Moving Bridges

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1 General

Bridges link, overcome obstacles, establish connections. They ease transport and traffic problems and, most importantly, bring people into closer contact with each other. *Life without bridges* would be unthinkable nowadays.

Whatever the type or location of a bridge, it will always be associated with the term "connection". Take away the bridge and you break the connection.

It is therefore not surprising that in times of war it was these bridges which were such strategically important targets, to be protected or destroyed, as the case might be.

Who is not familiar with the old draw-bridges found on our castles, which traversed deep ditches or moats. In times of danger these connections were broken, causing fear and anxiety among those affected, and indeed in many cases even causing death.

Little wonder, then, that broken connections immediately gave rise to a gamut of emotions among those affected.

This is still true even of our modern moving bridges today.

Nowadays, the sole purpose of moving bridges is to alternately connect two different intersecting traffic routes in a practical manner. And there we have the real problem of moving bridges - they can only make one connection at a time. In order to make the other connection, it is necessary to break the first connection.

This enforced situation may be compared with the so-called "double mill" in the game of "mill".

You may be asking yourself what this long, rambling introduction is in aid of. Well, it is hoped that it will arouse your interest in the enormous importance of the drives for such bridges.

In recent years, these drives have all too often been so underdimensioned that they have been subject to constant failures, and indeed have completely broken down after only a year or two. In the case of very busy traffic routes this meant, because of the roused emotions already described, an enormous amount of trouble for the operator. Just how much trouble is described in detail in the following paper.

First, however, a look at present-day bridge systems. If we classify moving bridges purely on the basis of physical features, we find there are three basic types:

2 Bascule Bridges - Swing Bridges - Lifting Bridges

For each basic type, various drive systems are available, which in part are dependent on the particular type of bridge in question. We shall now look at the important characteristics of the various designs and drive systems in order to highlight the differences.

2.1 Bascule Bridges

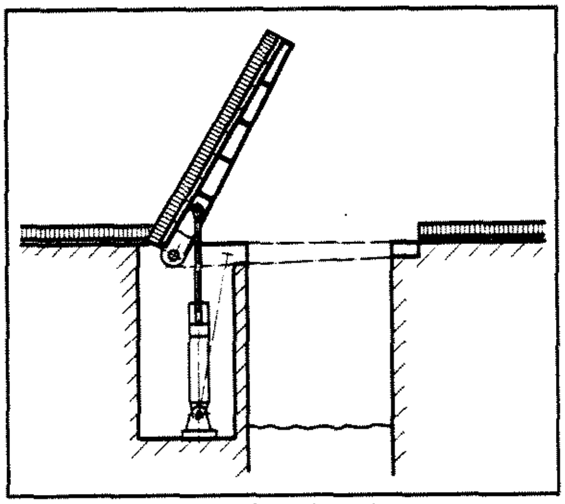

Fig. 1 *Bascule bridge with fixed pivot point*

This system is normally used for *small road bridges*, in which the cylinder operates directly onto the bridge arm. The disadvantage is the relatively high drive power and the high space required for the cylinder(s).

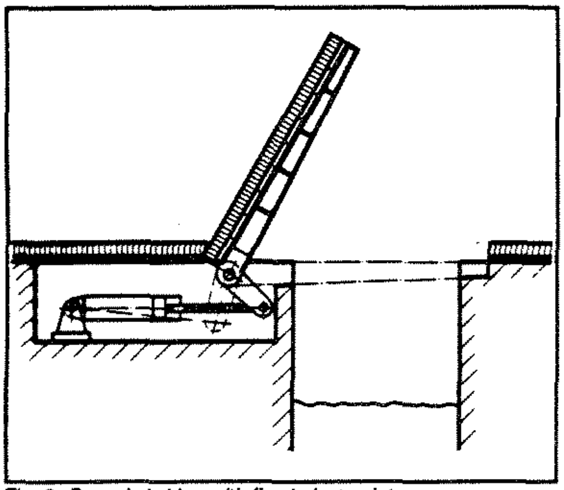

Fig. 2: *Bascule bridge with fixed pivot point*

In contrast to the system shown in *Fig. 1*, the cylinder operates against a lever. The big advantage of this arrangement lies in the depth of excavation necessary. In many cases, the cylinder operates via a torsion tube, which in turn makes accessibility to the cylinder and hydraulic system even easier.

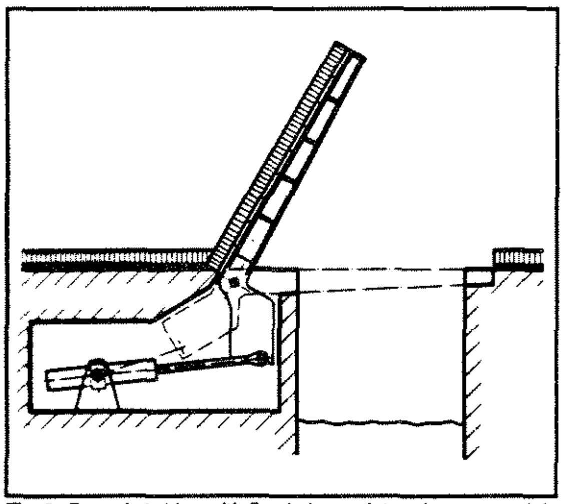

Fig. 3: *Bascule bridge with fixed pivot point and counterweight*

This is, in fact, a true bascule bridge with a counterbalance, and must be employed when bridges exceed a certain size, particulary in view of the energy costs. Bridge systems using a counterweight considerably reduce the drive power, together with the size of the cylinders and the costs for the hydraulic and electrical components. Particularly in rural areas, the electrical mains are not sufficiently heavy for a directly driven bridge so this becomes yet another point in favour of using a bridge with a counterbalance. With the rise in energy costs in recent times, bridges without counterbalance weights can rarely be considered.

The bridge shown in *Fig. 3* has such a counterweight, to which the cylinder is therefore working in compression. This is normally unfavourable, as this type of bridge is not fully balanced. The disadvantage is mainly in the area of the underground construction, which requires room for the counterbalance weight and drive cylinder.

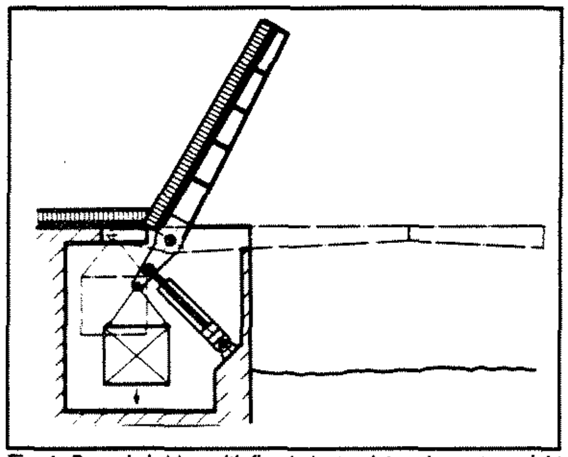

Fig. 4: *Bascule bridge with fixed pivot point and counterweight*

In contrast to *Fig. 3*, the bridge shown here has the weight free to swing on a balance arm. This arrangement is not particulary good because of the large volume required for the counterbalance. However the cylinder is in tension when the greatest load is required.

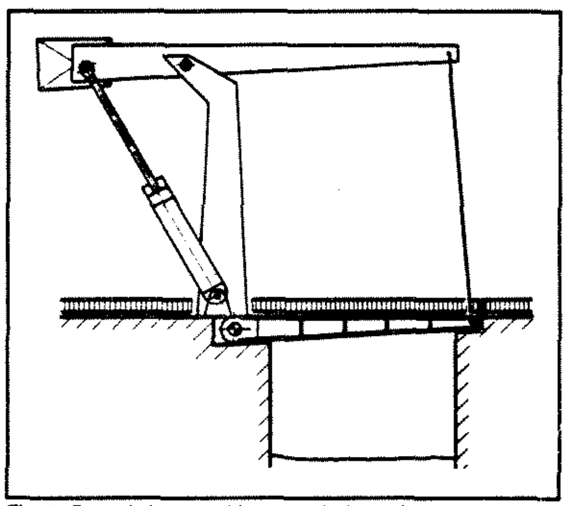

Fig. 5: *Bascule bridge with counterbalance beam*

This system is very old, as may be seen from the famous painting by Vincent van Gogh, which is familiar to people from all walks of life.

The advantage is clearly that all major parts, and in particular the counterbalance arm, lie above ground. This system is generally used for small bridges.

One further remark must be made at this point:
All bridges with a fixed pivot point have one thing in common, and this is that, if water traffic is to pass through without hindrance the operational angle must be approximately 85°, or the bridge itself so wide that an angle smaller than 85° becomes unimportant.

In order to save costs, on the one hand, and at the same time to achieve a sufficiently wide opening, a small trick is played. Instead of a fixed rotational point, this point is made to move. *The system employed is that of a rolling* bascule bridge (the Scherzer system). As the name implies, the bridge does not only swing about a fixed point, but rolls at the same time giving a wider opening for the same angular movement.

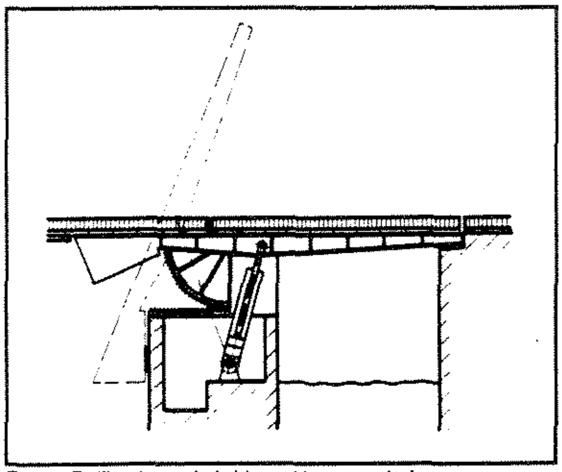

Fig. 6: *Rolling bascule bridge with counterbalance*

Such a rolling bascule bridge is shown in Fig. 7, and it will be appreciated that relatively narrow piers can be used to achieve full opening to water traffic.

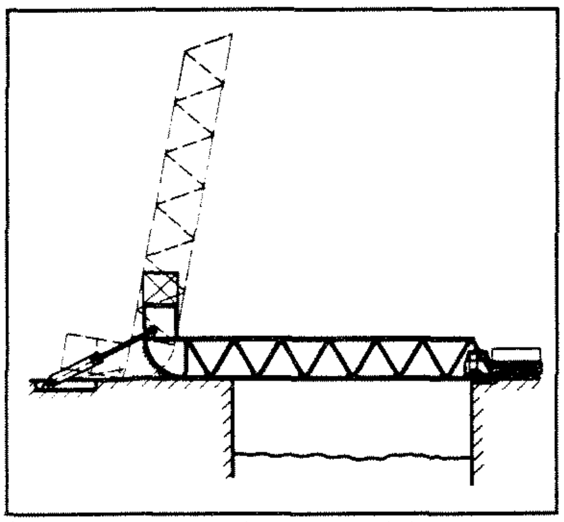

Fig. 7: *Rolling bascule bridge with counterbalance*

The bridge shown in *Fig. 7* is particulary economic with regard to the necessary excavations. The only disadvantage is the appearance of the bridge. For this reason, such bridges are mostly found in industrial and harbour areas.

The systems shown in *Figs. 1 to 7* can only show the basic differences. There are, of course, numerous variations to each system, particulary in the arrangement of the drive. For example, these may be either hydraulic *cylinders, oil hydraulic motors*, or rack and pinion systems.

Whether the hydraulic drive comes from a cylinder or a motor, need not concern us here.

All these bridge systems have one thing in common: when opening or closing, the load is continually variable in both direction and value. The reason for this is the wind forces.

When laying out the hydraulic drive, this change of load must be given due consideration.

A further point which is common to all systems is that the moving masses are very large, and are moved relatively quickly.

These criteria determine the hydraulic system used.

2.2 Swing Bridges

There are also a wide variety of swing bridge systems.

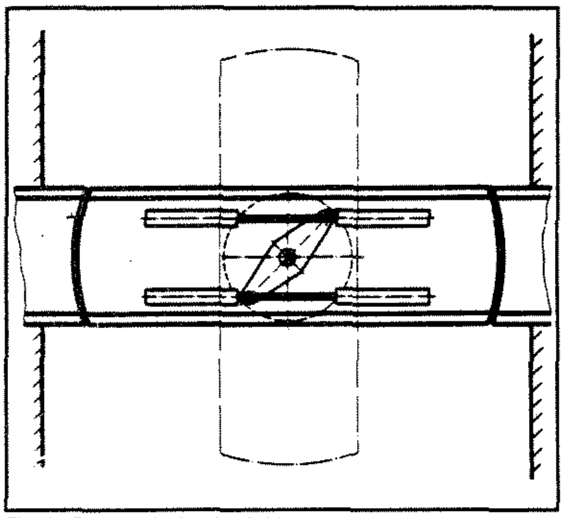

Fig. 8: *Symmetrical swing bridge*

The swing bridge shown in *Fig. 8* is a steel and concrete bridge mounted on a kingpost. The drive is transmitted via four single-acting cylinders working in opposed pairs.

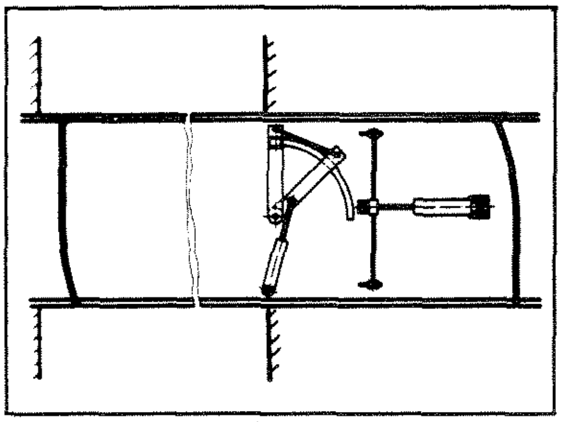

Fig. 9: *Asymmetrical swing bridge*

This particular bridge is somewhat smaller, being approximately 12 m wide. The drive is via a double-acting cylinder working on a triangular linkage.

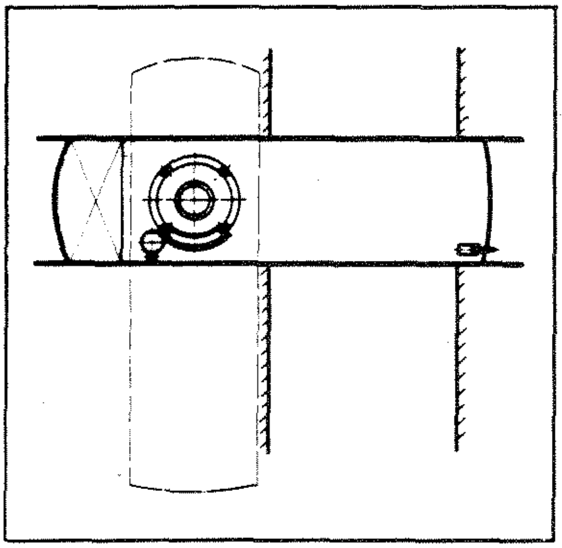

Fig. 10: *Asymmetrical swing bridge*

This swing bridge of approximately 40 m in length is arranged at one side of the waterway, and is mounted on a kingpost. It is fully counterbalanced. The drive is via an oil hydraulic motor and gearbox.

Swing bridges have the same general criteria which must be considered:

a Reversing load direction.

b Relatively large masses and short operational times.

c Bending under their own weight

Criteria a) and b) are identical to those for bascule bridges.

There is no such thing as an absolutely stiff bridge, all bridges bend somewhat depending on their design and length. This means that, before bridges can be swung or lifted out of their rest position, they must be lifted somewhat. There are further solutions available, in which the bridges are allowed to sink from their road use position.

Fig. 11

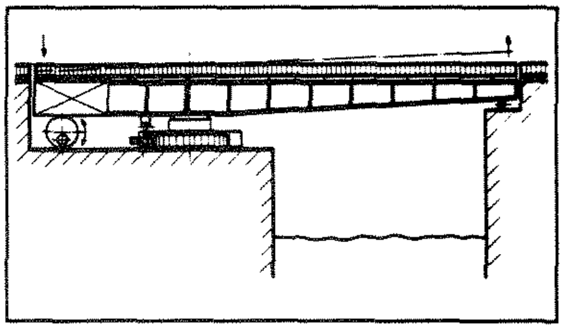

Fig. 11 shows a side view of the swing bridge illustrated in *Fig. 10*. The counterbalance arm is arranged above an excentric, rotation of which tips the bridge about the kingpost. In this case, the counterbalance weight was larger than the weight of the bridge arm.

Even this operation of tipping the bridge may not be carried out suddenly, due to the danger of causing the bridge to oscillate.

2.3 Lifting Bridges

Lifting bridges - and by this we mean parallel lifting bridges - have their own particular problem, in that the bridge must lift evenly in each direction. This problem is greater, the greater the number of cylinders.

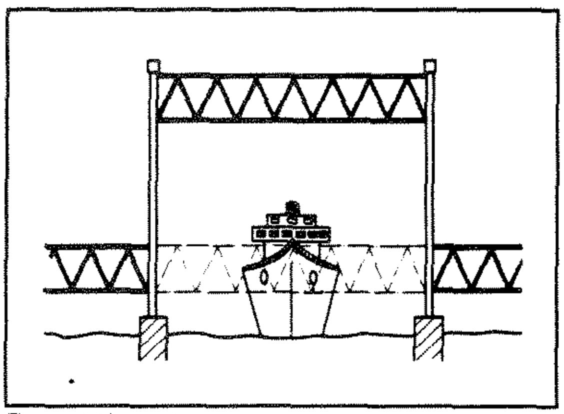

Fig. 12: *Lifting Bridges*

The problem here does not lie with the hydraulic components, but with the system employed for measuring movement.

Up to the present time, practically all lifting bridges with hydraulic drives have a mechanically enforced parallel motion.

With modern costings, this becomes extremely expensive. On the other hand, electrical and electronic devices are now available which will measure movement extremely accurately and at the same time work reliably under the rough conditions experienced on this type of installation. The conversion of the signals generated by these measuring systems is also easily overcome using modern techniques.

Operational reliability, is however another matter, whilst electronic controls require highly skilled maintenance staff. No company can hold such staff in readiness. Either the operator solves the problem himself, or allows long delays (and incurs high costs) waiting for the relevant service person to arrive.

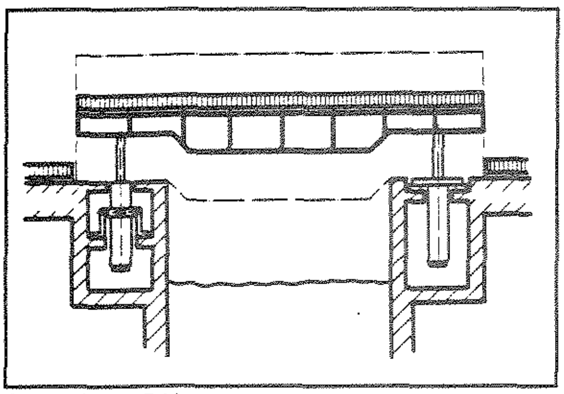

Fig. 13: *Lifting Bridges*

On lifting bridges with more than 10 m stroke, cylinder drives are ruled out. On the lifting bridge shown in Fig. 13, the main drive was electro-mechanical and the auxiliary drives hydraulic. The main drive could also be carried out hydrostatically. The electromechanical drive is very expensive because the acceleration and deceleration of the drive must be regulated due to the high masses.

On the coast, yet another type of lifting bridge is to be found, connecting the road to ships of various types. These are so-called "roll-on/roll-off" bridges.

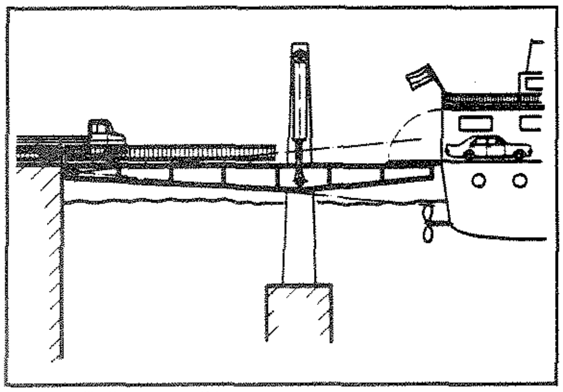

Fig. 14: *Roll-on/roll-off bridge*

These must not only cater for the difference in the loading of the vessel, but also the state of the tide.

In this case, not only must the bridge be set at fixed positions, but it must be able to have its height varied constantly during loading and unloading. Normally, this type of bridge is fitted with a moving flap, to allow vehicles to pass over more easily.
Larger ferries usually have their own stern flap which can be laid on the roll-on/roll-off bridge.

All bridges systems shown here serve only as a general guide. Naturally there are variations in design and drive.

In every case, however the same criteria apply to the general design of the hydraulic system.

Notes