

A new system for raising spillway gates

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If spillway gates fail to open, a dam may be overtopped and fail, leading to damage and possibly a large loss of life. In recent decades, the majority of dam failures caused by overtopping have resulted from the malfunctioning of spillway gates. Therefore current practice is not as safe as it needs to be. This paper describes an innovative system for lifting spillway gates which offers a substantial improvement in reliability. The gates are lifted by simple, low cost rams instead of the conventional, expensive, tension rams. The extra security is unlikely to increase the overall cost. The new system offers a simple, low cost solution to the problem of modernizing obsolete winch lifting systems.

If one or more spillway gates fail to open during a flood, a dam may be at risk. Dam failures have occurred during minor floods because none of the gates opened. Common causes of failure are: reliance on operators to open the gates; failure of the main and (if provided) backup power supply; and, failure of a lifting ram or associated piping.

Swiss and French dam safety authorities (and probably many others) require that a gated spillway is sized so that the design flood can be passed with one gate out of action. While this is a sensible, although expensive, approach to the risk of gates failing to open, it still does not cover the situation if all the gates should fail to open.

Each gate should have a backup lifting system which is completely independent of the main system and will open the gate without human intervention and without requiring an external power supply. This is the primary objective of the system described in this paper.

The concept has its roots in various gates designed by Leyland Consultants Ltd for hydropower and irrigation schemes in New Zealand and Australia since 1974. All of these gates were for unattended schemes. From the outset it was decided that the manual backup system relied on at the heavily manned schemes owned by New Zealand's State-owned generator was not applicable.

All the gates were designed to open without manual intervention in the event of a power failure. In the later designs, we used push rams for gate lifting and a water turbine driven by overflowing water to provide emergency drive for the oil pumps, see photo (a).

This new concept builds on the experience gained during the design, commissioning and operation of these gates. It was further developed for the 450 MW Rudbar Lorestan hydropower scheme in Iran which will have three spillway gates on a 180 m-high RCC dam. This paper describes an improved version of the concept designed for Rudbar.

1. The concept

The new design concept for lifting spillway gates has a simple and completely independent backup lifting system. This is achieved by having one pair of rams for normal operation, and one pair for backup, each supplied by an independent hydraulic system. Failure of one system cannot stop the other system opening the gate.

2. Lifting system for normal operation

Most gates with hydraulic lifting gear use rams in tension, see photo (b). The rams are very long and require specialist manufacture, hence, they are expensive. With the new system, each gate has two rams which push instead of pulling, in other words, these rams extend to raise the gate.

The rams are supplied with pressure oil from a main hydraulic system with AC electric pumps, which can serve several gates. Because there is a separate backup system, there is no need for an emergency generator or a backup diesel-driven oil pump. The pumping unit has main and backup pumps sized to raise its associated gates at whatever speed is required to cope with the design flood profile (see Fig. 1).

Each gate has its own electrical control system which opens the gate to control the rise in lake level. When the lake level begins to fall, the gate position will follow the water level down in the same way as it did when the water level was rising.

3. Backup lifting system

If the primary control system, or the associated hydraulic pumping unit, or the piping or the lifting rams, fail for any reason, a completely separate and independent backup system will control the gates. The backup system comes into operation when the lake level is above the level at which the main control system should have completely opened the gates.

The backup system for each gate comprises a second pair of rams and a hydraulic oil pump, driven by a water turbine. The water turbine is driven by an overflow arrangement which provides a flow of water to the turbine driving the backup oil pumps. The backup

(a) Below: The lifting system with a push ram at Patea, New Zealand.

(b) Below right: Conventional lifting gear.



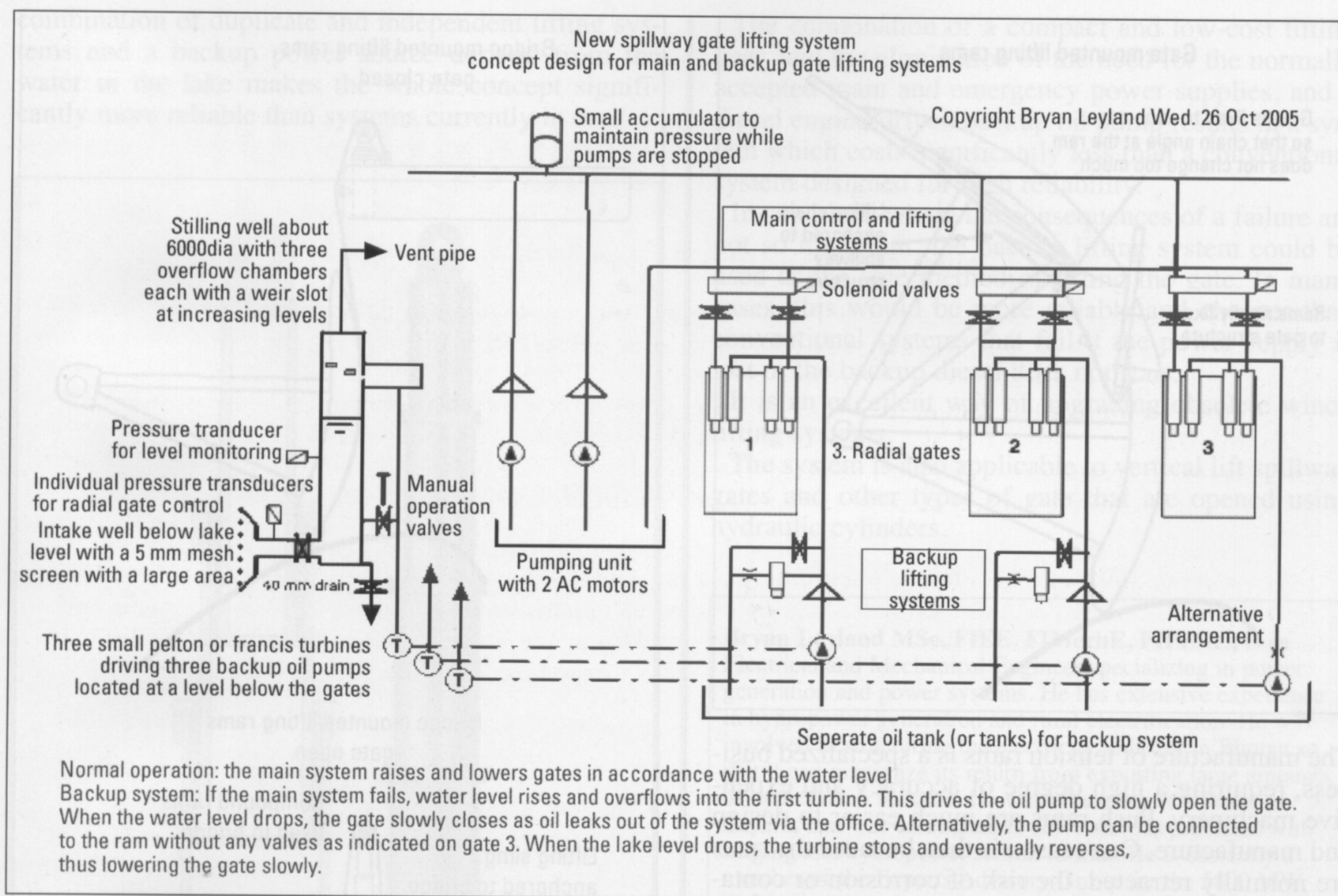


Fig. 1. The control system.

rams can override the primary operating system and raise the gates whatever the mode of failure of the primary system. In most cases, the required rate of opening will be quite slow, so a pumping power of 2-10 kW may be all that is needed.

The backup pumps lift the gate steadily until the lake level has dropped, and reduces the supply of water driving the turbine and pump. As the turbine power decreases, it first stalls and then reverses, with the oil pump acting as a motor driving the turbine backwards. This allows the gate to close at a speed set by an orifice. The same result can also be achieved by the use of control valves, as shown in the control system diagram: this alternative adds complexity which may not be needed.

Manually operated valves are provided to allow the operators to test the operation of the emergency system by connecting the turbine supply pipe directly to the lake.

The backup systems for all the gates can be arranged to come into operation at a single preset level or over a range of levels.

4. Lifting rams

The rams are secured to the gate, see photos (c) and (d) and Figs. 2 and 3, or a bridge structure just upstream of the gate, see Figs. 4 and 5. A roller attached to the ram pushes on a chain or webbing sling, which is secured to the gate at one end, and to an anchor point on the spillway structure at the other. The arrangement lifts the gate by 2 m when the ram extends by 1 m.

The new system is ideal for replacing obsolete or unreliable winch systems using wire ropes. One reason that they have fallen out of favour is that the wire ropes on the front face of the gate can suffer from serious corrosion problems. This problem can be eliminated with the push ram system, because it can use modern technology in the form of high strength slings made of woven synthetic fibre which can lift in excess of 100 t and cannot corrode.

The rams are standard 'push rams', similar to those used in forklifts. They can be single stage or compound. Standard units are available in capacities of up to 100 t and strokes of up to 5 m. A pair of the largest standard rams available from one major manufacturer could lift a 100 t gate 10 m (Fig. 6).

The cost of these rams is probably less than half the cost of an equivalent conventional tension cylinder.

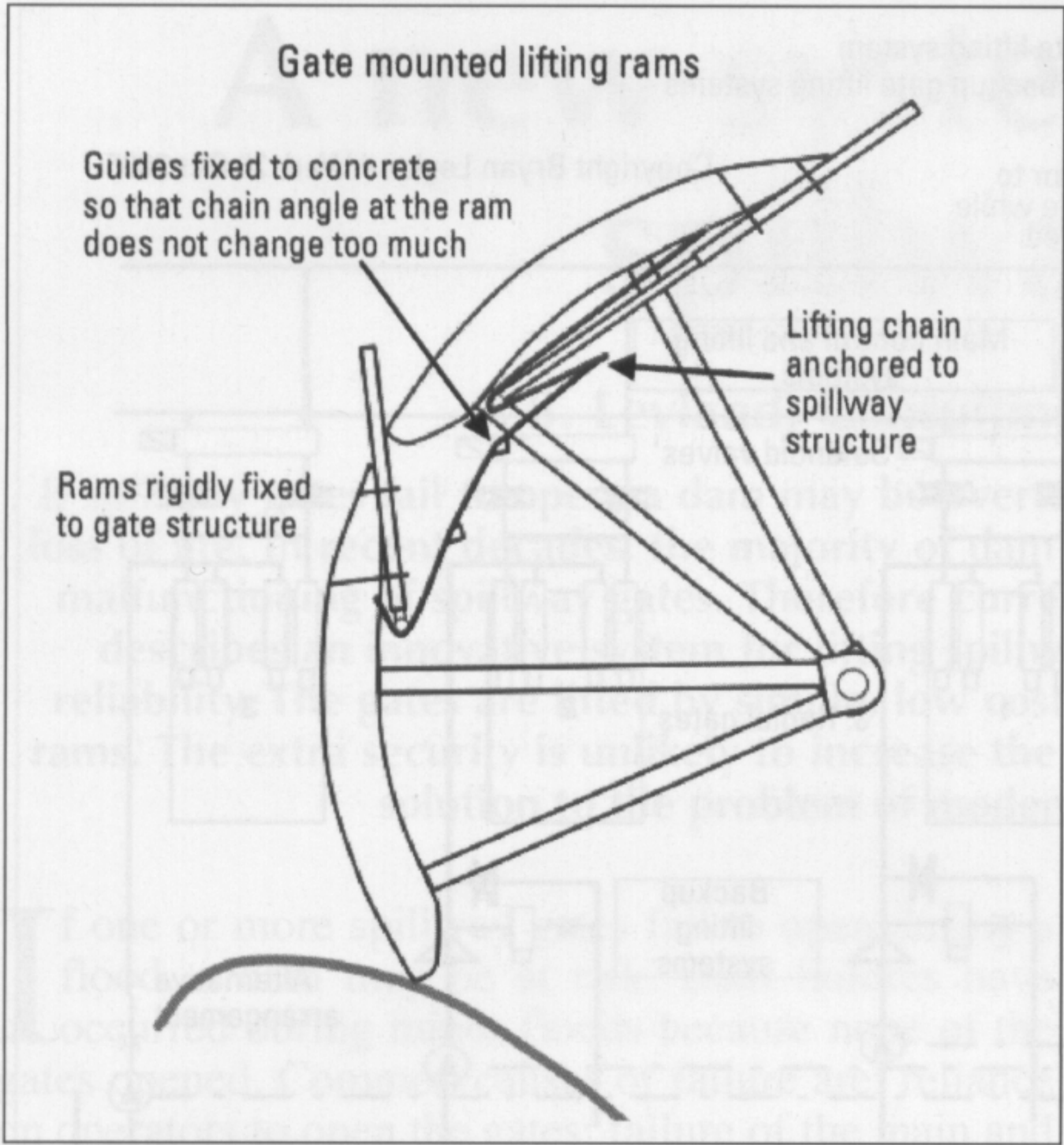


(c) The gate at Yarrowonga, Australia, using push rams.



(d) The Yarrowonga gate with its lifting gear.

Fig. 2. Ram mounted on the gate - side view.



The manufacture of tension rams is a specialized business, requiring a high degree of accuracy and expensive machinery. Push rams are much easier to design and manufacture. One reason is that, because the rams are normally retracted, the risk of corrosion or contamination damaging the seals when the gate needs to be raised is eliminated. This means that the rams can be made of standard stainless steel tubing rather than the chrome-plated high strength stainless steel rod needed for conventional tension rams.

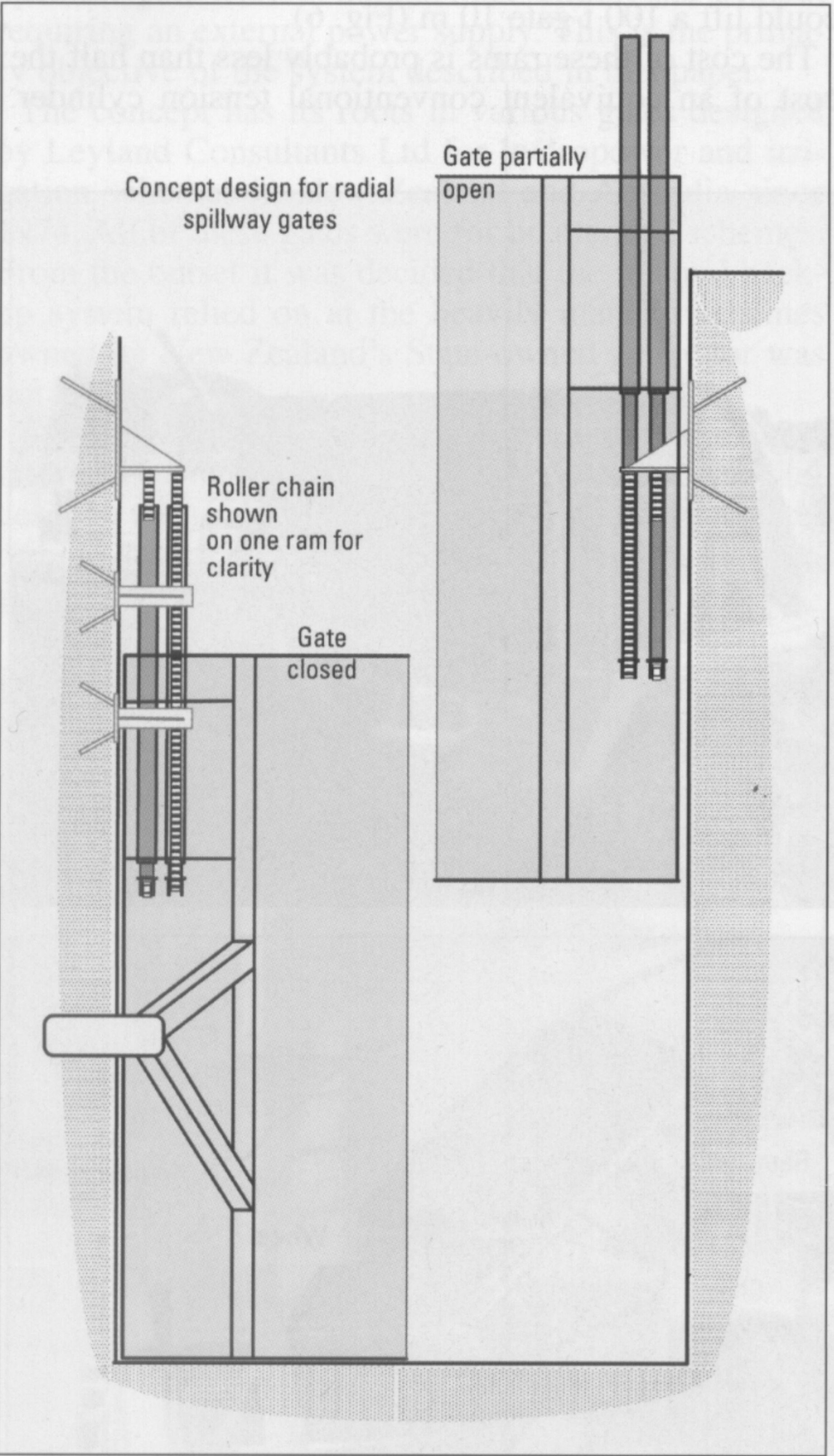


Fig. 3. Ram mounted on the gate - view from rear.

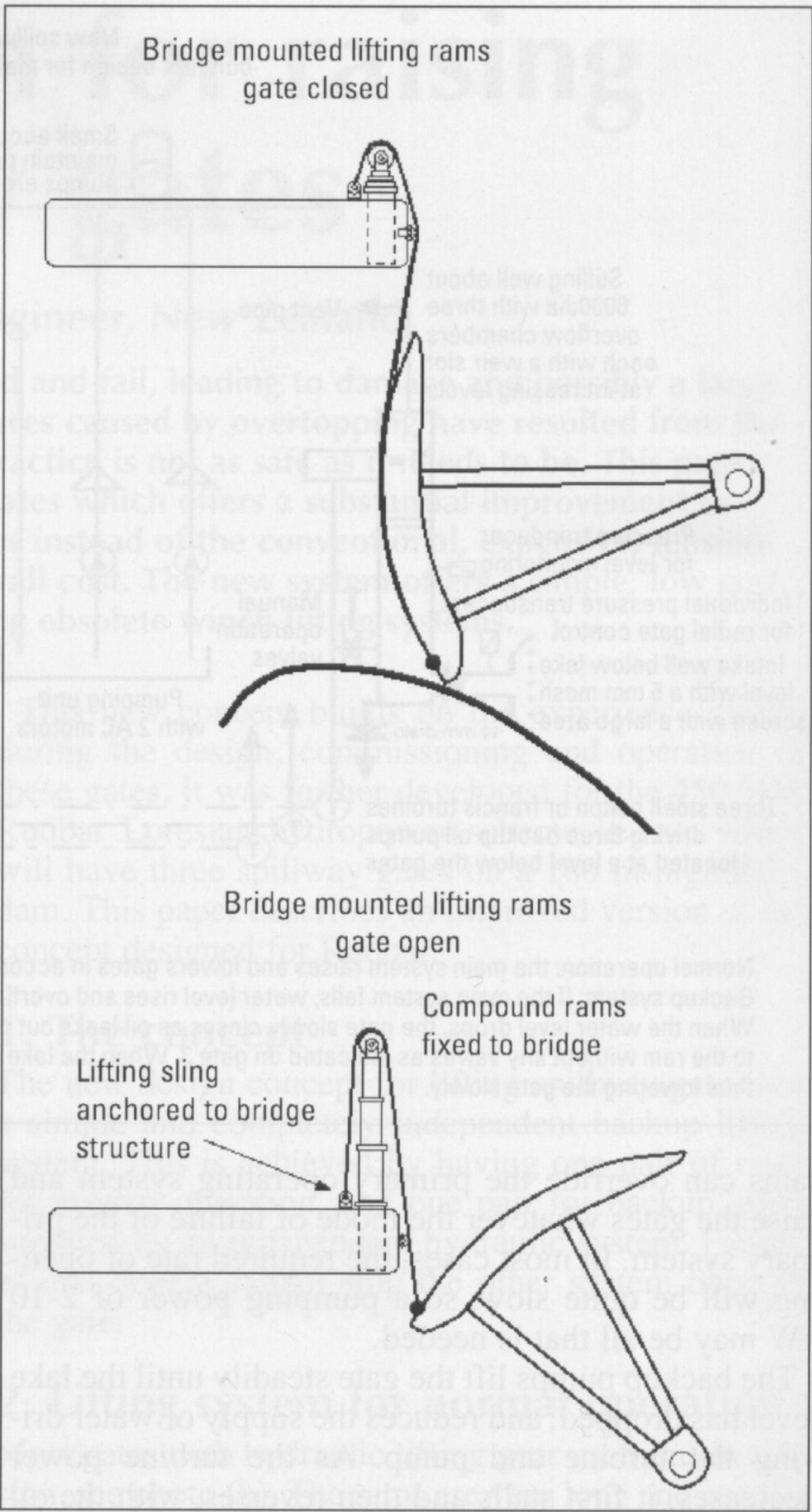


Fig. 4. Bridge-mounted rams.

5 Advantages over current technology

This appears to be the first hydraulic gate lifting system with a 100 per cent backup, which is completely independent of external power supplies. The novel

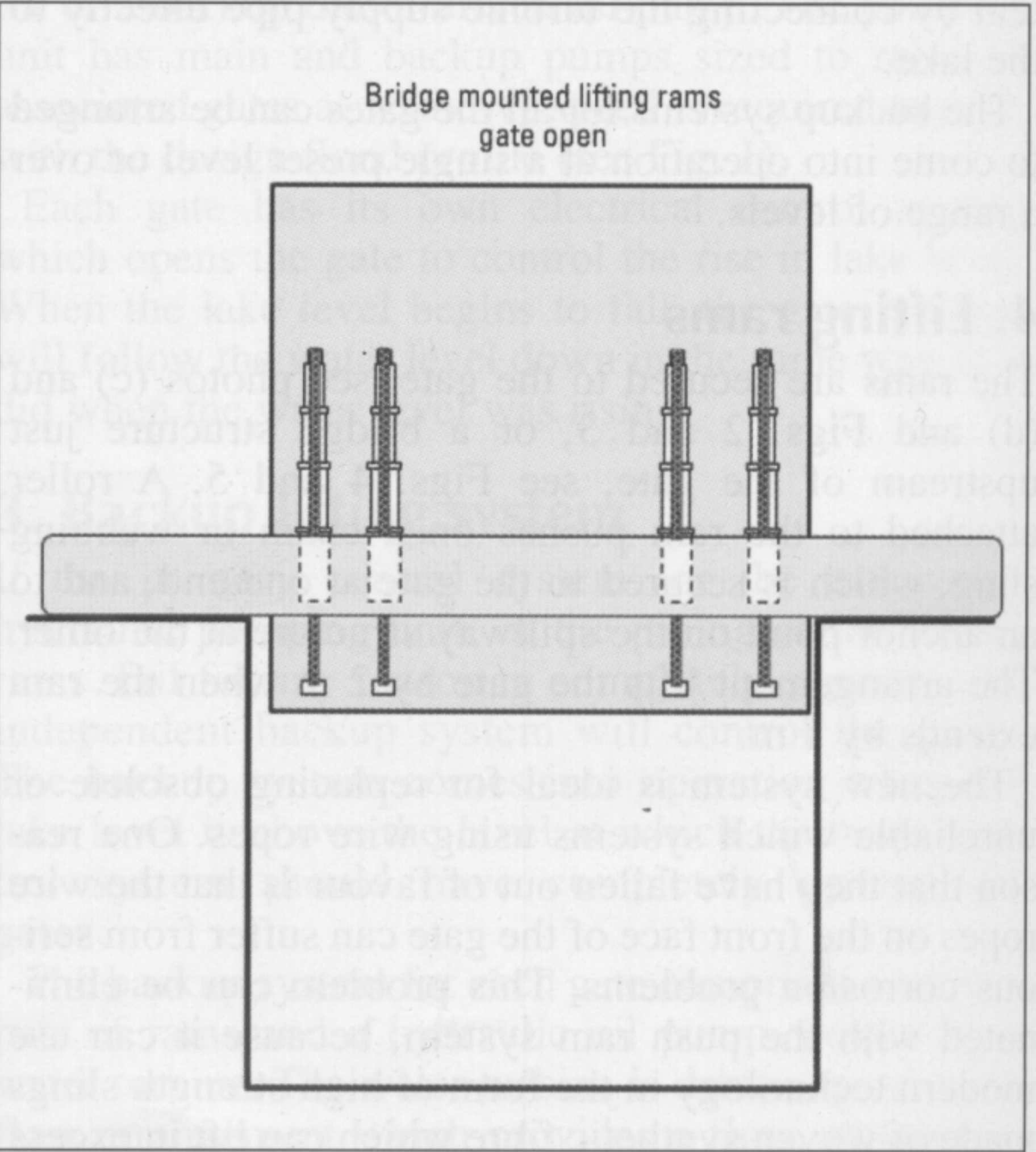


Fig. 5. Arrangement of twin rams.

combination of duplicate and independent lifting systems and a backup power source derived from the water in the lake makes the whole concept significantly more reliable than systems currently in use.

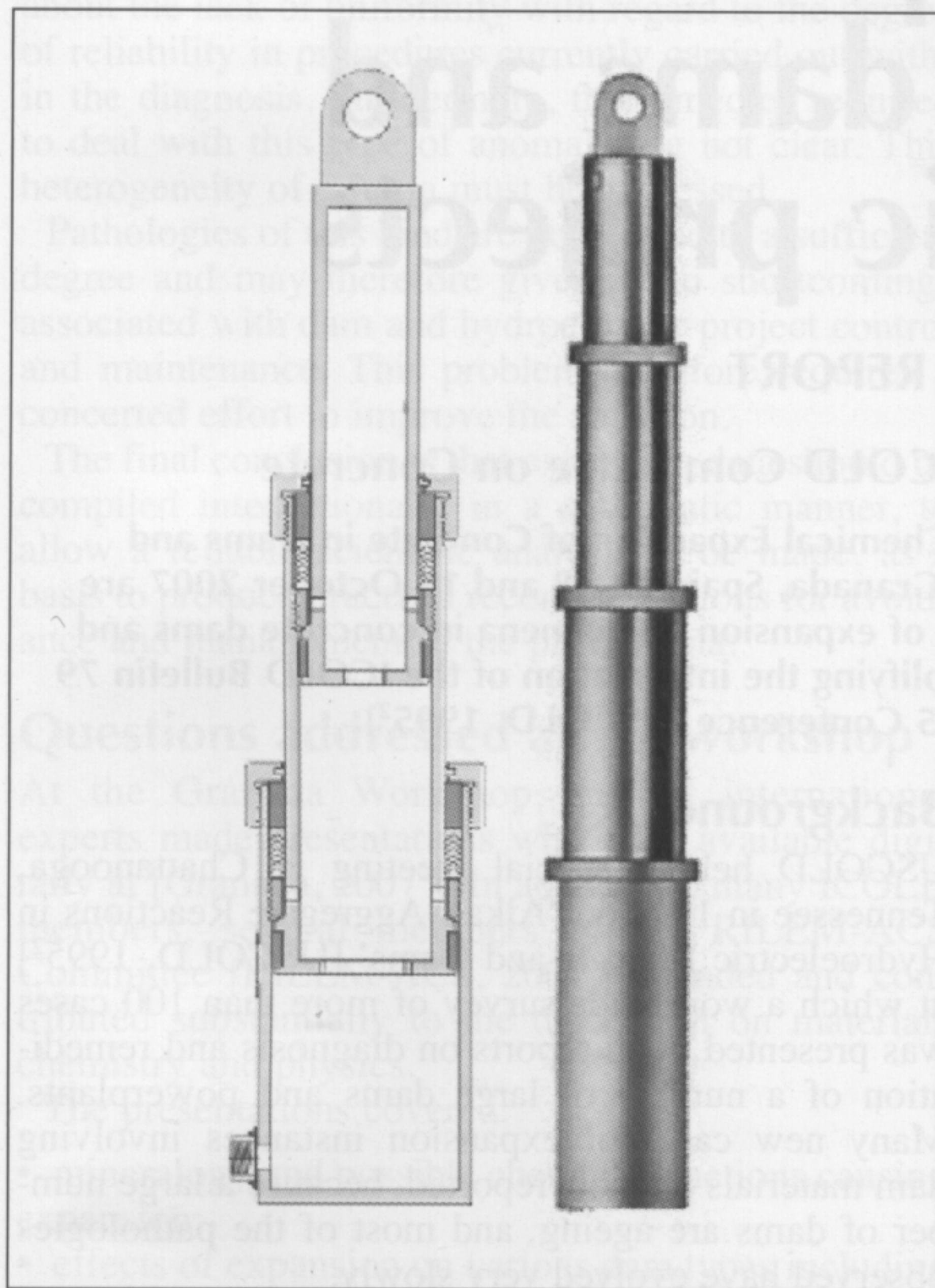


Fig. 6. The compound push ram.

The combination of a compact and low-cost lifting gear, and the elimination of the need for the normally accepted main and emergency power supplies, and a diesel engine-driven backup oil pump results in a system which costs significantly less than a conventional system designed for high reliability.

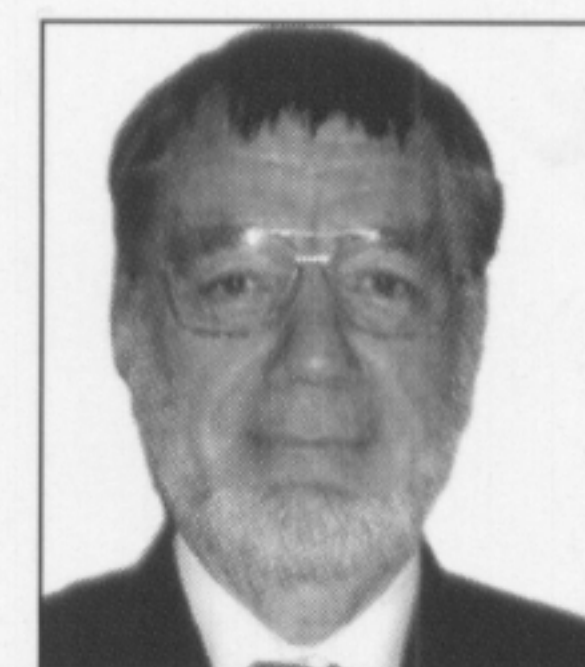
In situations where the consequences of a failure are not so important, the backup lifting system could be used as the sole method of lifting the gate. In many cases, this would be more reliable and cheaper than conventional systems that fail if the power supply is lost or the backup diesel does not start.

It is an excellent way of upgrading obsolete winch lifting systems.

The system is also applicable to vertical lift spillway gates and other types of gate that are opened using hydraulic cylinders. ◇

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