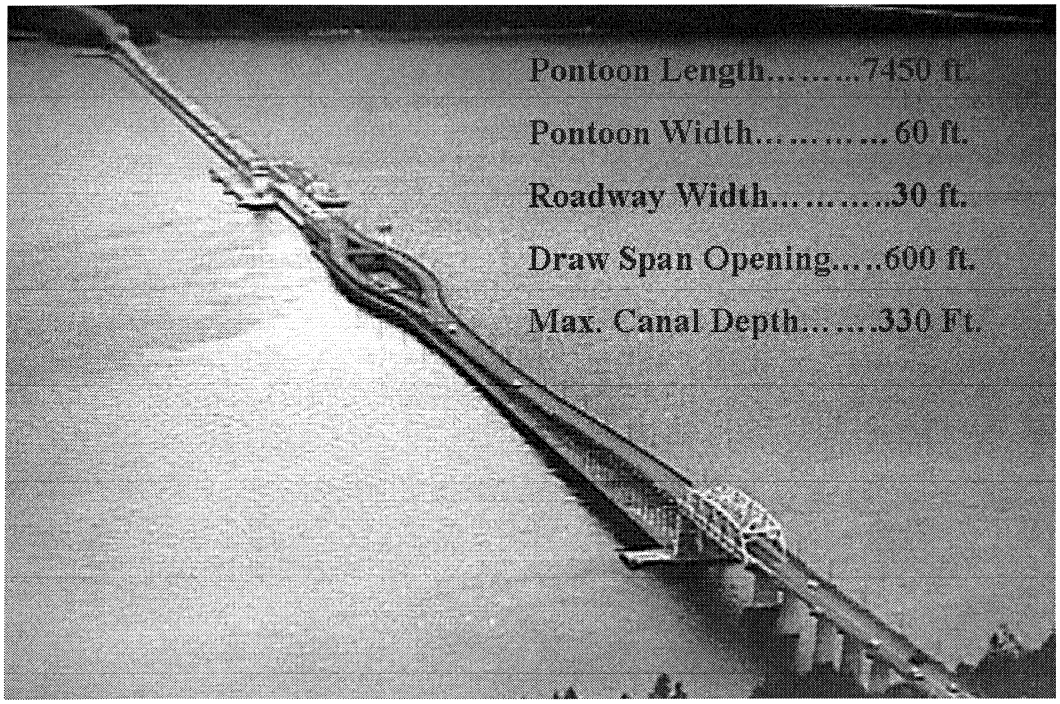
Photograph 6: Original Hood Canal Bridge. 1961.



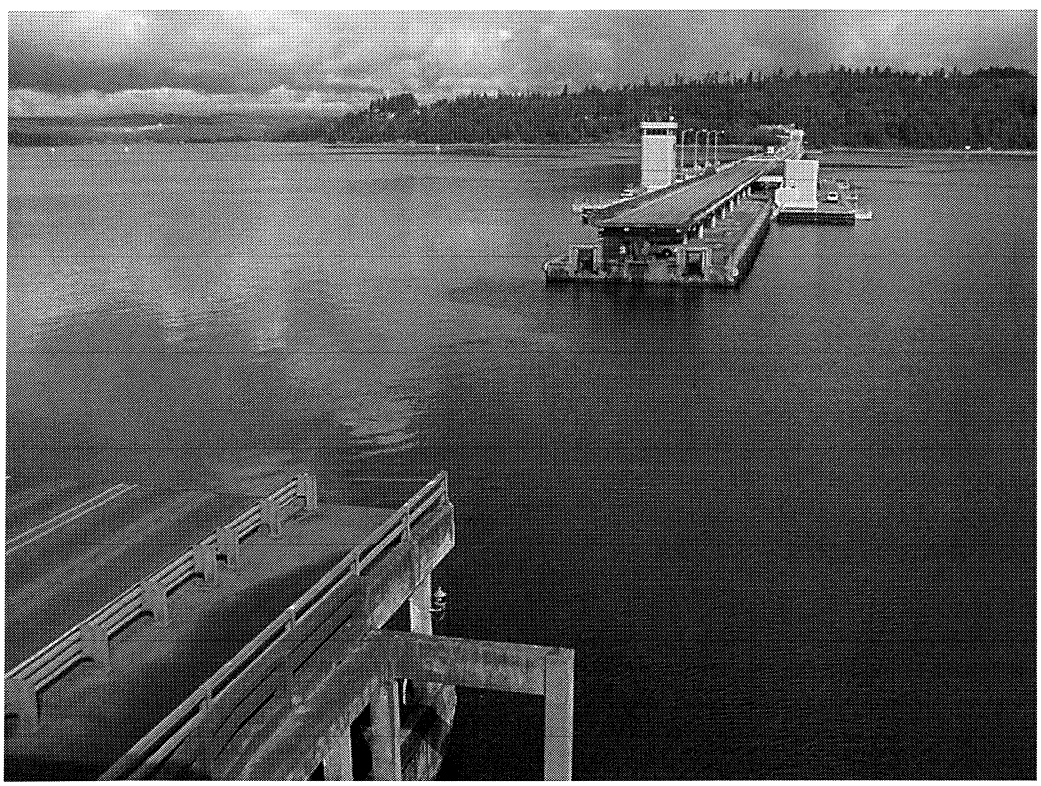
Photograph 7: Storm at Hood Canal.



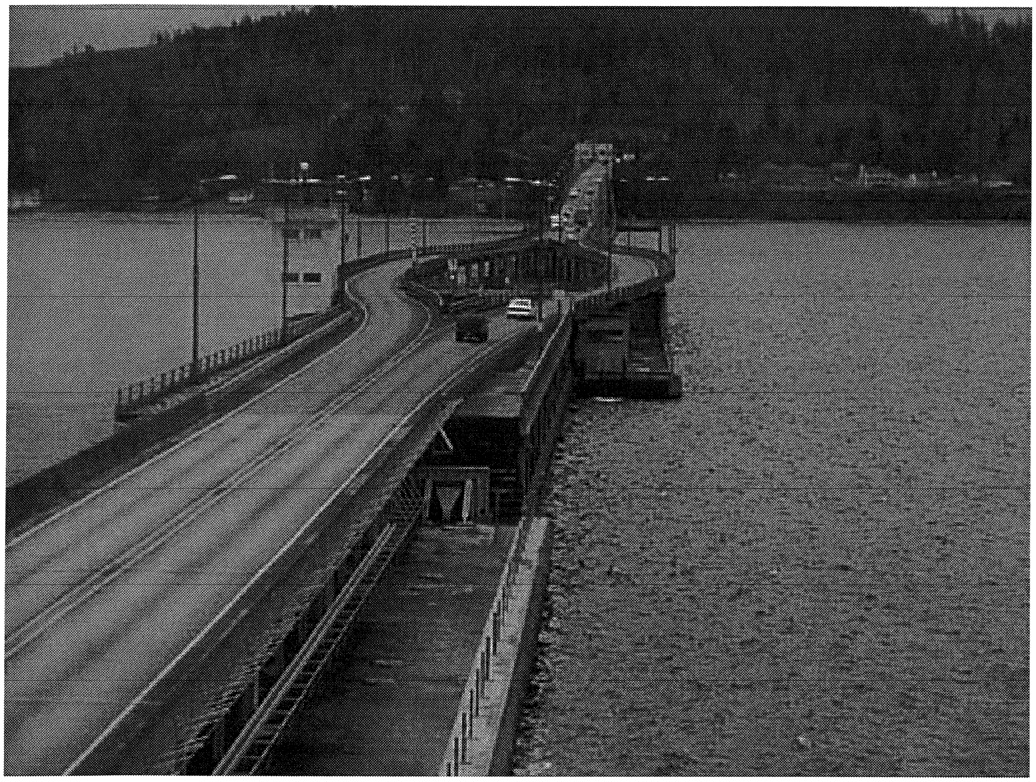
Photograph 8: Hood Canal Bridge with West half missing. 1979.



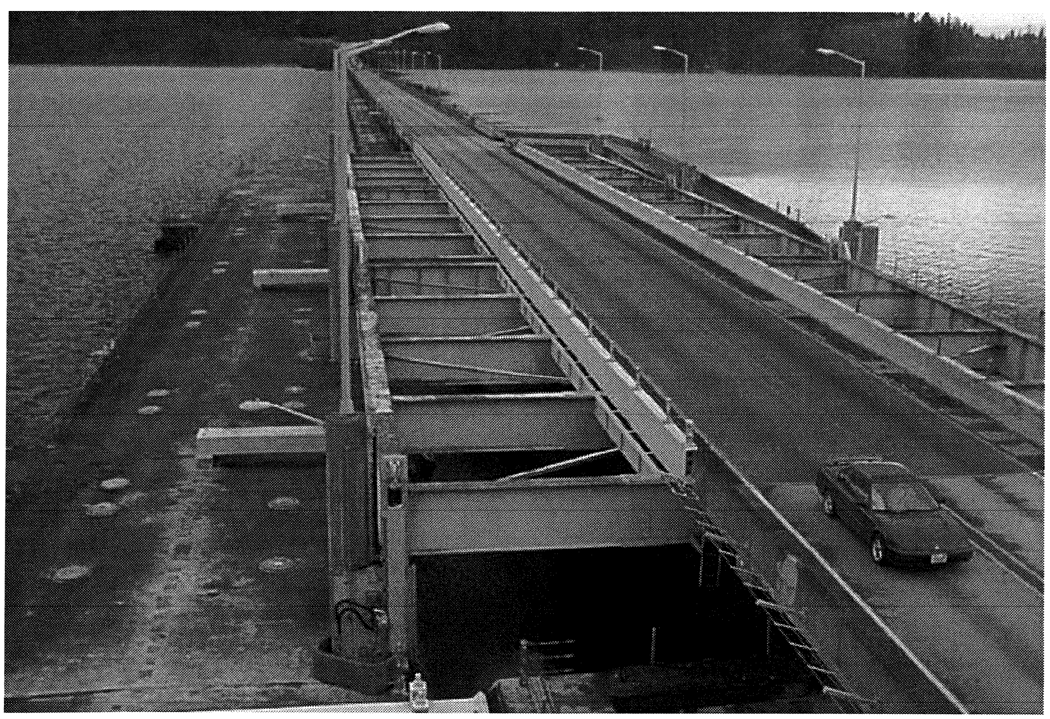
Photograph 9: Hood Canal Bridge with West half replaced. 1982.



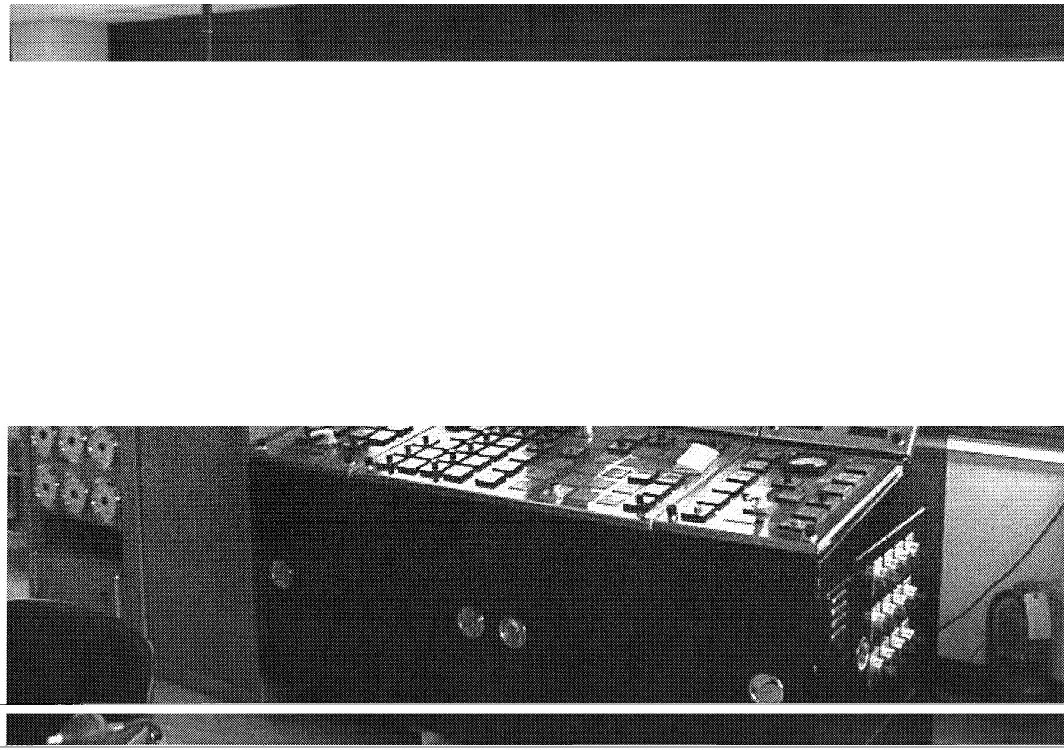
Photograph 10: Draw spans open 600 feet.



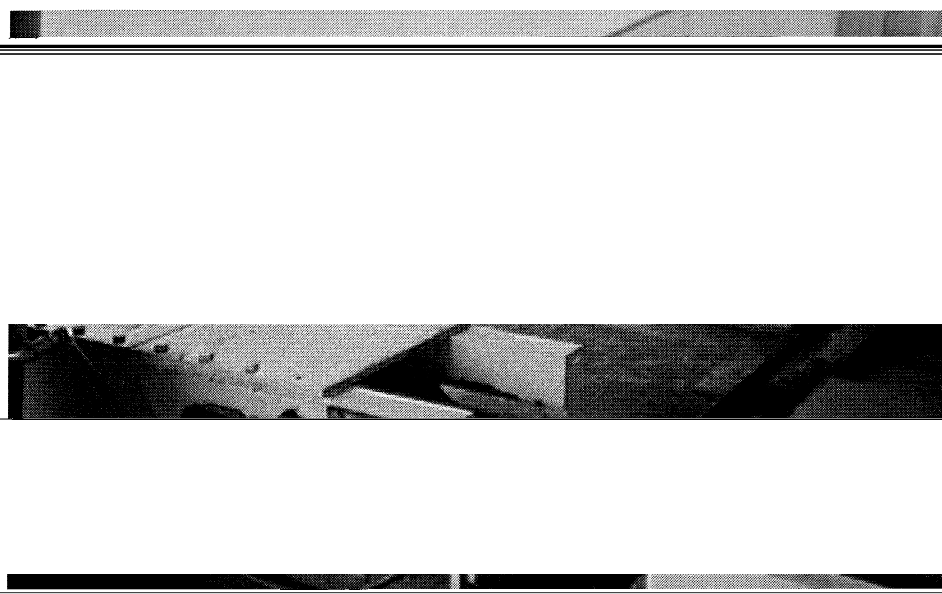
Photograph 11: "Tuning Fork" at East Half for retracting draw span.

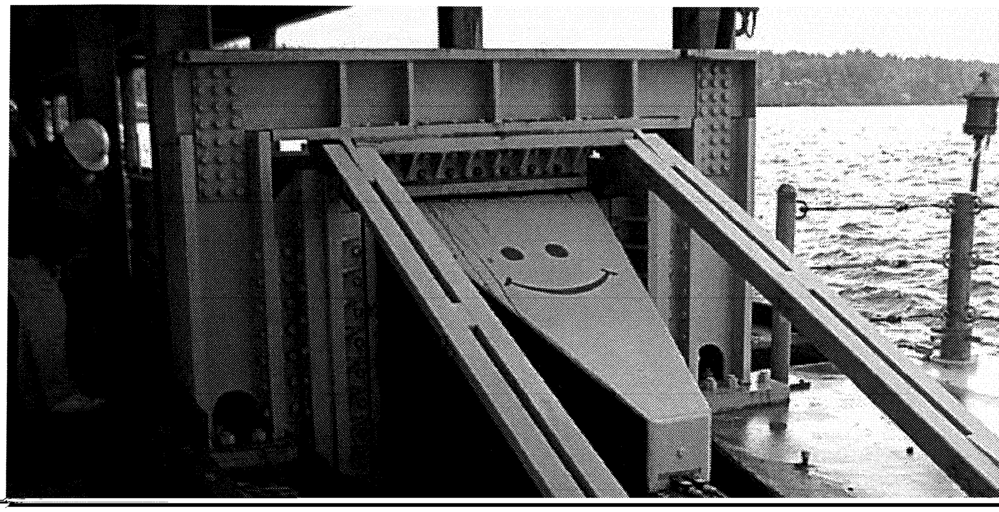


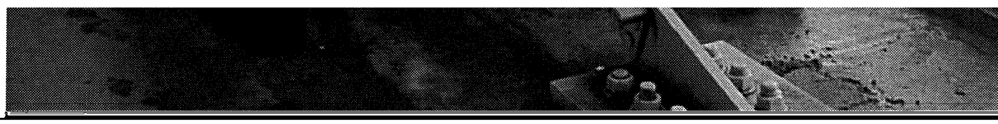
Photograph 12: Hydraulically operated lift spans at West half.

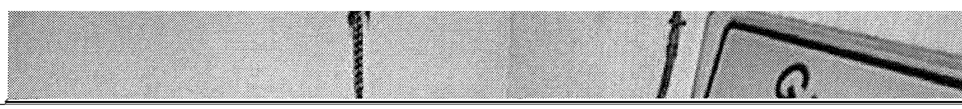


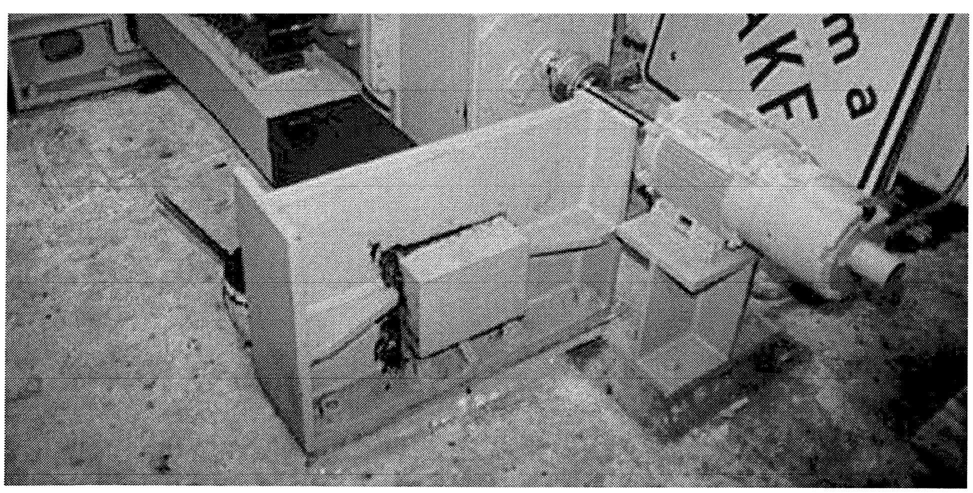
Photograph 13: Hood Canal Bridge Control Desk.



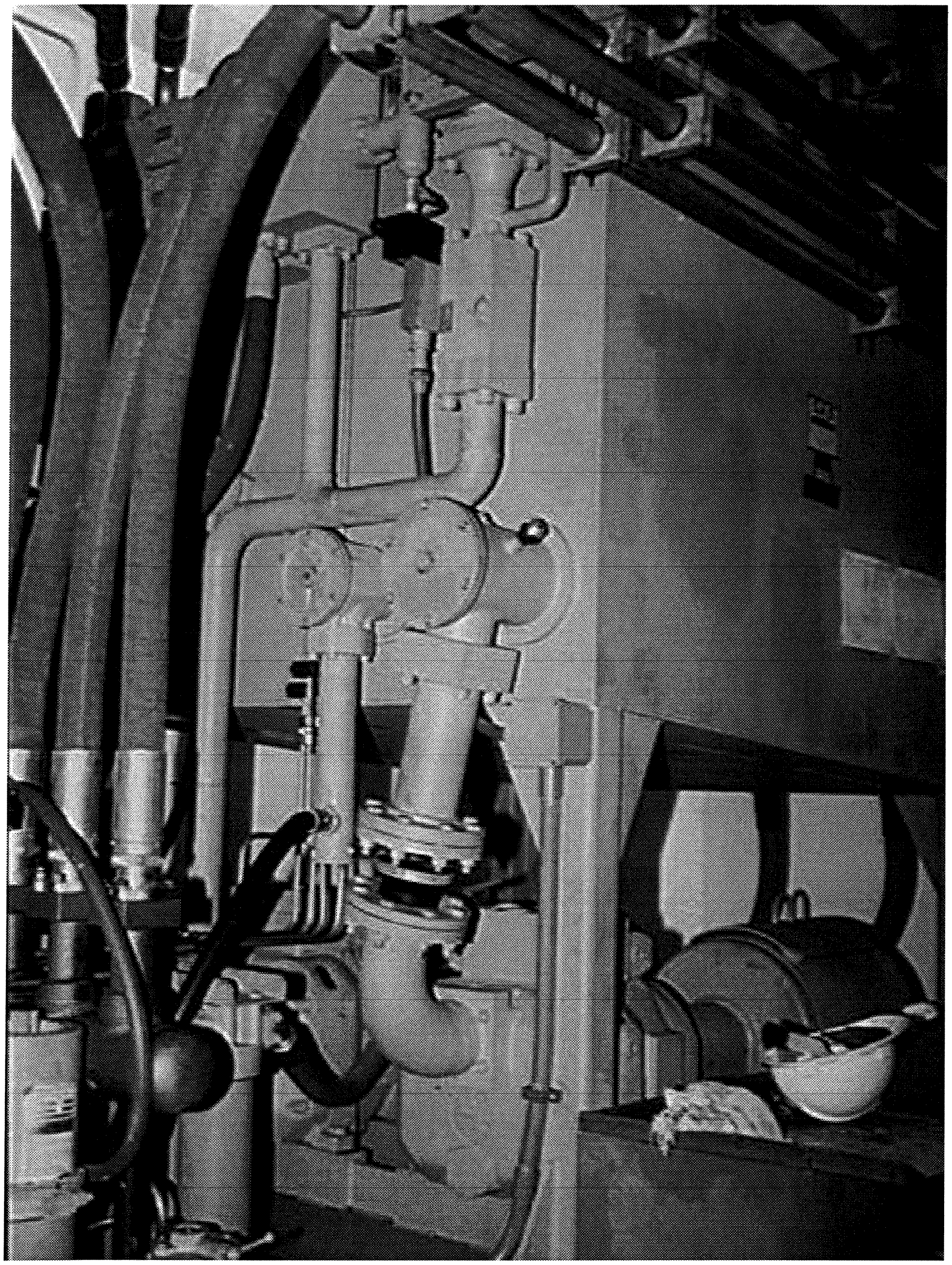




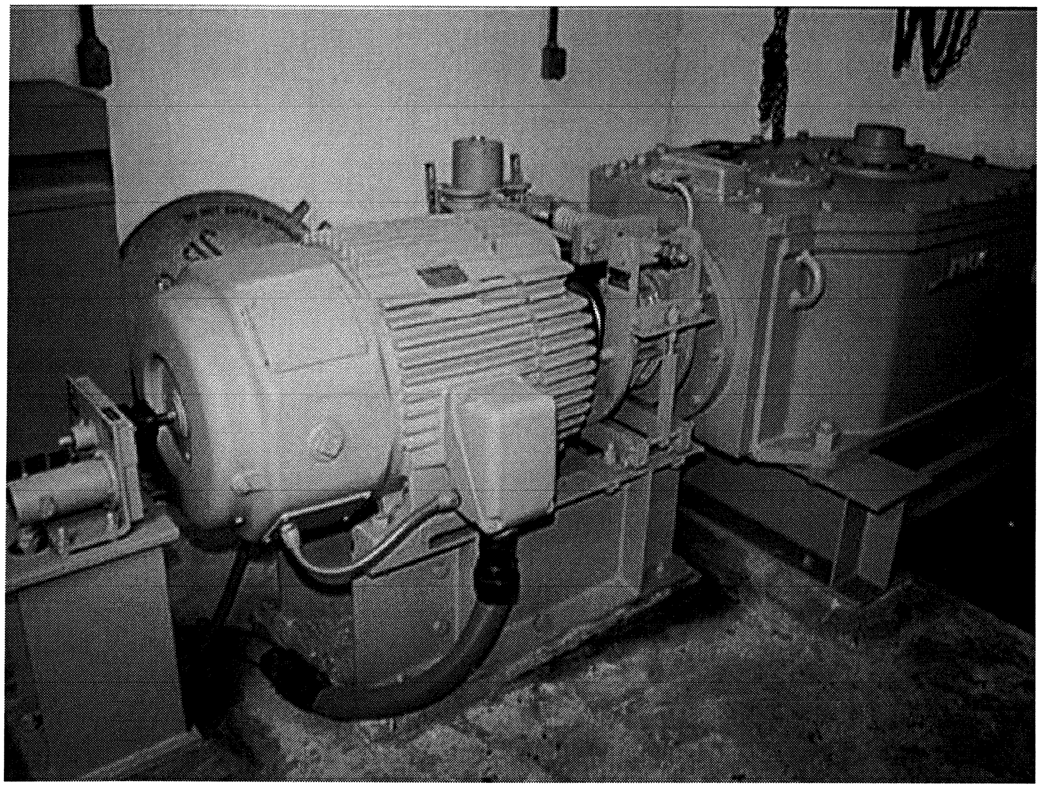




Photograph 16: End lock machinery for West half.

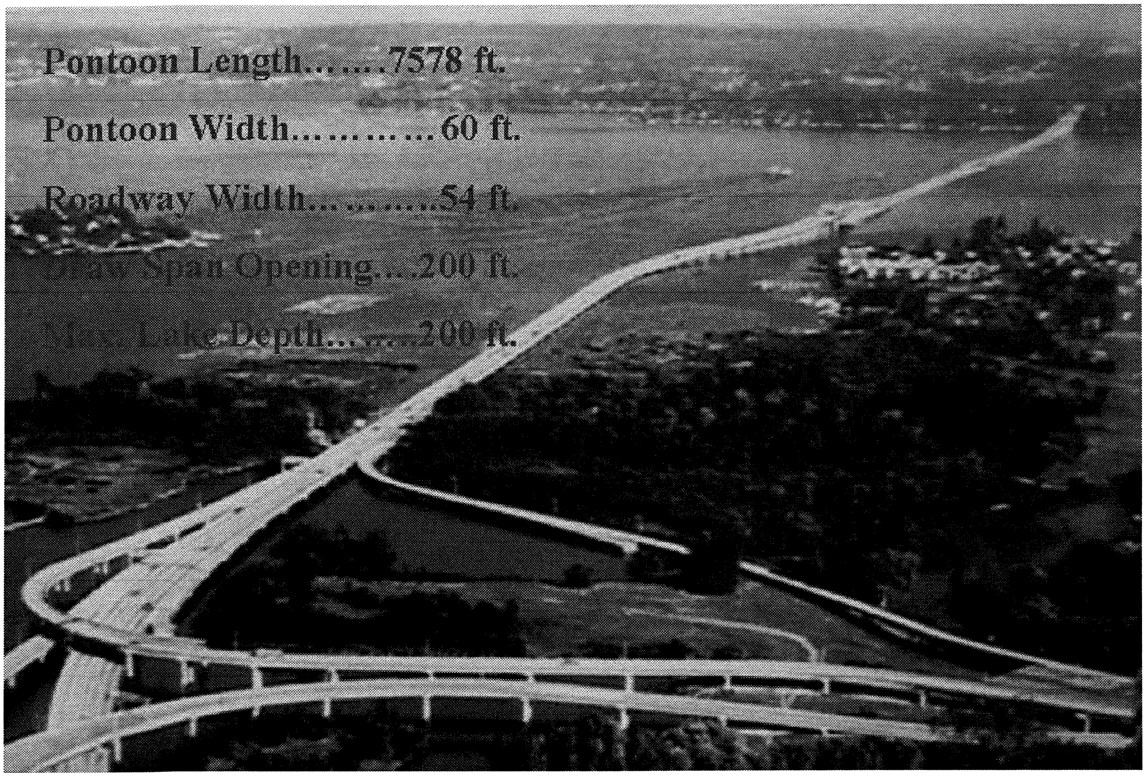


Photograph 17: Lift deck HPU.

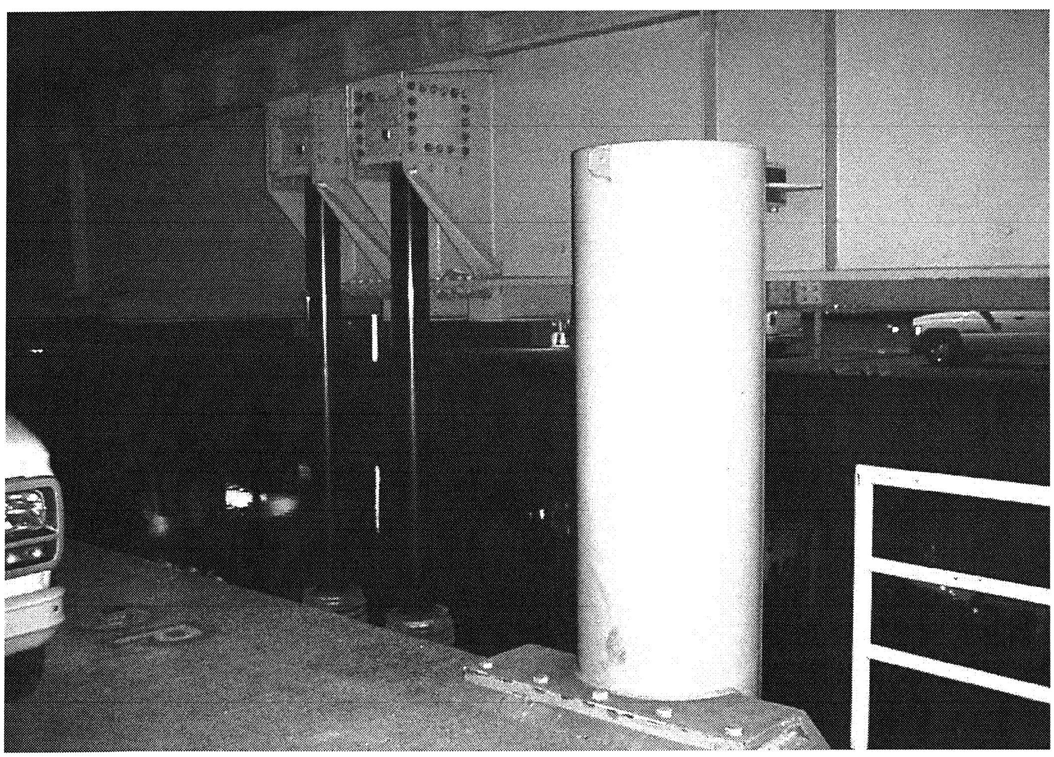


Photograph 18: West draw span drive machinery.

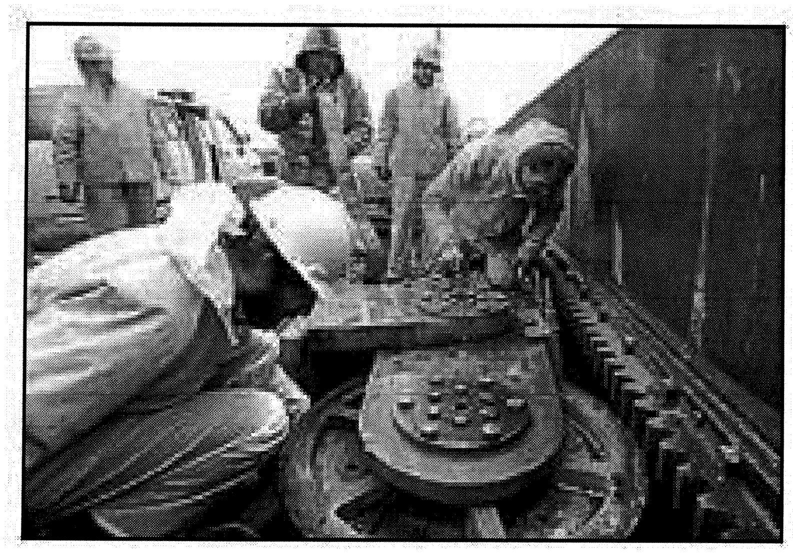
Photograph 19: West draw span guide rollers, guide track, and rack.



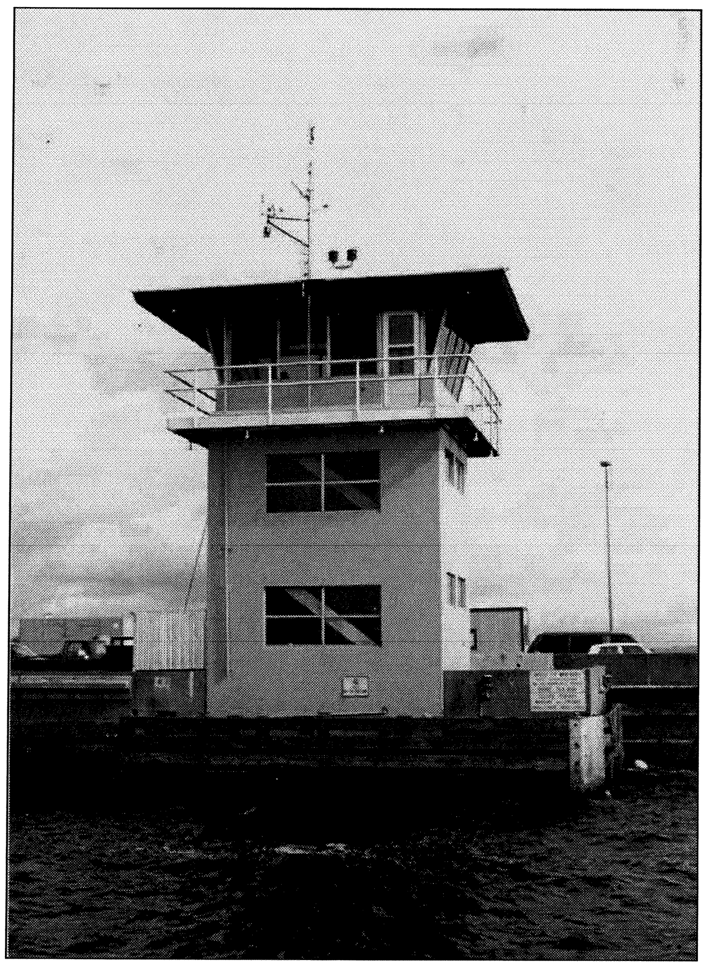
Photograph 20: Evergreen Point Bridge. 1963.



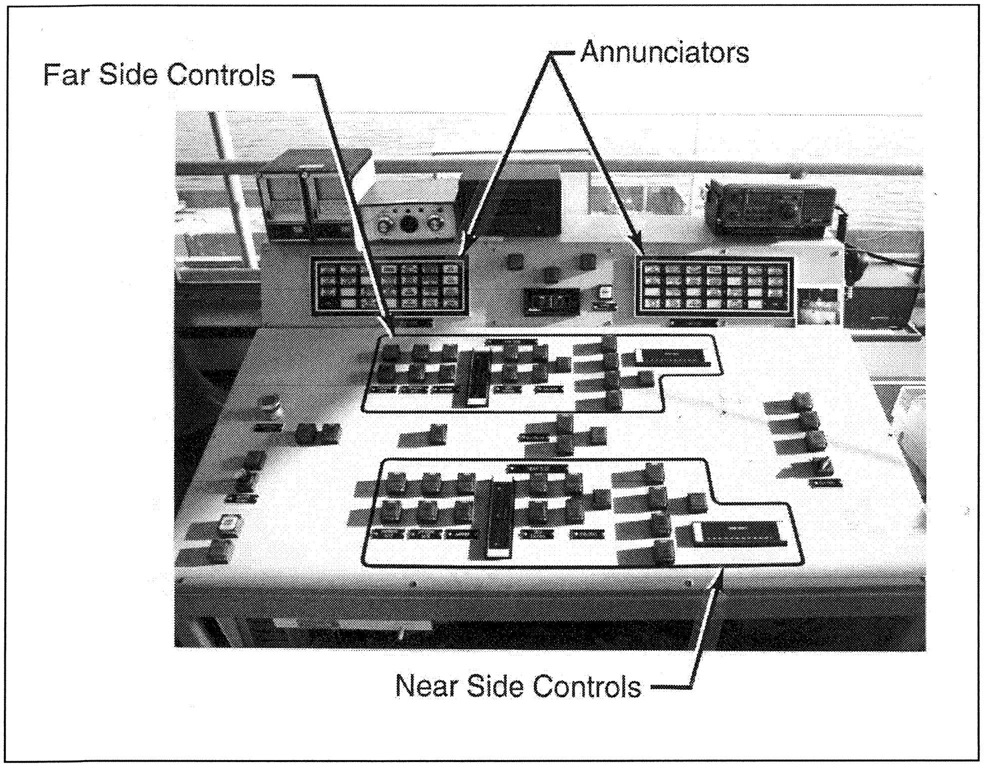
Photograph 21: Hydraulic lift cylinders and lift deck guides.



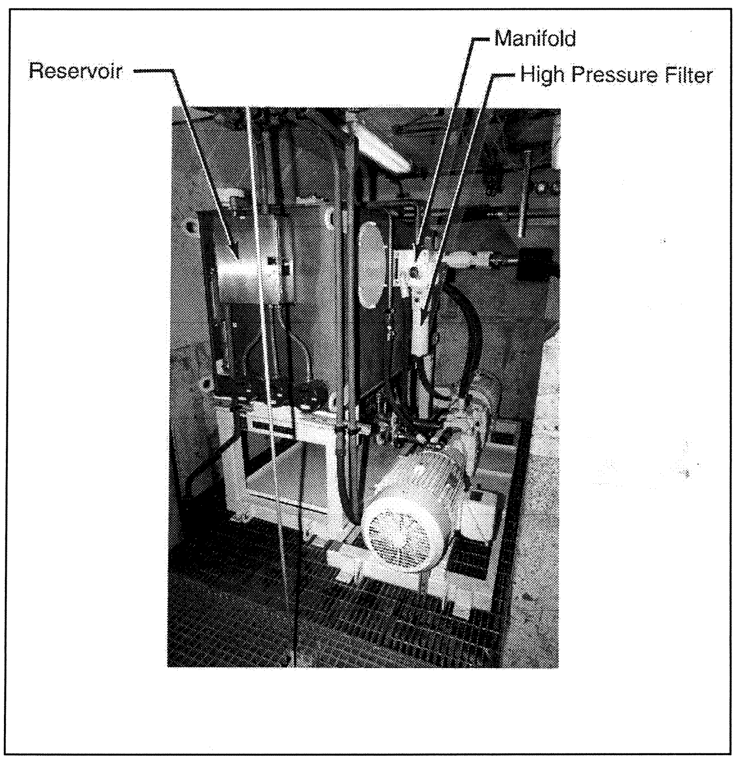
Photograph 22: Repairing damaged horizontal guide roller. 1999



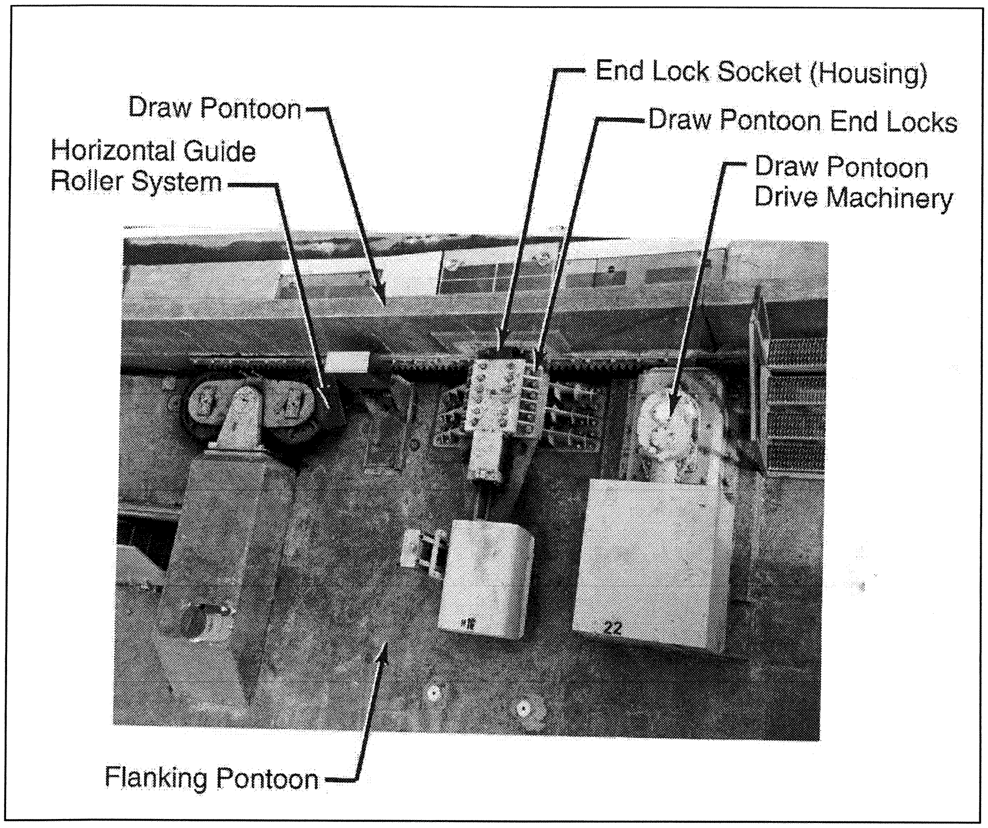
Photograph 23: Evergreen Point Bridge Control tower.



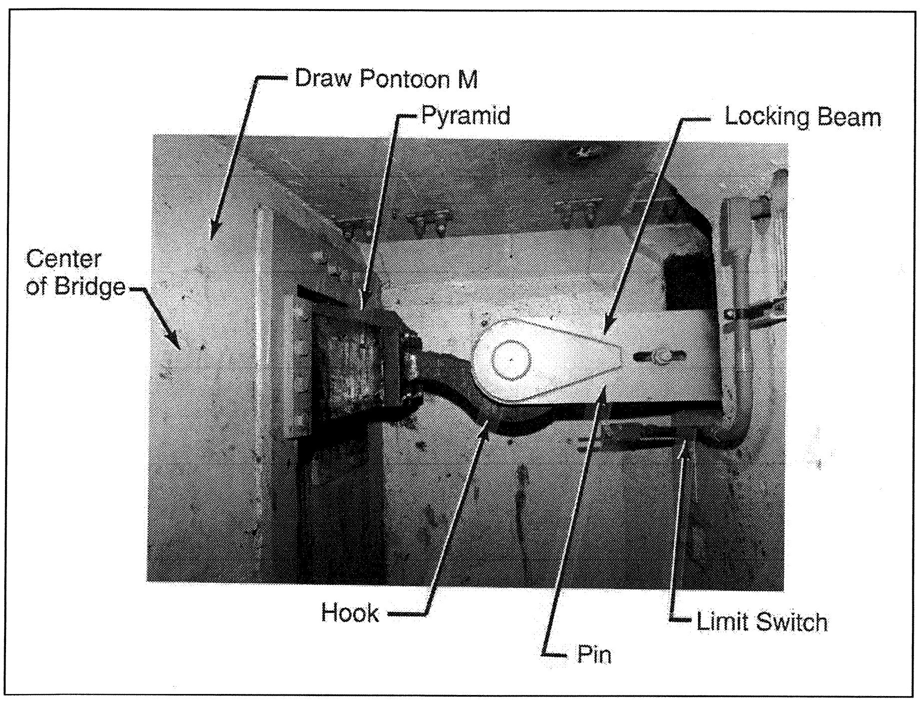
Photograph 24: Evergreen Point Bridge Control Desk.



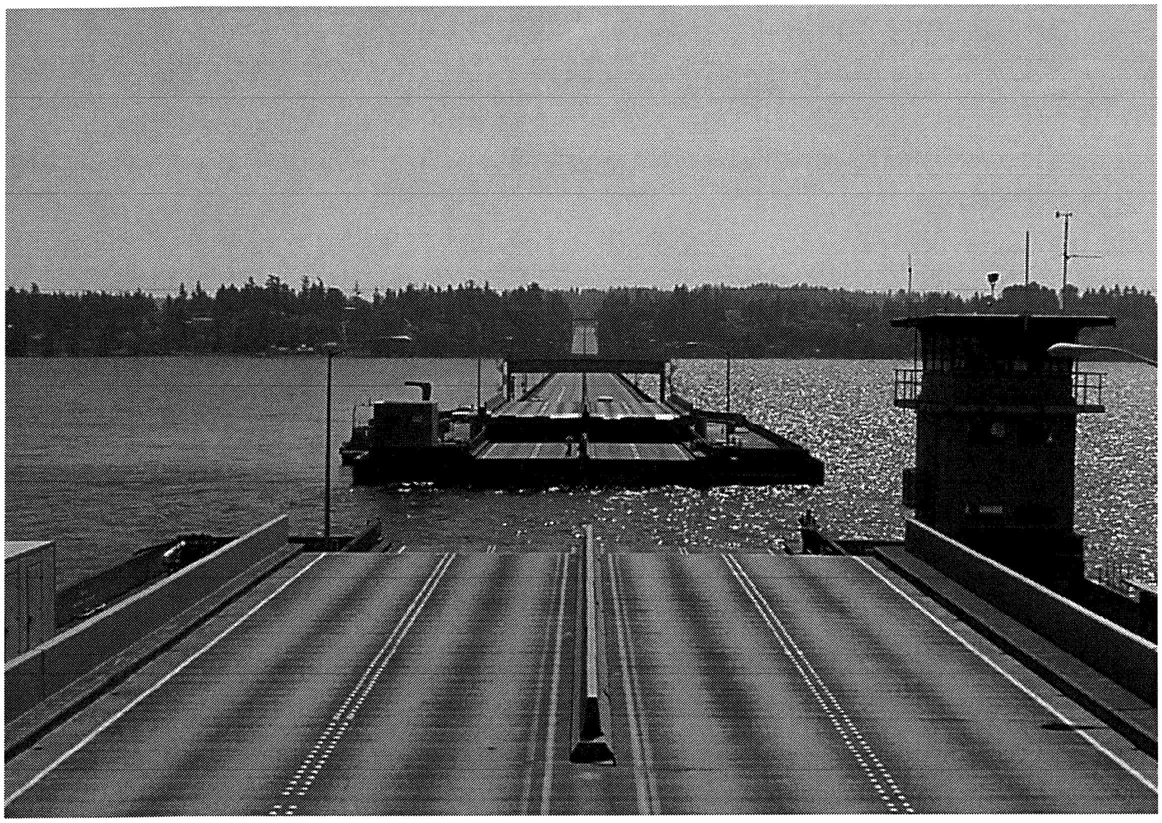
Photograph 25: Typical lift deck HPU.



Photograph 26: Drive machinery, end lock machinery, and horizontal guide roller.



Photograph 27: Center lock hook engaged with lock bar.



Photograph 28: Draw spans retracted for a 200 foot opening.