Heavy Movable Structures, Inc.

SIXTH BIENNIAL SYMPOSIUM

October 30 - November 1, 1996

Doubletree Resort Surfside
Clearwater Beach, Florida

Unique Moving Bridge on the A29 Motorway, LeHavre, France

by

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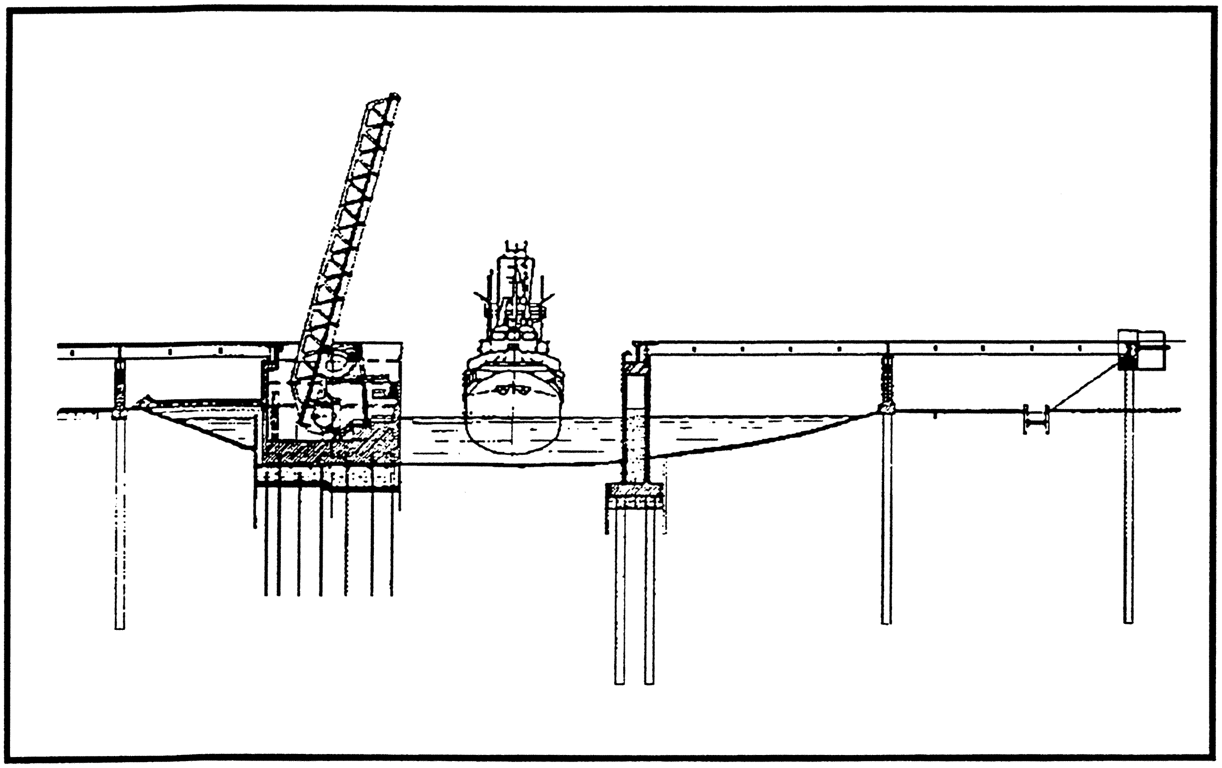
UNIQUE MOVING BRIDGE ON THE A29 MOTORWAY LEHAVRE - FRANCE



HEAVY MOVABLE BRIDGES SYMPOSIUM

OCTOBER - 1996

CLEARWATER BEACH

USA

E. ALLANSON
OILGEAR TOWLER
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ENGLAND

A new Autoroute, the A29, was to be built passing through the outskirts of LeHavre in Northern France. The objective was to construct a fast highway to feed the coastal areas of the region, considerably reducing travelling time across the Seine Estuary (see Figure One).

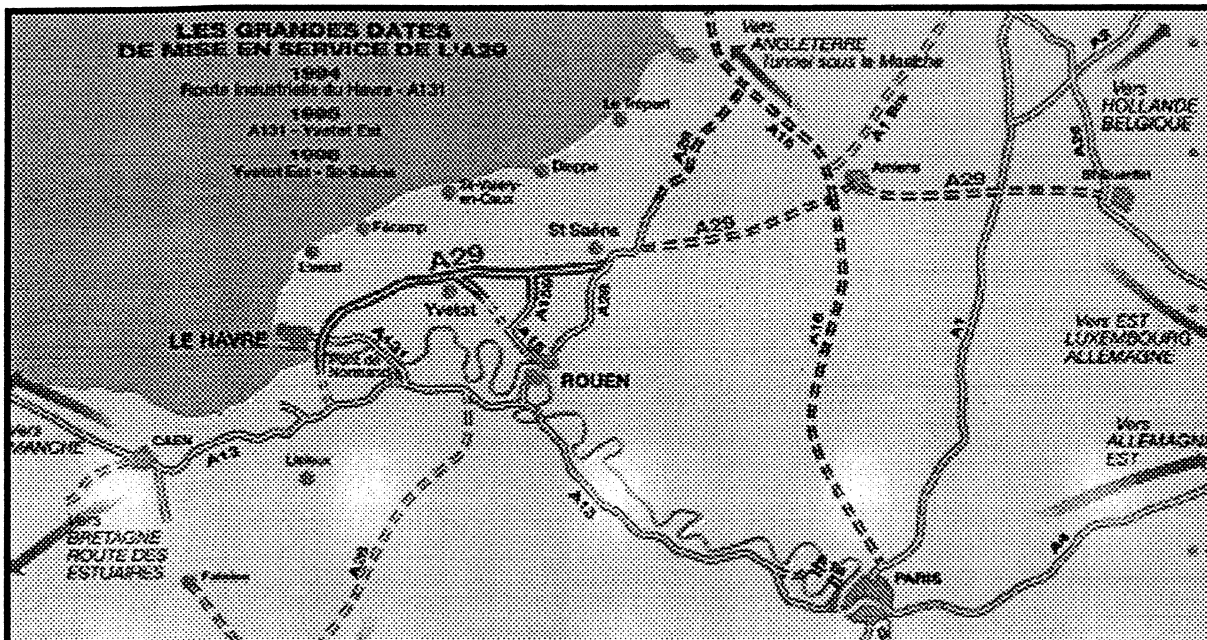

Figure One

A major problem to overcome was the crossing of three waterways within a few miles of one another - the River Seine, the Canal du Havre and the Tancarville Canal (see Figure Two).
The crossing of the Seine and du Havre canal were made using fixed bridges. The Seine bridge - Pont de Normandie is believed to be the largest in the world of its type (direct wire suspension from towers) with a span of 800 metres (2600 ft). The crossing at the Canal du Havre is a fixed viaduct design some 50 metres clear of the water.

The Tancarville crossing was to prove to be a far more taxing problem. A viaduct or fixed bridge was ruled out. It would have had to have adequate shipping clearance and this could not be achieved within the space and approach available. On one side of the location was a chemical plant and on the other an oil refining plant. French Industrial security laws restrict the use of tunnels in such an environment due to the possibilities of leaking pollution or gas entering the tunnel.

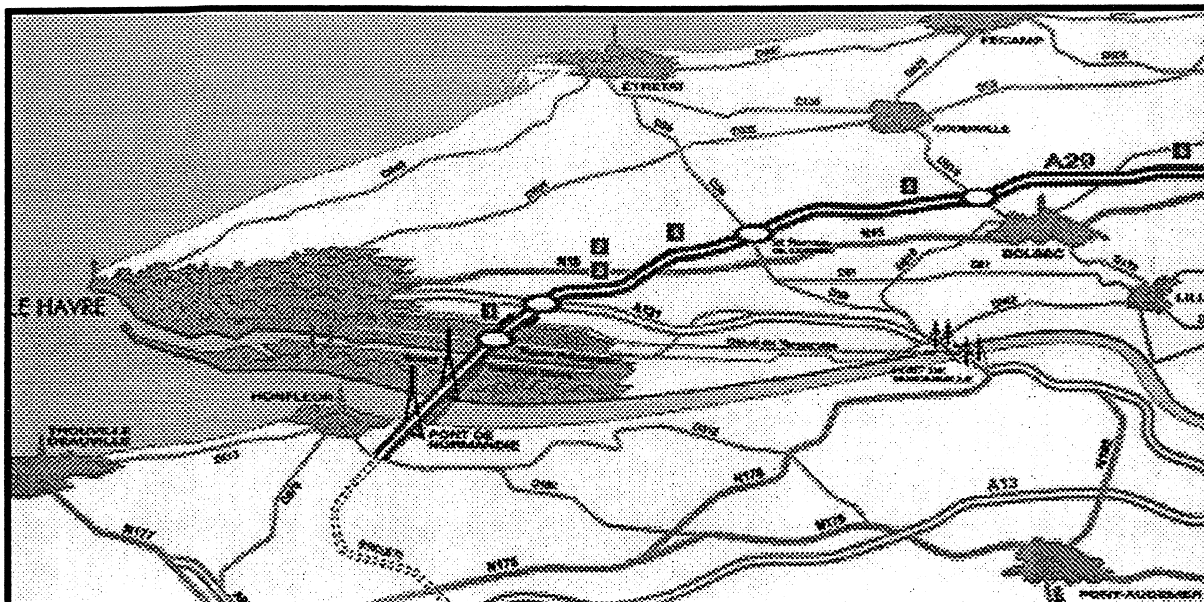

Figure Two

The solution derived was a moving bridge. The concept of using a moving bridge on a motorway had never been used in France before.

The bridge was to be designed with sufficient height to permit normal canal shipping to pass without opening (10 metres), opening only being required for the occasional special vessel. The Tancarville Canal feeds the port of Le Havre and has lock gates at the river Seine entrance. These gates and the lock are serviced by a floating crane, normally moored at the LeHavre port. This is typical of the type of vessel for which the bridge would be opened. The river traffic is normally 40 to 50 vessels per day, but the bridge requires opening only once a day or even less.

A Swing bridge was ruled out. There was a requirement to have individual bridge leaves for each direction of road traffic. This would ensure limited road opening in the event of one failure. A swing bridge of this nature would require excessive ground area and costs would be very high.

A major concern was the ability of the design to withstand the constant vibration loading, generated from the expected heavy fast moving traffic. The Engineers were aware that a local moving bridge on a busy highway had suffered structural damage around the pivot area due to high vibration loading.

The concept of balancing a lifting bridge to reduce power requirements is all very well, but obviously reduces the preponderance at the nose and increases the loads at the rear pivot positions when lowered into the road position.

To ensure a high positive preponderance and overcome any tendency to move under vibration, a totally new concept of balance was designed.

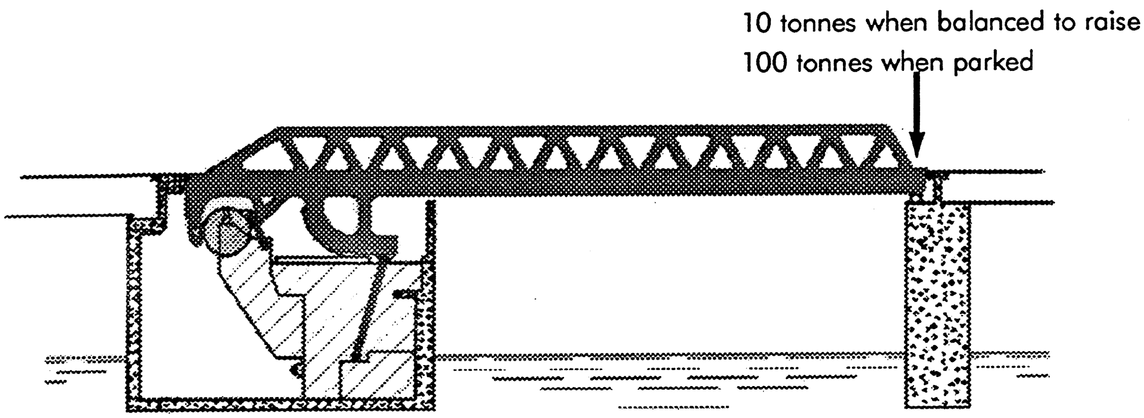

Figure Three

The counterbalance weight would only be applied when the bridge was being raised. When in the lowered position the counterweight would be repositioned to be supported totally upon the concrete civil supporting structure.

Thus the total weight of the bridge was redistributed (see Figure Three).

The Scherzer Design was chosen for its reliability and low cost. The local Le Harve Port Authority were familiar with this design and had expressed a preference for it.

The total elevated section of the highway would be 220 metres (720 ft) between abutments. The moving span would be central with a shipping passage of 35 metres (115 ft), the canal is 115m (377 ft) wide. Each bridge is 13.2 m wide (43 ft) for two lanes of traffic plus one emergency slow lane, and 54 m (180 ft) long.

The Eiffel company of Paris were awarded the contract to design and manufacture the bridge. The subcontract for design and manufacture of the hydraulics was placed with Oilgear Towler.

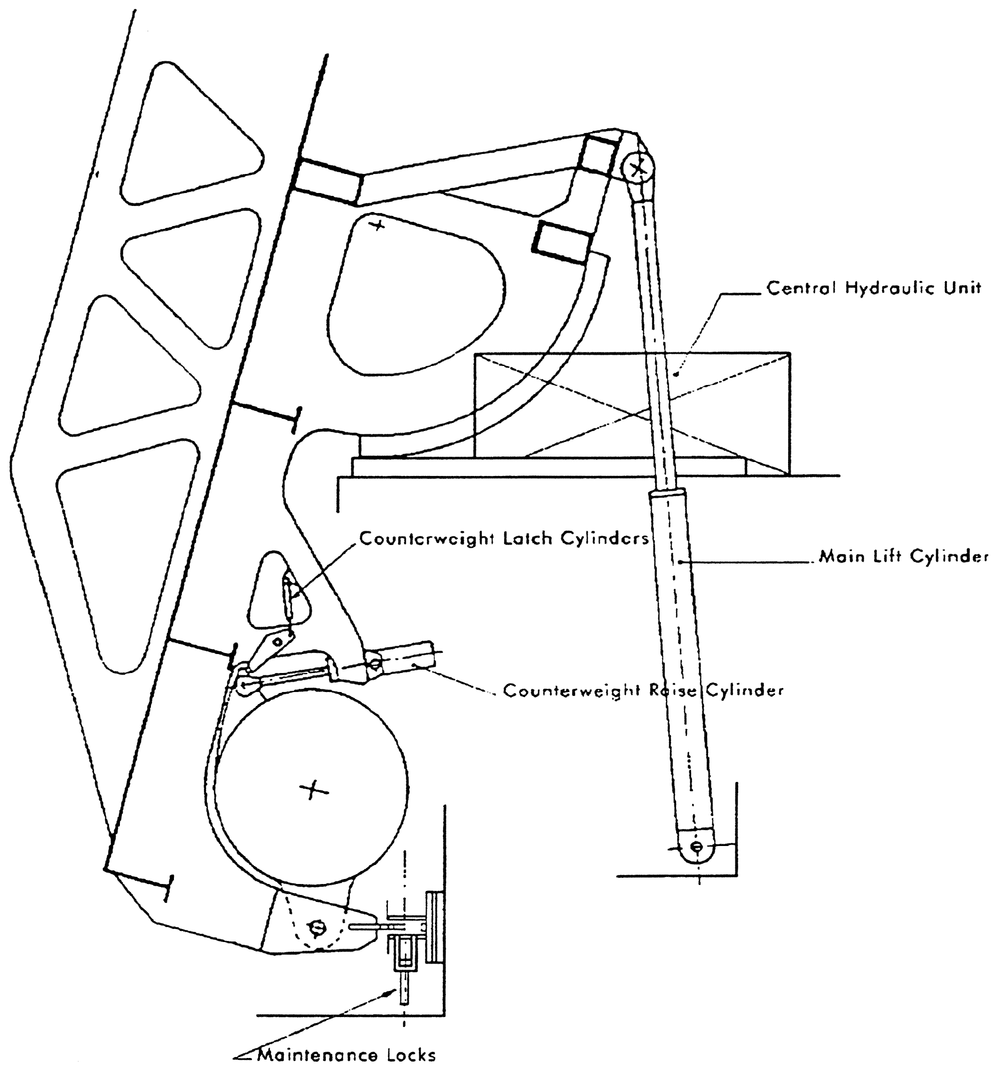

Figure Four

BRIDGE DESIGN

The bridge (Figure Four) is based upon the Scherzer Principal operating through quadrant gears and racks, raising on two centrally positioned hydraulic cylinders. The counterweight is of a pivoted cylindrical design and operated through two further cylinders.

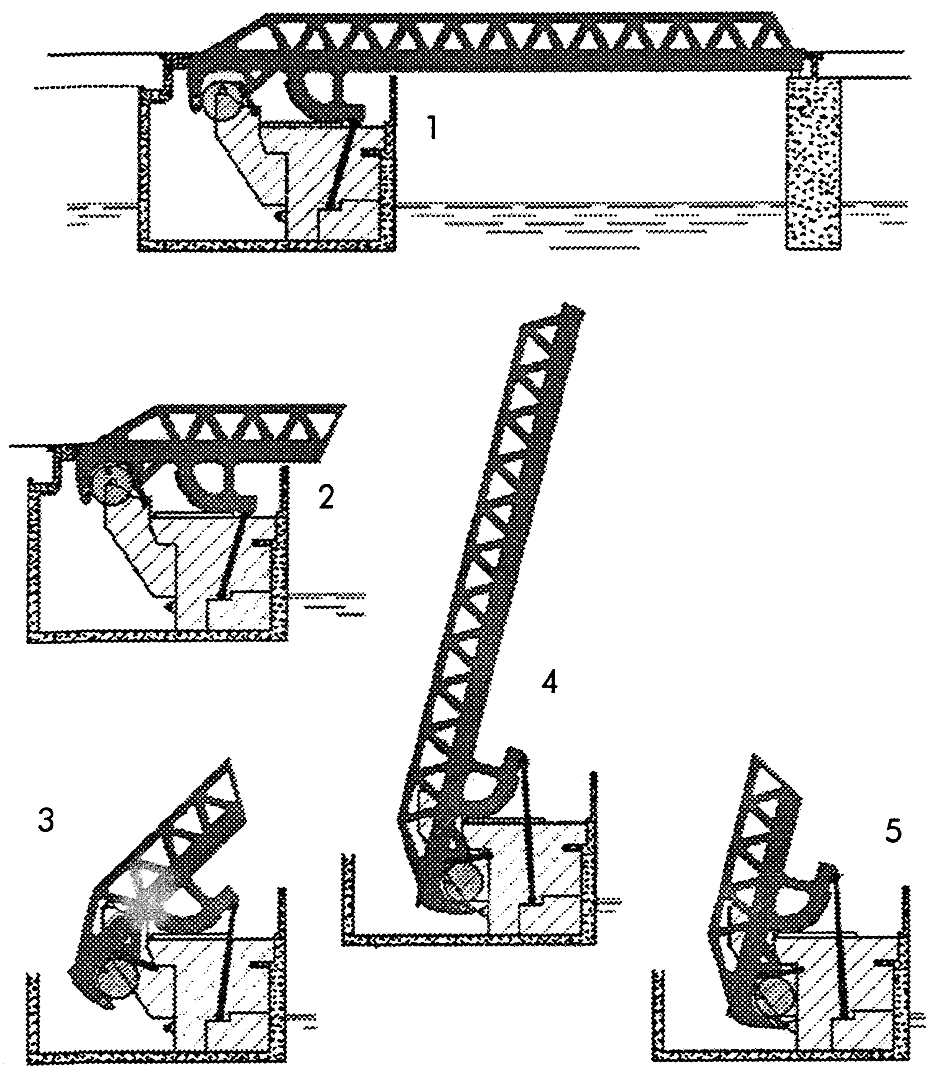

Figure Five

On Figure Five

1. The bridge is in the road service position. The counterweight is supported upon the civil abutment and the nose preponderance is 100 tonnes.
2. Preparation to raise. The counterweight is hydraulically raised, its weight now transferred and acting directly upon the bridge span. The preponderance at the nose is now reduced to 10 tonnes.
3. The bridge is raised on the main hydraulic cylinders.
4. The bridge is at the normal 75 degree fully open position.
5. The bridge may be raised a further distance and the tail locked, for maintenance only.

Each of the moving spans weigh 500 tonnes and each counterweight a further 500 tonnes. The counterweight has fixed ballast of 400 tonnes with adjustable ballast compartments of 40 tonnes. The filling is an high density inert non corrosive material.

The bridge will raise and lower fully in 3.5 minutes in normal wind conditions. The maximum operational wind condition is 120 km/hr (70mph).

HYDRAULIC DRIVE SYSTEM

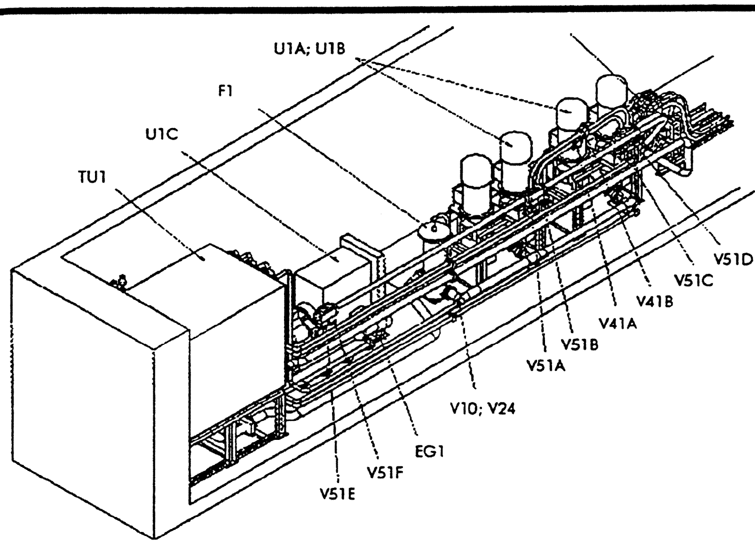

Figure Six

Both bridges are driven from a common centrally located hydraulic power pack (see Figure Six).

The normal working pressure is a maximum of 170 bar (2500 psi), but the design for emergency conditions, single cylinder operation in the highest winds cater for 350 bar (5000psi).

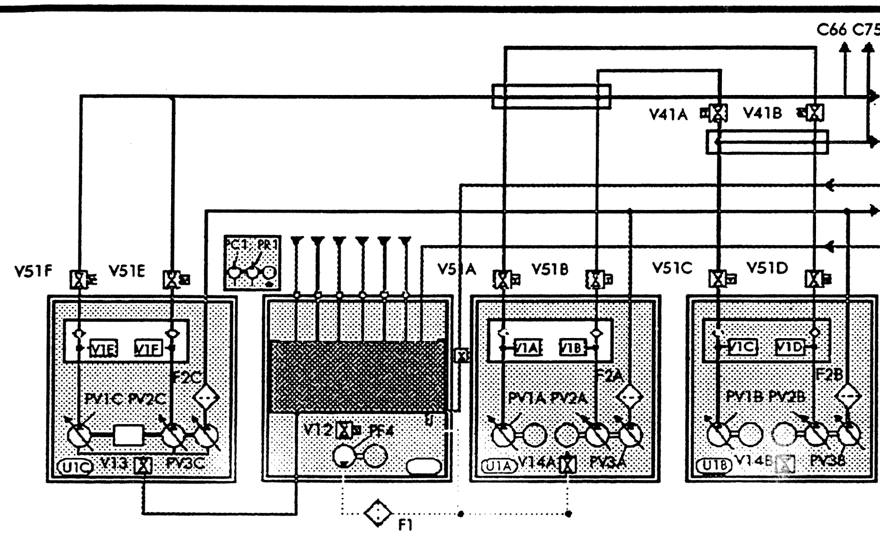

Figure Seven

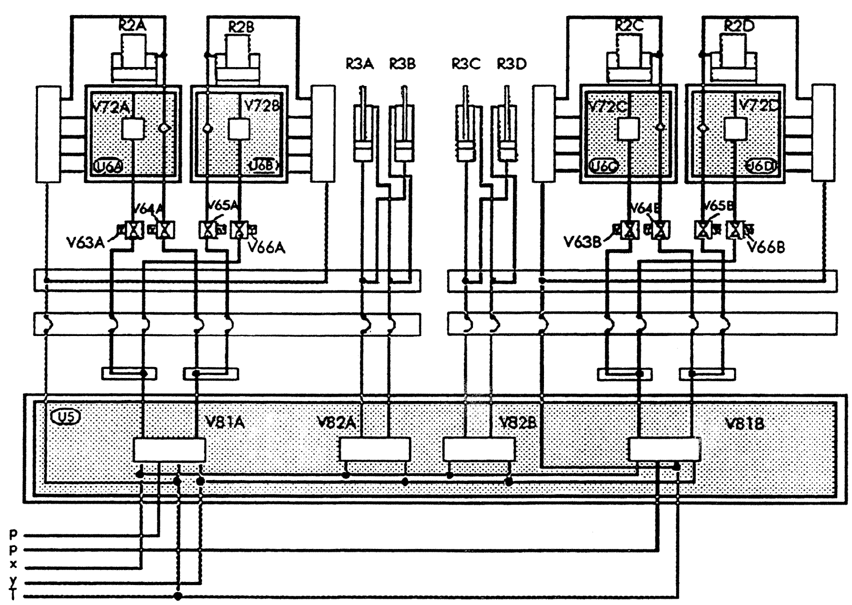

Figure Eight

The principal components of the hydraulic system are:-

a) The Supply tank and pumps (see Figure Seven).

An oil supply tank with temperature controls, level switches, a 3000 l/m boost/circulation pump and full flow filtration. Oil is fed to the four main, vertically mounted Oilgear PVV540 variable delivery axial piston pumps. Each is set to deliver 320 l/m up to 350 bar maximum pressure. They are driven by 55kw 1000rpm electrical motors. Flow control of the pumps is via an electro-hydraulic servo valve. Off loading and maximum pressure valves (V1) are mounted locally to each pump. The pumps are power limited - that is, they give maximum flow available within the restrictions of the motor power and governed by the pressure generated (see Figure Eight).
In addition to the motorised pump units is an emergency diesel engine driven dual pump unit. The 180 kw engine drives two PVV540 pumps through a double output reduction gearbox.

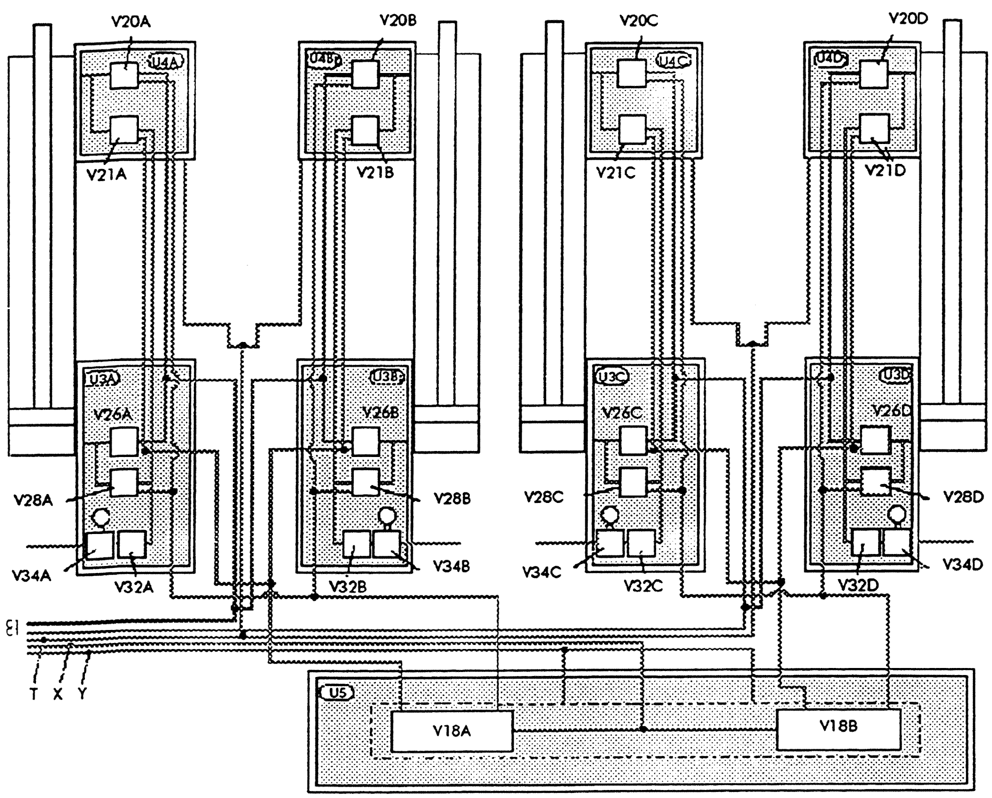

Figure Nine

b) Flow is diverted to the selected counterweight cylinders through a manifold valve block (see Figure Nine).

At each cylinder are directly mounted the valve blocks which support the counterweight. To lower the counterweight, the lock cylinders (R3A/D) are retracted and oil is fed into the annulus of the counterweight cylinders (R2A/D). Oil from the piston side is forced over the relief valves (V72A/D), ensuring a controlled lower operation. Each cylinder is raised and lowered within 90 seconds.

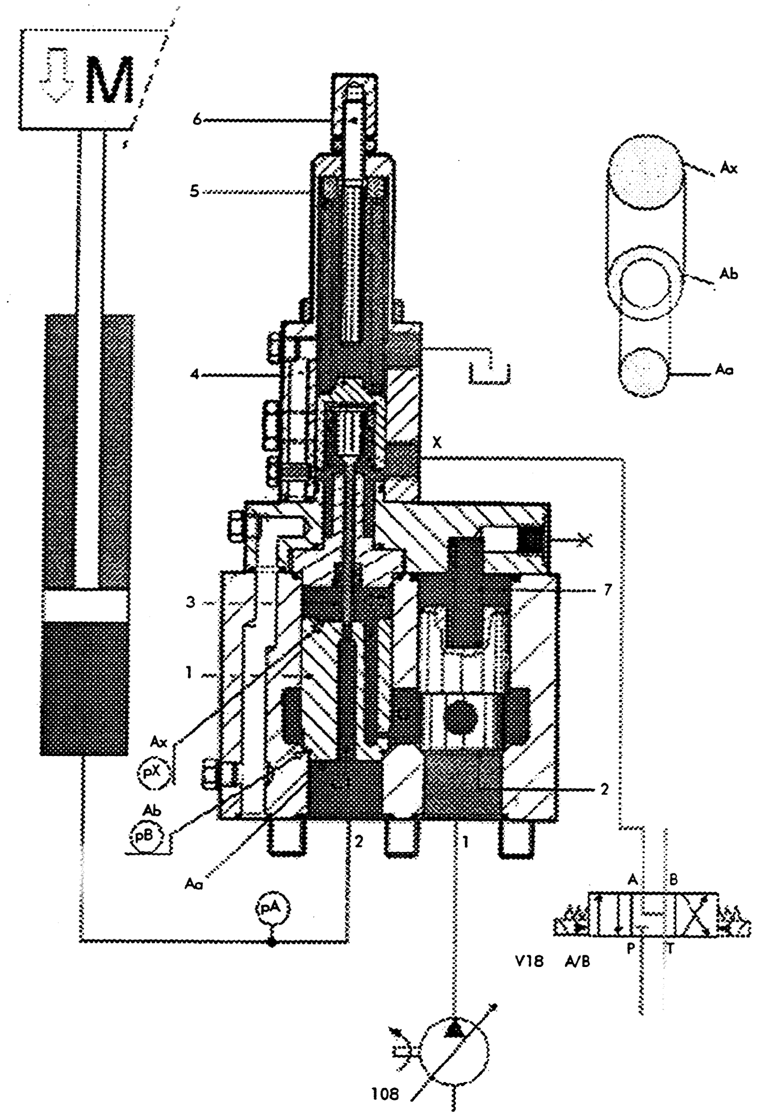

Figure Ten

c) The pump flow is also diverted to the selected main lift cylinders through a manifold valve block (See Figure Ten).

The manifolds are directly mounted to the cylinders for safety reasons. On the top block are admission, outlet and safety relief valves. The admission valves (V20) and outlet (V21) are ultra safe Oilgear Towler Amplifier seated valves (See Figure Eleven). On the lower block are similar valves (V26/V28) and the flow control valves V32 and V34. Oil is fed from the cylinder, depending upon direction of movement, from the annulus or piston, to the reducer valve V32.

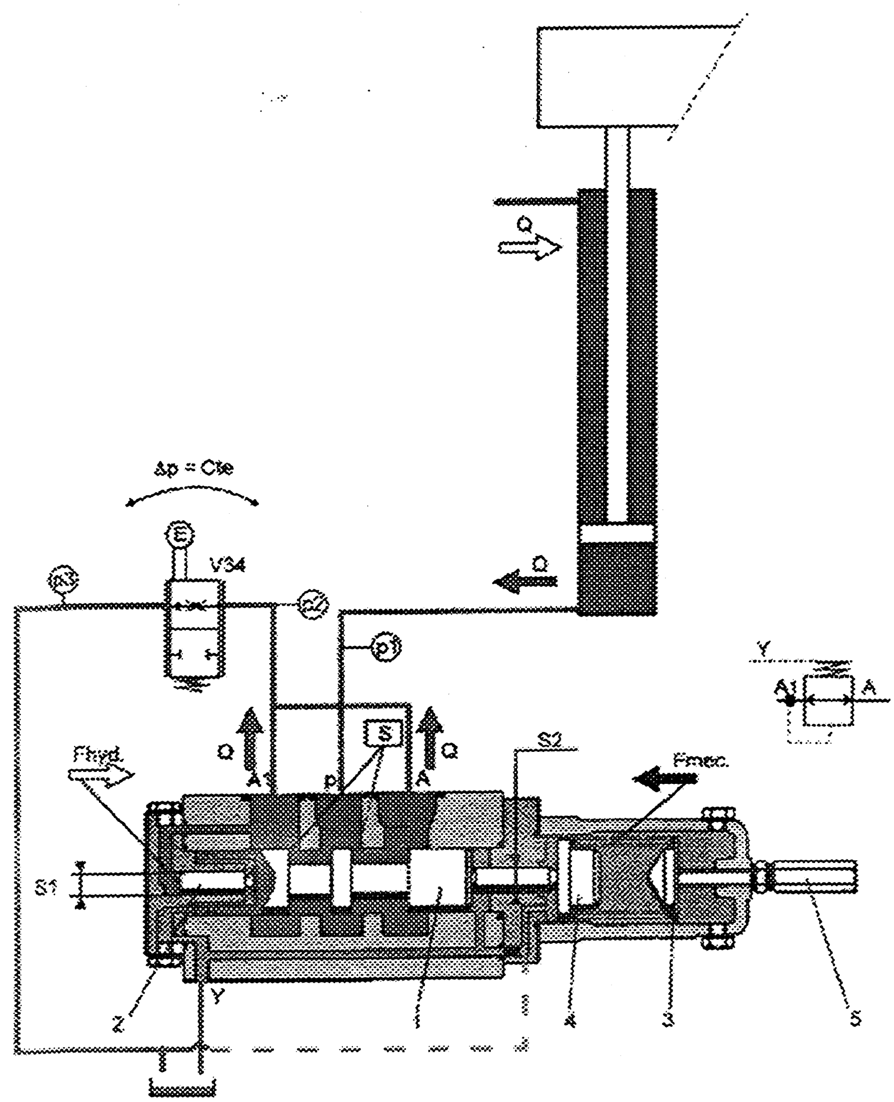

Figure Eleven

This valve is set to give a constant 21 bar at the inlet of V34. V34 is opened or closed to control the movement and speed of the bridge. Changing wind speeds and pressures generated at the cylinder (particularly during lowering) do not effect the programmed speed of the bridge. The opening of valve V34 is electronically set from the PLC and thus controls the acceleration, maximum speed and deceleration of the bridge (see Figures Eleven and Twelve). The system is fitted with manual and motorised isolation valves for selection during emergency conditions to allow free wheel operation of cylinders and manual lowering.

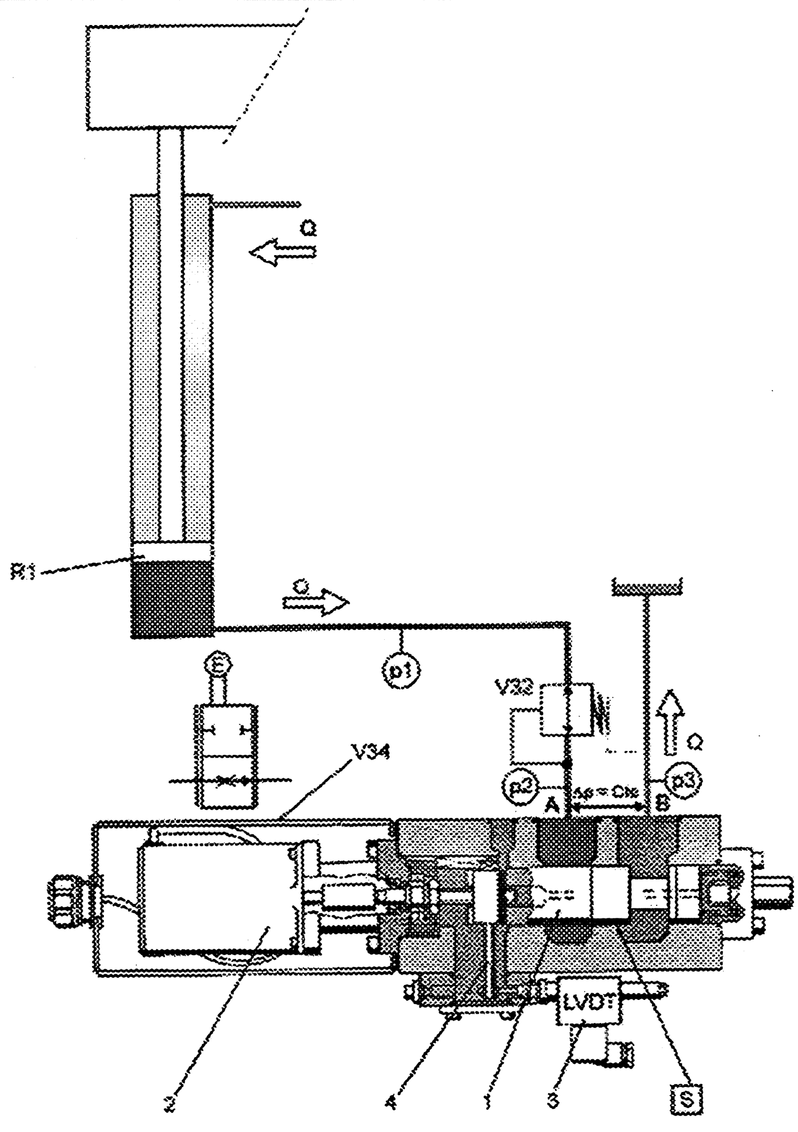

Figure Twelve

ELECTRICAL CONTROLS

There are two PLCs, one main and the other standby. They are programmed to control all speeds and functions of the bridge. All cylinders and valves are fully interlocked to prevent operator error. The operation of the bridge is from the central tower. A standard PC is used in conjunction with a mouse for function selection (see Figure Fourteen).

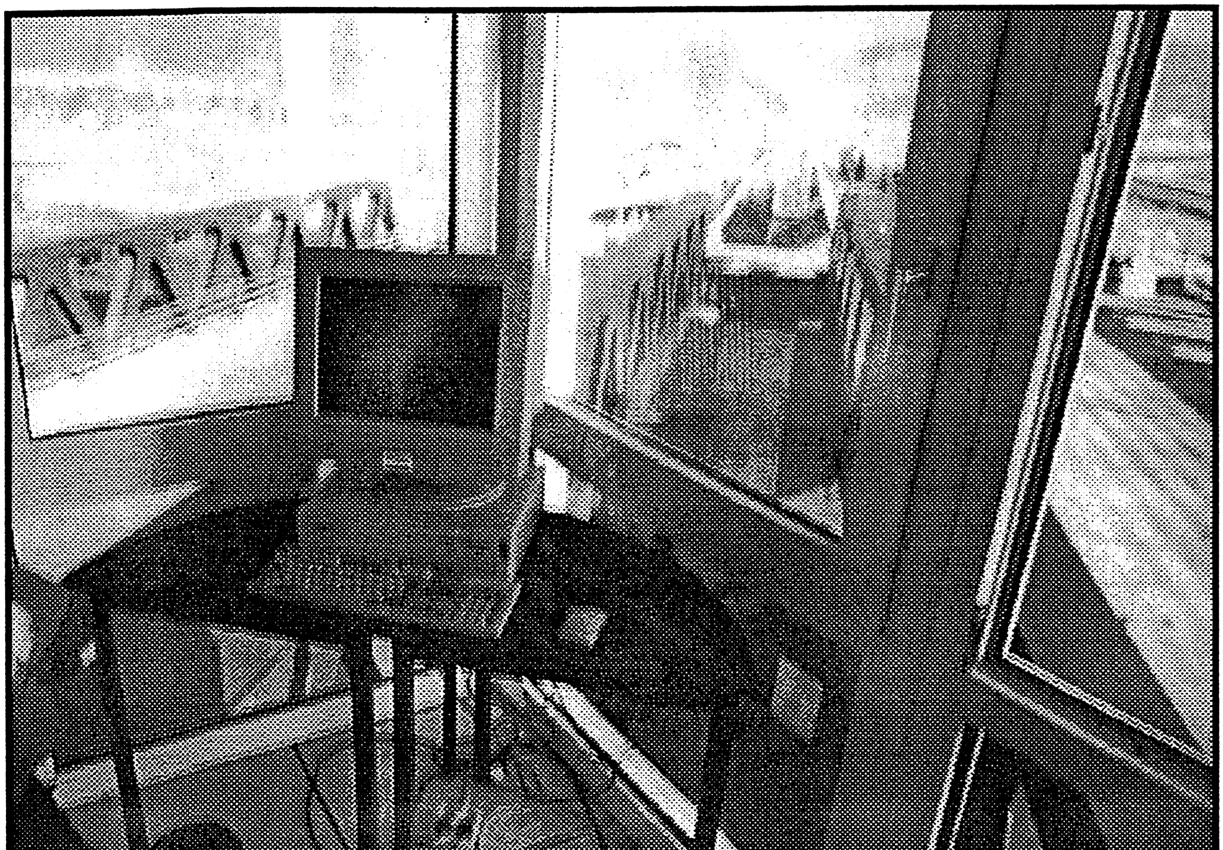

Figure Thirteen

There is a live mimic display of both bridges on the PC screen. The operator has to simply select the Raise and a signal is sent to the PLC which controls all functions, interlocks etc. The bridge will raise to the fully open position then stop. The bridge movement may be stopped at any time, in order to check interlocks, functions, pressures etc. The pump room contains a remote sequence control panel with push buttons for individual operations of all movements. This is a maintenance/emergency operation tool. Angular position is monitored through a rotary encoder and interlocked back to the PLC for speed and position control.

BRIDGE OPERATION

The bridge is normally unmanned, the operator arrives as necessary. Telephone instructions are

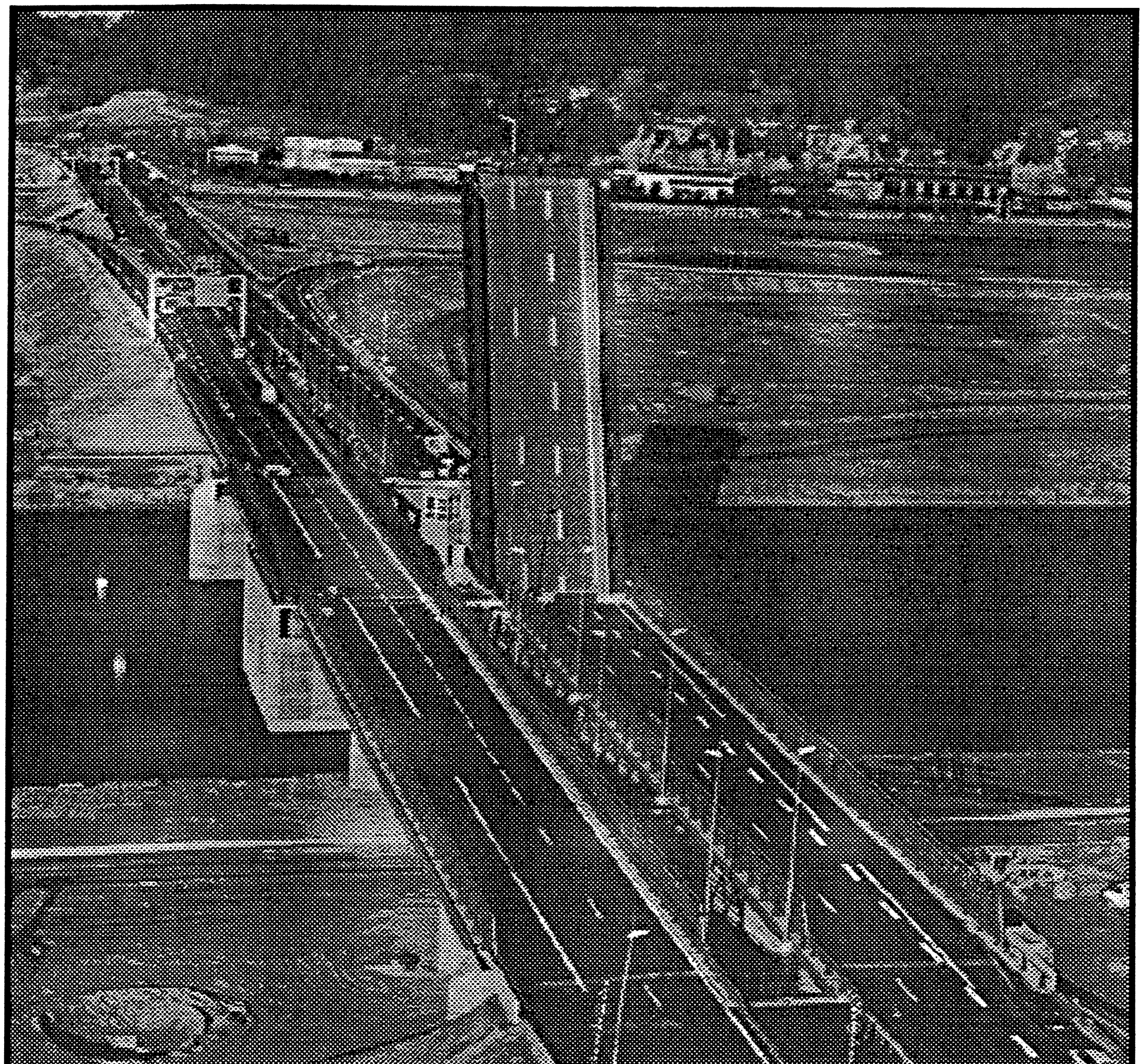

Figure Fourteen

received from the Road Supervisor located 1 km away at the Normandie Bridge over the Seine, this is also where the road toll both is located). The message is also confirmed by facsimile. The motorway is closed at the Canal du Havre and traffic diverted around the A131 to rejoin at a point north of the bridge. The diversion of traffic is normally a thirty minute operation, and takes some 10 minutes dependent upon road traffic at the time. The River traffic control is via the Harbour Authority, there being no direct contact from shipping to the Motorway Control Authority.

ACKNOWLEDGEMENTS

The bridge is operated by the LeHavre Harbour Authority, although it is owned by the Motorway Authority. The concept design study was carried out by consultant engineers Scetauroute and Eurodim. Design and construction of the bridge was by Eiffel, civil construction by Razel. The hydraulic design and construction was by Oilgear Towler and electrical controls by Cegelec.