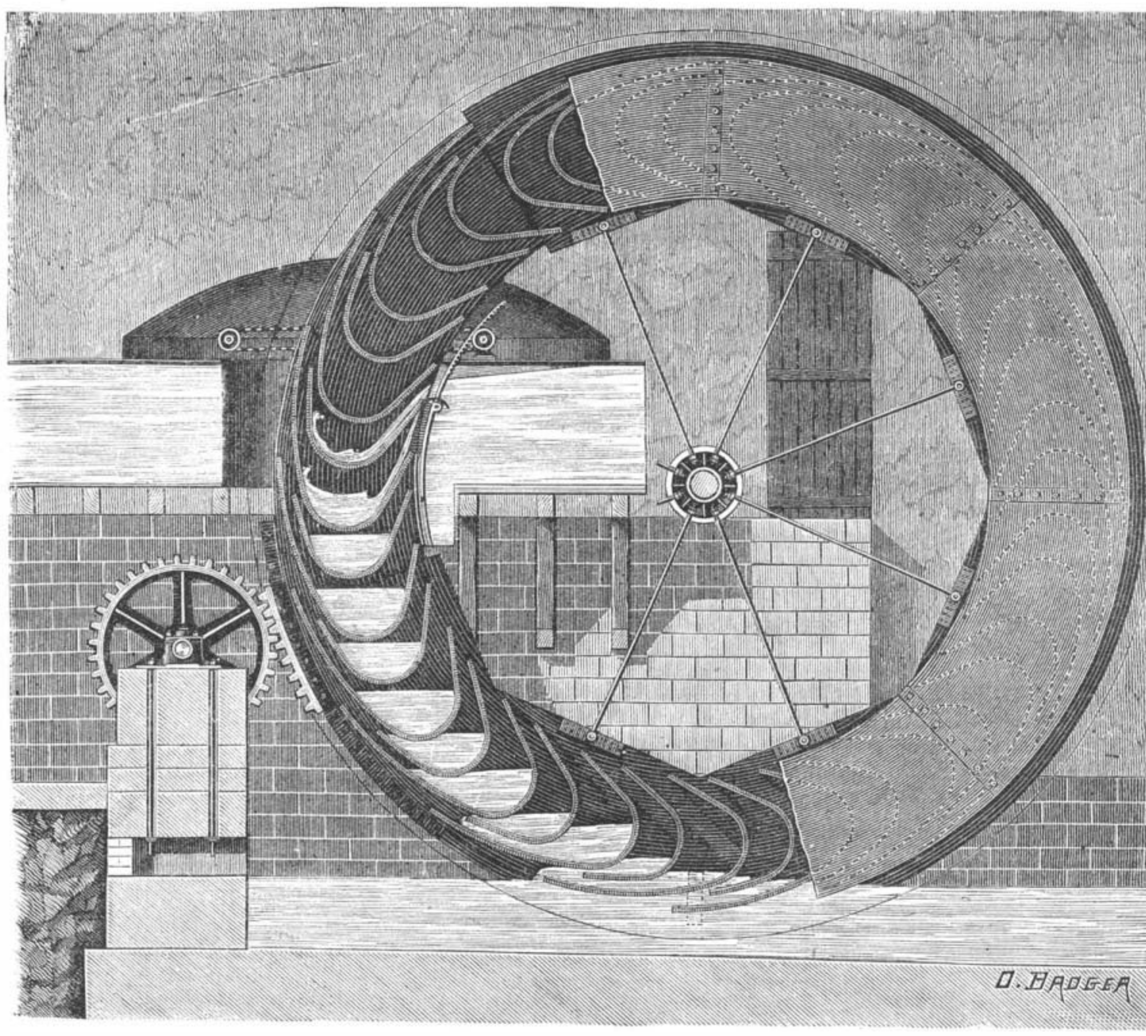
MILLOT'S HYDRAULIC WHEEL.

In the setting up of a hydraulic wheel, the following conditions always have to be satisfied: The water must be led from the head race with the least possible loss of velocity; it must be made to act without shock; and it must be discharged without velocity into the tail race. Such conditions cannot be rigorously fulfilled with undershot wheels, as the water loses a portion of its velocity before reaching the wheel, through friction against the sides of the race, and then, at the moment when it reaches one of the buckets, it suddenly loses its velocity and takes on that of the wheel; and, finally, it leaves the latter with considerable velocity. The performance of such a wheel rarely exceeds 25 per cent.

With the overshot wheel, provided it moves slowly, we obtain better results, since its motion, in which the water in the buckets participates, brings about a centrifugal force that modifies the form of the free surface of the liquid in each bucket. Such surface falls toward the interior of the wheel, and rises toward the exterior, so that the water tends to escape from the bucket before accomplishing its work. On another hand, if the water enters with slight velocity from the channel, it does not produce any shock on running into the buckets, if the wheel is moving slowly, and, when the buckets empty, the water is deposited in the tail race without velocity.



THE MILLOT-HAUVEL WATER WHEEL.

Well arranged overshot wheels utilize 75 per cent of the motive work developed by the action of the water, especially with heads varying from ten to forty feet.

With the breast wheel, the total weight of water that acts does not exert itself solely upon the wheel, for the pressure is merely a component of the weight of the water, and the race supports the other component or part of such weight. It results from this that the wheel, while receiving the same quantity of work from the water, is much less charged, and consequently the friction of its shaft upon the supports is less. But such advantages are counterbalanced by drawbacks due to the fact that the play necessarily existing between the edges of the buckets and the race occasions a loss of water, and also to the fact that the water, in running through the race, experiences quite a good deal of resistance.

To prevent too great a loss of water at this place, it becomes necessary to run the wheel with greater velocity than we do an overshot one, and the result is that the water leaves the wheel with a notable velocity that carries with it a loss of work. This wheel, nevertheless, utilizes about 66 per cent of the work developed by the water.

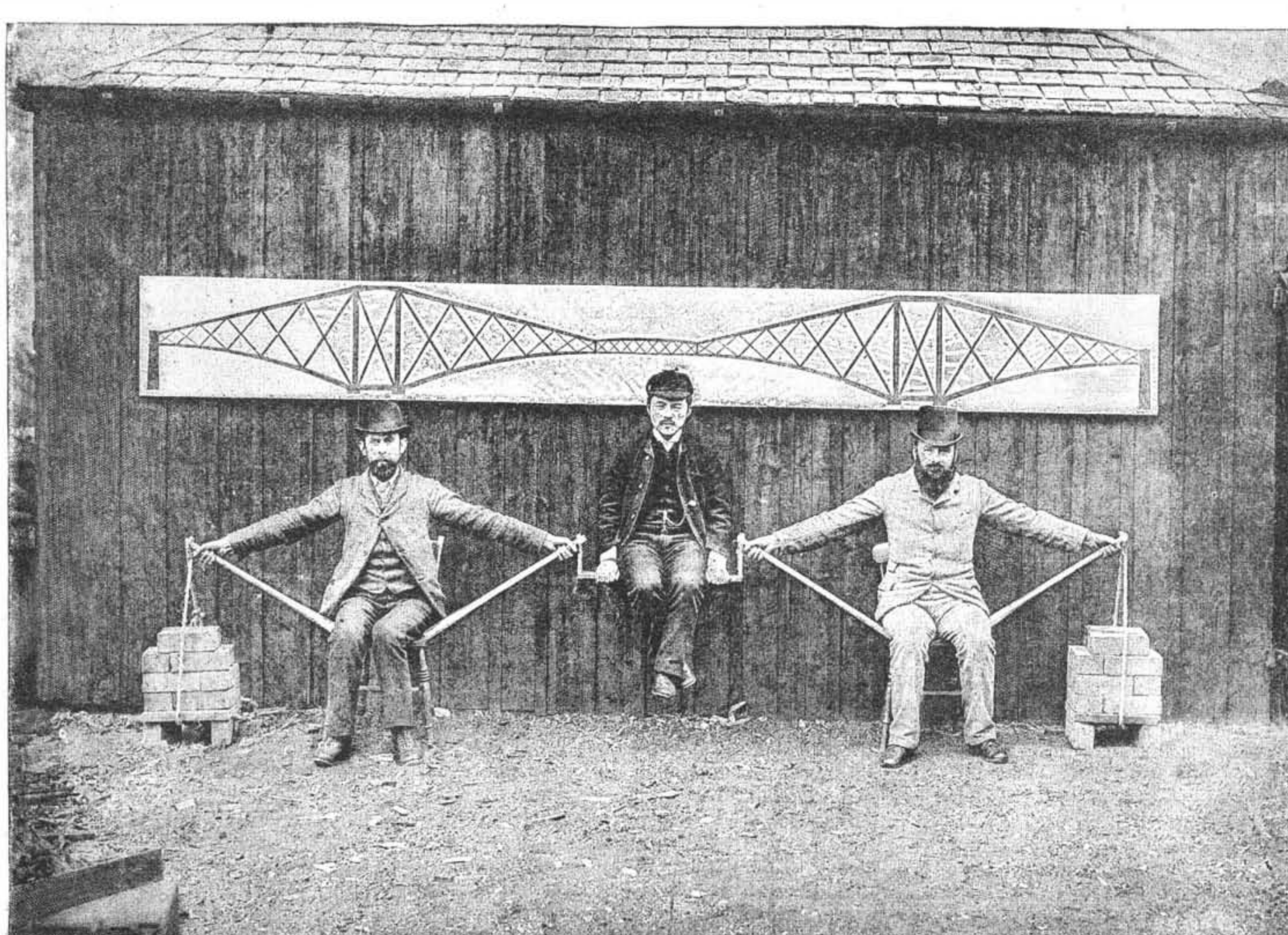
The Poncelet wheel is an undershot one, so modified as to make it utilize a greater fraction of the work furnished by the water, while at the same time allowing it the advantage of speed. Instead of flat buckets, it has curved ones, and its performance amounts to 60 per cent. The Sagebien wheel is a modification of the breast wheel, which, without being too wide, discharges a large volume of water, thus giving a better performance (80 per cent) than the ordinary breast wheel.

Such are the principal peculiarities of common water wheels.

The accompanying figure represents a Millot wheel, as modified by Mr. C. Hauvel. This wheel keeps up a high performance, despite variations in the head of water and in the discharge, since it always utilizes the total height of the fall. Moreover, it admits the water without velocity. Compared with overshot wheels, it presents a greater width of rim, that permits of taking in three or four times more water. If we compare it with breast wheels, or even with the Poncelet water wheel, we find that it does away with the construction and keeping in repair of a wheel race, and it is not exposed to damage or accident from ice or the passage of a foreign body. The objection has been made to it that its diameter is nearly double the height of the fall, and that it is slow, thus multiplying gearings; but the arrangement here illustrated and now used by Mr. Hauvel shows that it is possible to obtain great speed on the driving shaft. As may be seen, the inclination of the buckets allows it to be immersed to some depth without loss, and the slight velocity that is ascribed to it permits of following the current without meeting with resistance therein.

Mr. Hauvel employs iron plate buckets. The interior of the rim is toothed, thus rapidly multiplying the velocity of the driving shaft. The long shafts have been suppressed, and the heavy and cumbersome spokes have been replaced by simple bolted rods, that pass between the two distinct parts of the channel. The head race is thus divided into two portions of water, that join each other on their fall into the bucket. This arrangement, which is simple, light, and strong, is very ingenious.

In order to facilitate the exit of the water, the external lips of the buckets are made alternately long and short, so that the starting section is doubled. This receiver can, therefore, be applied to the utilization of a large discharge without the necessity of increasing its width out of measure. This arrangement does not produce any diminution in the performance due to the anticipated overflow of the water, because the latter does not fall into the race, but into the succeeding bucket. An official committee has found that the performance of this motor reaches 86 per cent.—*Revue Industrielle.*



THE PRINCIPLE OF THE FIRTH OF FORTH BRIDGE.

THE FIRTH OF FORTH BRIDGE.

BY B. BAKER, M. INST. C. E.*

If we could transport one of the tubes of the great Britannia Bridge from the Menai Straits to the Forth, we should find it would span little more than one-fourth of the space to be spanned by each of the great Forth Bridge girders. And yet it was of this Britannia Bridge that Stephenson, its engineer, thirty years ago, said: "Often at night I would lie tossing about seeking sleep in vain. The tubes filled my

* From a lecture delivered at the Royal Institution.—*Engineering.*