Heavy Movable Structures, Inc.

SIXTH BIENNIAL SYMPOSIUM

October 30 - November 1, 1996

Doubletree Resort Surfside
Clearwater Beach, Florida

Hydraulic Drive System for Bascule Bridges

by

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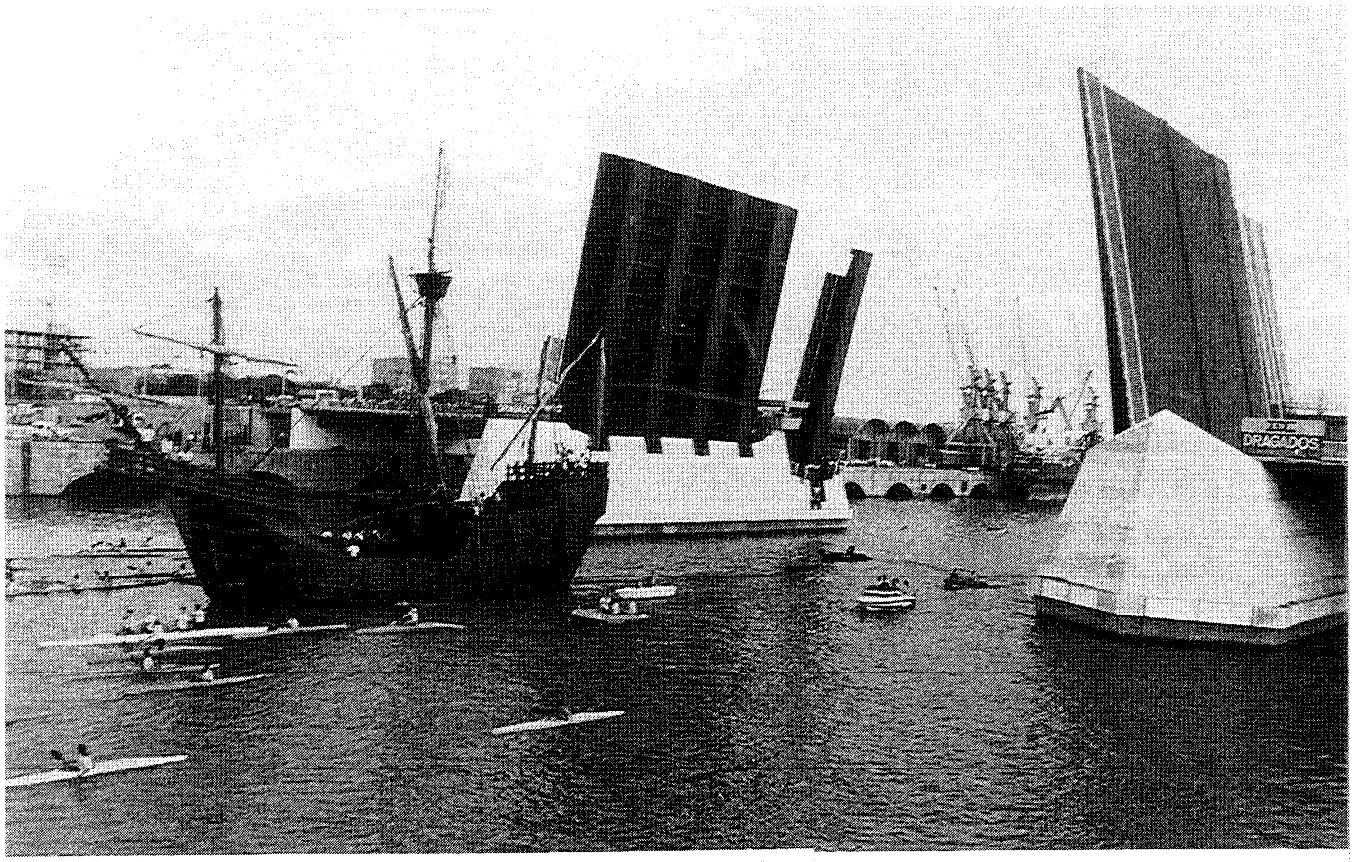


SEVILLA BRIDGE

Which demands of modern bridge-drives are to be met?

1.) Acceleration, de-acceleration and slow-drive into end-positions
2.) Oscillation-free (vibration-free) operation
3.) Long life-expectancy
4.) Safe operation
5.) Emergency stop
6.) Overload protection
7.) Free oscillation of bridge-flap under load of traffic without blocking by the drive
8.) Maintenance-friendly and easy to service
9.) Energy-efficient
10.) Environmentally safe
11.) Economical

Today's expectations of a modern hydraulic bridge drive are that the bridge flaps accelerate from the end-positions, move with constant speed and, before reaching the end-position, de-accelerate and slowly drive into end-position.

The complete movement process should be vibration free in order to conserve the bearings, the bridge construction and the super-structure and thereby achieve a long life expectancy.

The hydraulic part must be absolutely safe in operation as lives can depend on this under certain circumstances.

For operational safety, the bridge flaps can be stopped in any position by an emergency-stop-button and can be held safely.

In order to prevent overload of the bridge construction, bearings and super-structure, an overload protection must be provided.

In the closed bridge position the hydraulic drive must be flexible in order to allow a free oscillation of the bridge construction under traffic load.

Furthermore the drive unit must be maintenance friendly, easy to operate, energy efficient, environmentally safe and economical.

How can all of these requirements be fulfilled by a drive-unit?

In general, there are 2 possibilities to actuate a bridge flap:

a) Through hydraulic cylinders (Fig. 1)
b) Through hydraulic motors via rack and pinion (Fig. 2)

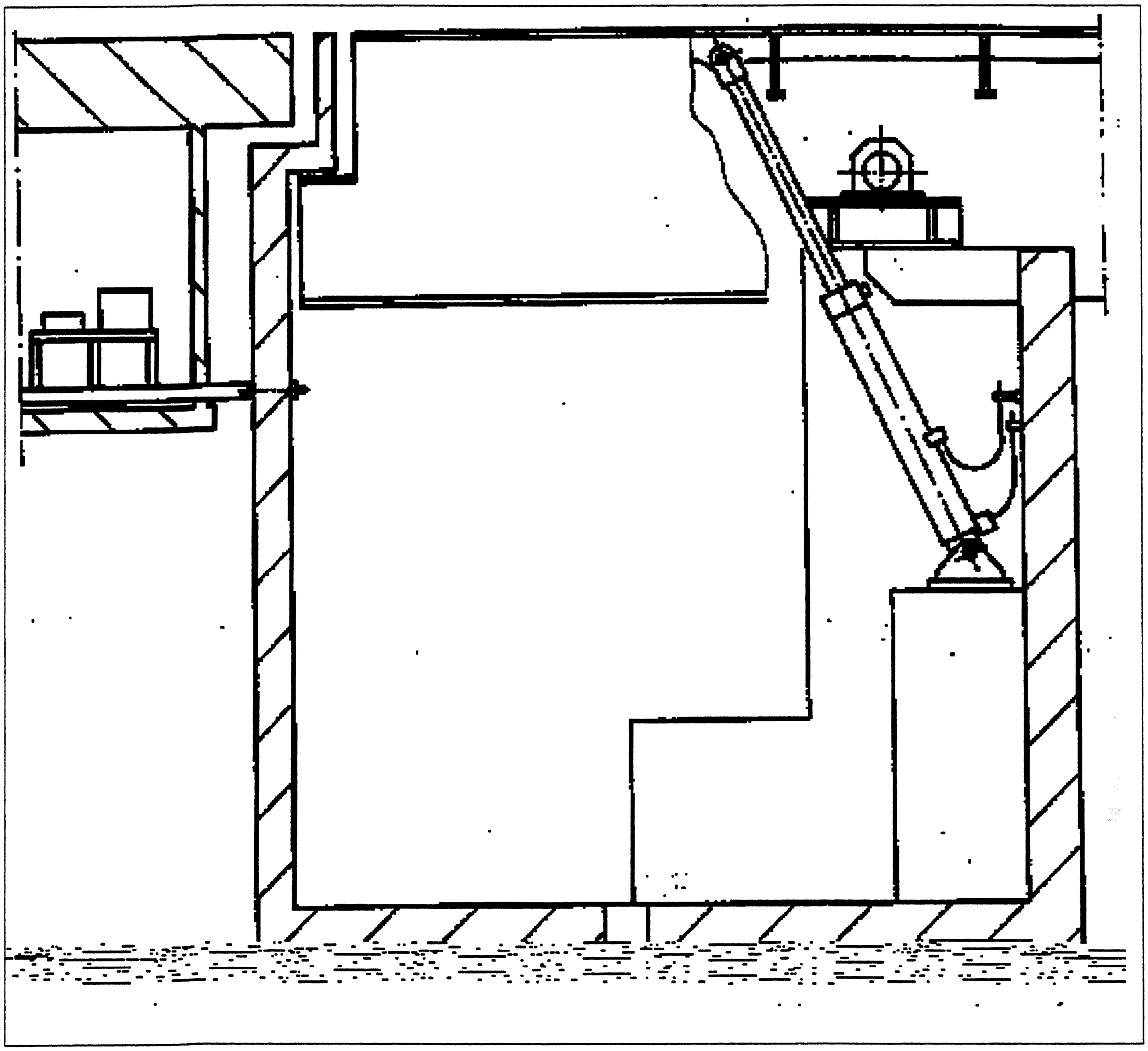


Figure 1 - Bridge with Cylinder Drive

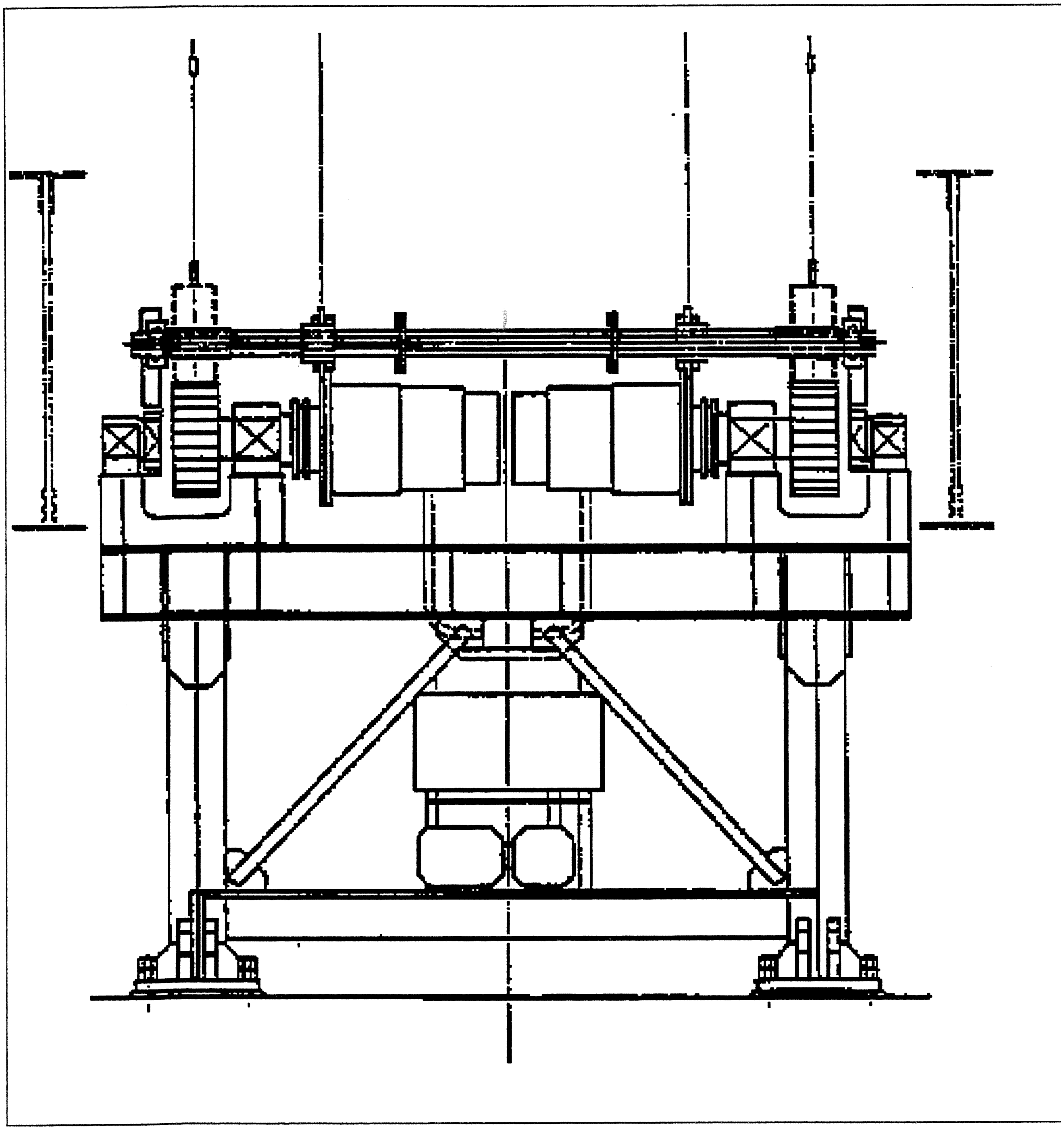


Figure 2 - Hydromotor Drive

Assuming that in both cases the hydraulic control is designed in the same manner, the drive with hydraulic motor, however, has 2 main disadvantages against the cylinder drive.

a) Between rack and pinion, as well as in the gear, play occurs which does not allow an oscillating movement especially during load changes. (For example, at the changing of wind direction.)

b) Because of leakage losses in the hydro motor, the bridge flap cannot be held safely after an emergancy stop. In this case an additional brake must be installed.

With a cylinder drive, for example, the bridge flap will be held safely in every position via directly arranged lock valves at the cylinder. Play between mechanical drive components does not occur.

How must the hydraulic drive be built up in order to meet the above listed 11 requirements?

The first demand for acceleration, de-acceleration and operation with different speeds can be fulfilled by the installation of proportional controlled displacement pumps. (Fig. 3)

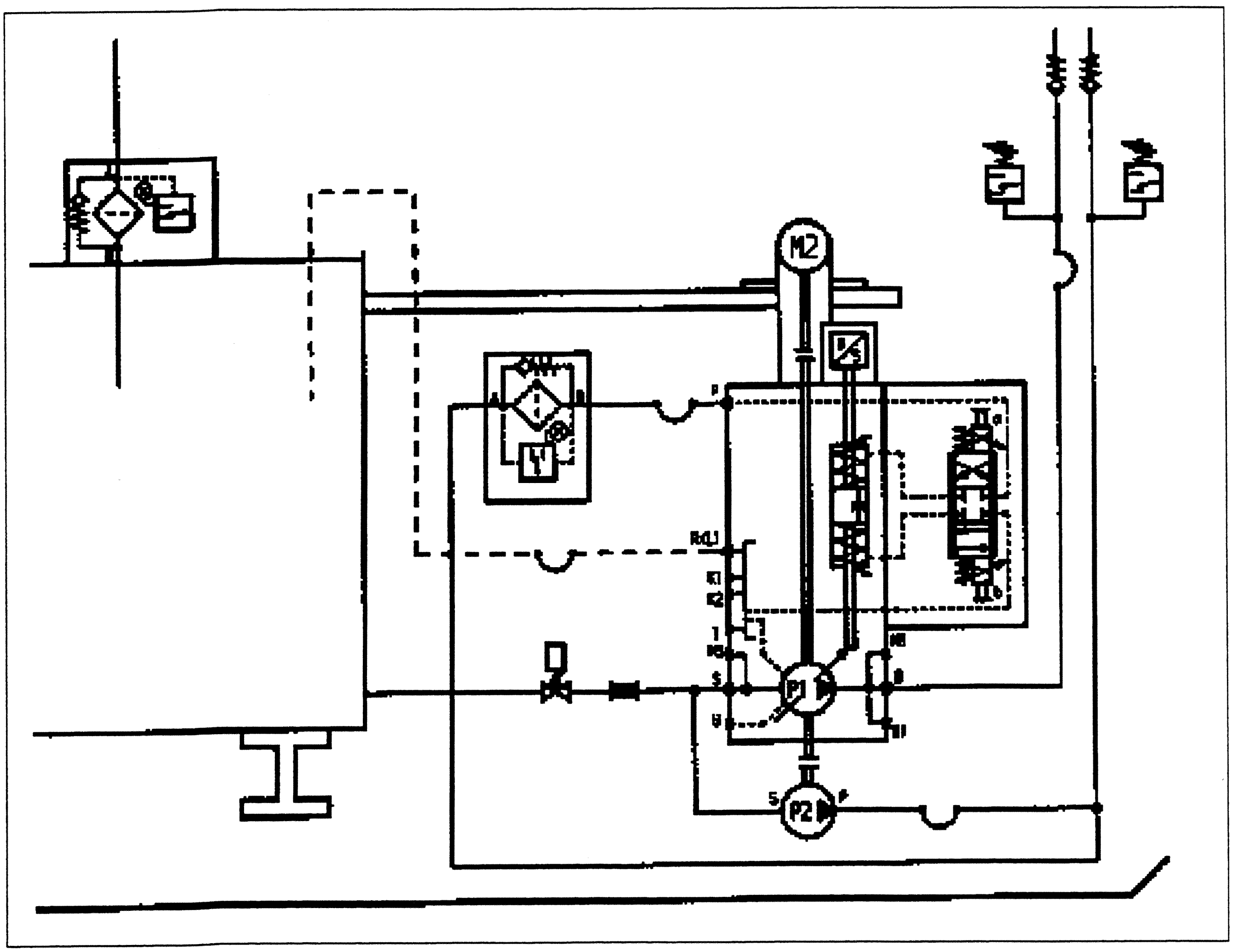


Figure 3 - Proportional Variable Displacement Pump

By applying displacement pumps, the requirements of an energy efficient drive is fulfilled. By varying the flow of the variable pump, only the required displacement for the particular speed is produced and thereby required power is utilized.

It would also be possible to apply a proportional flow control valve in the pump line, in combination with a fixed displacement pump. This solution, however, is not energy efficient, since hereby the complete pump oil flow is constantly available and therefore maximum power is continually called for.

The same applies for the use of a proportional valve in the system. In applying a proportional valve it adds on that the control piston of the proportional valve must be adjusted to the area ratio of the cylinder.

The vibration free operation of the bridge flaps is guaranteed by:

a) the application of hydraulic cylinders and
b) by the arrangement of check-q-meters on the cylinders

At operating the bridge flap by a cylinder check-q-meters are directly flanged at the cylinder-heads and -bottoms. Should 2 or more cylinders be in operation for the operation of a bridge flap, then check-q-meters are arranged in the supply / feed line to the cylinder piston resp. rod area.

The requirement of long life expectancy is fulfilled by application of high quality components, i.e. at a maximum system pressure of 200-220 bar only components with an maximum operating pressure of 315 bar are applied. This means that the components are never strained beyond their limits of power range, which leads to a long life expectancy of the unit.

Through vibration free operation of the bridge flaps the life expectancy of the flaps resp. super structure is considerably higher. An additional proof of fatigue strength also is given by the mathematical safety calculations.

Safety in operation and emergency stop are basic demands on a drive of hydraulic operated bridge flaps. Emergency stop in any position is no problem for the hydraulic drive.The check-q-meter holds the bridge flaps in the specific position. An overloading of the drive is avoided by maximum pressure valves which are arranged parallel to the check-q-meter.

For further operational safety the following are installed:

a) Pressure switches for monitoring of pipe and hose lines
b) The selection of appropriate components
c) The application of overload protection at the bridge cylinders and at the pump

In traffic position the bridge flaps should oscillate freely under traffic load. This is reached by clearing the annulus of cylinder in this position, (i.e. the piston chamber and rod chamber are interconnected and connected to a small reservoir). This way the cylinder adjusts itself to the oscillations of the bridge flap. The bridge flap and hydraulic cylinder are not subject to a constant change of load, for example by rigid-mounted cylinders or mechanical drives.

The bascule bridges should be maintenance friendly and easy to operate. Here lies a further great advantage of the hydraulic drive against the mechanical drive. In a well-designed hydraulic drive the maintenance work is limited to changing the oil filter, stability of the pipe lines and the condition of the air and humidity, and condition of the silica gel. Through the filter contamination indicator the filter monitors itself and gives a signal when the elements are contaminated. A check of the silica-gel should be made approximately every four weeks.

The requirement for an energy saving drive is met through the use of a proportional variable displacement pump. The variable displacement pumps provide only the needed volume for the various speeds under the required pressure, caused by wind-load and weight of the bridge at the cylinder, i.e. no energy is lost.

With a hydraulic drive there exists the possibility of limiting the size of the electric motors as well as the electrical energy to be utilized. This is achieved by limiting the drive speed of the bridge flaps during high wind-load conditions. In other words, if we assume a wind-velocity of 10 meters per second, the speed of the bridge flaps is automatically reduced, so that a pre-set energy load at the electric motors is not exceeded. This solution has been used on various bascule bridges in recent years, such as the "largest in the world" bascule bridge, the GALATA BRIDGE in Turkey.

Protection of the environment is a major consideration in today's world. In no case should the hydraulic drives of the bridge flaps lead to environmental or water polution, even when cylinders or piping is over or next to the water. This means that the hydraulic drive must be so designed that a leakage of the hydraulic medium is not possible.

This is done through:

a) the use of blocking valves directly on the cylinder
b) monitoring of the piping and flexible hoses
c) use of fittings that contain a rubber gasket

In a system designed like this it can be guaranteed that no hydraulic fluid escapes from the system.

As a secondary control a hydraulic medium should be selected that is environmentally compatible so that, even in the event of an accident, no environmental polution occurs.

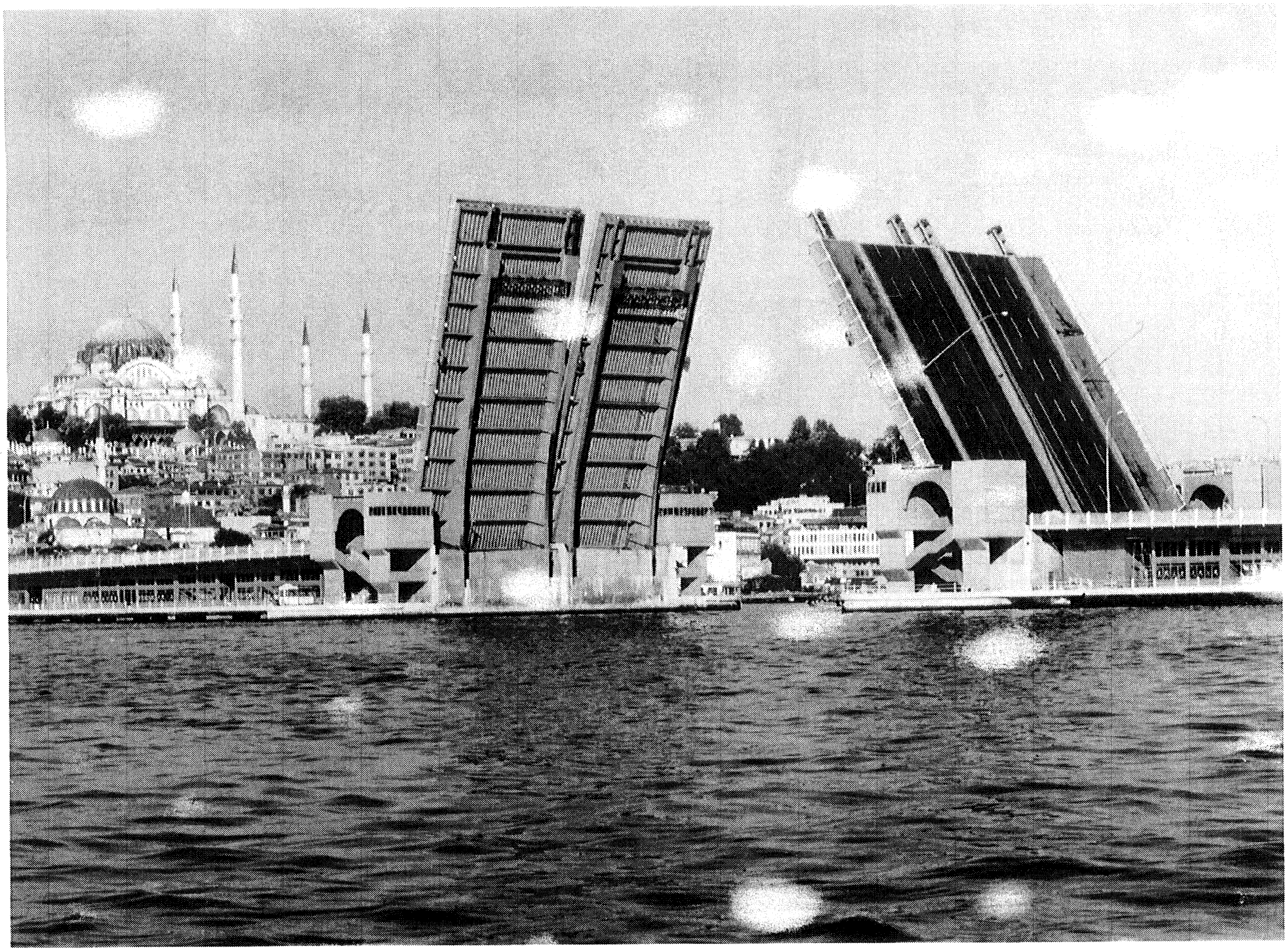
Any system should be economical. Economical does not mean, however, that the cheapest system is also the best one. In no case should it mean deviating from the aforementioned criteria for a hydraulic drive.

Research has shown that a hydraulic drive with all the stated safety features and reduced maintenance costs is the most economical solution for a bascule bridge system.

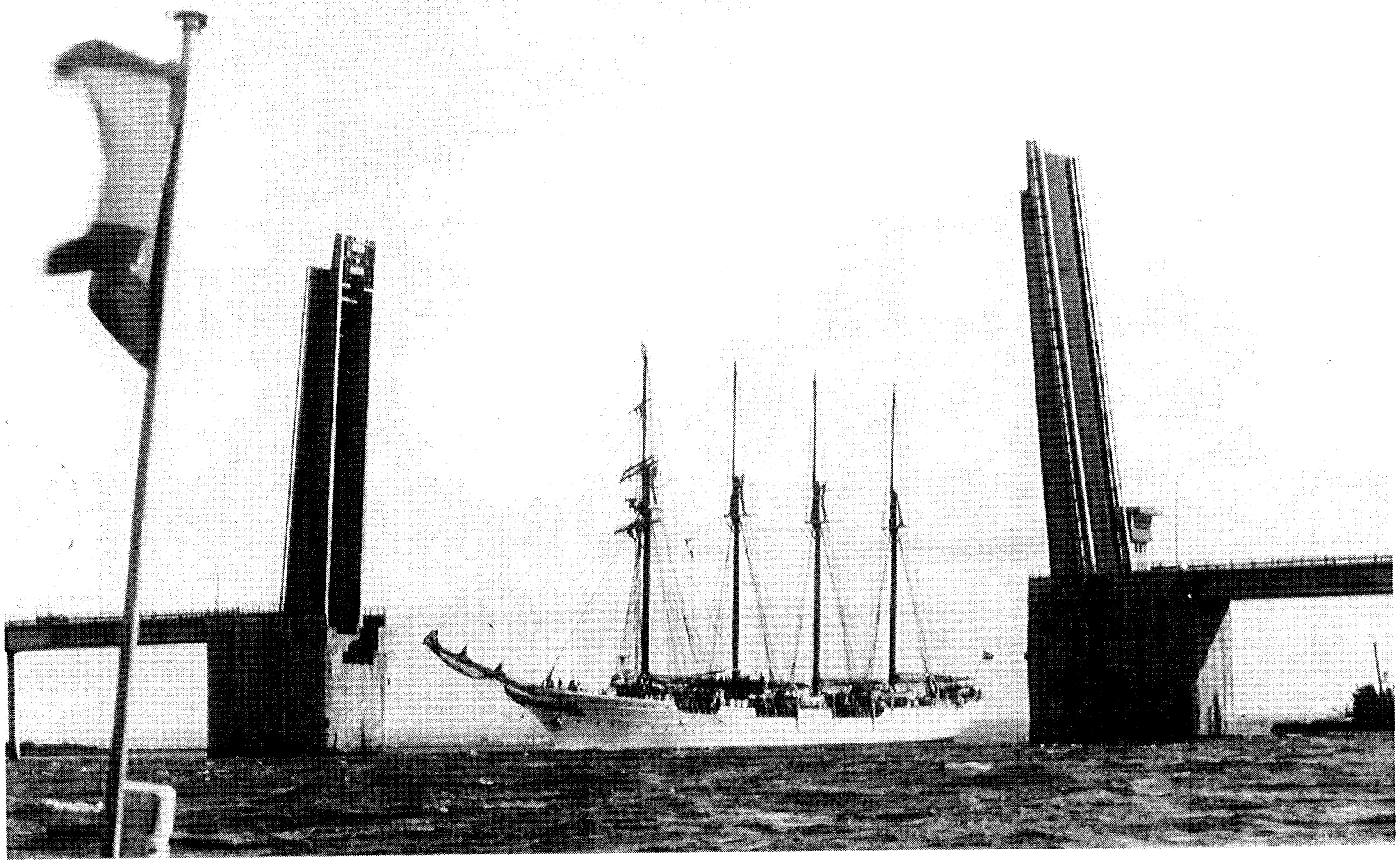
Worldwide, bridge drives show that these hydraulic systems are not only cost efficient but also operate safely and trouble free over a period of many decades.

Two examples:

1) The Cadiz-Bridge built in 1969
2) The Bascule Bridge Galata in Istanbul, finished in 1990



THE GALATA BRIDGE



THE CADIZ BRIDGE