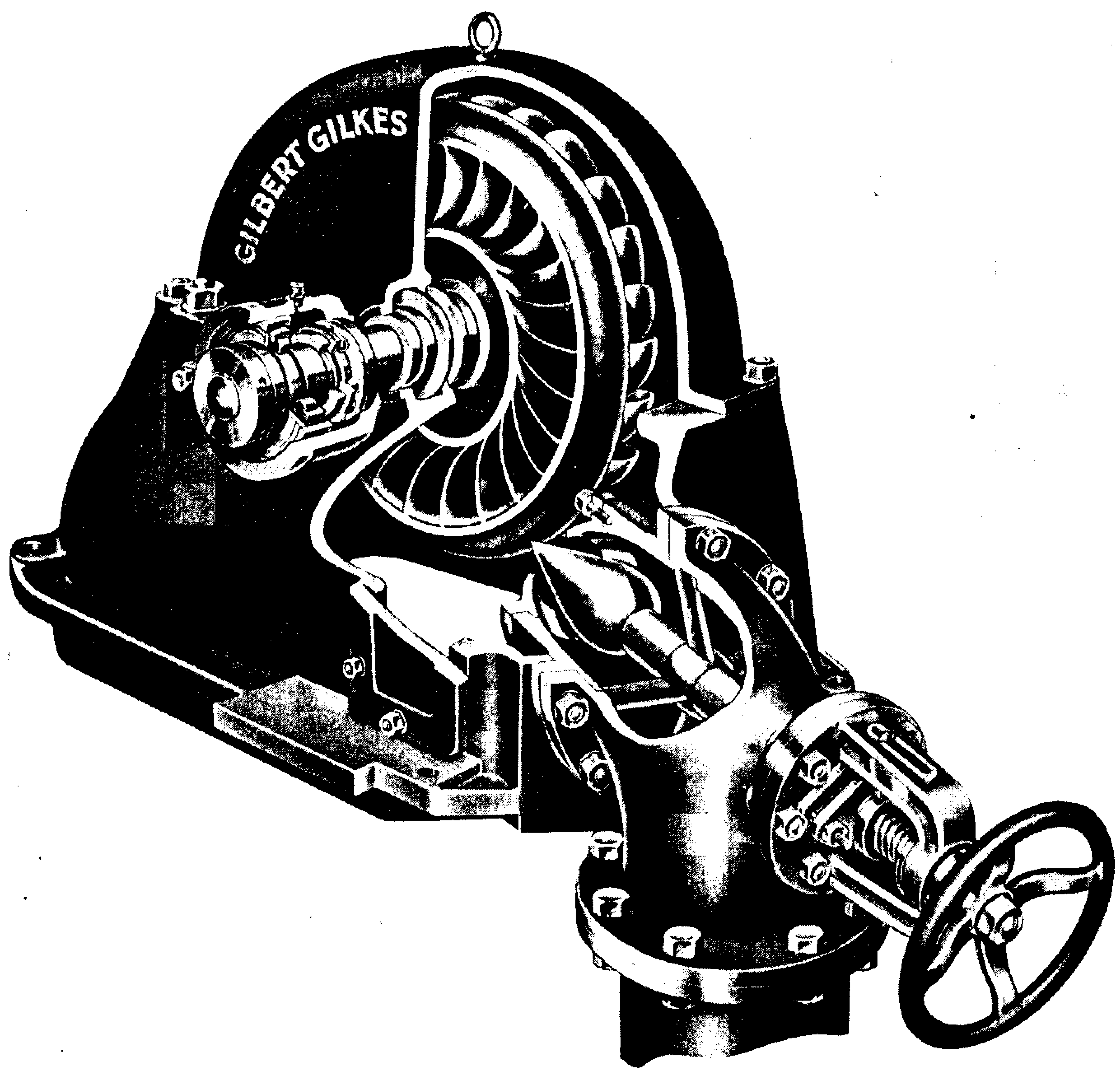

17 Cut-away view of a Gilkes Turgo Impulse turbine.

the bucket velocity will be 22 metres per second and the speed of rotation 420 revolutions per minute.

If the runner jet ratio could be reduced from 9 to $4\frac{1}{2}$, the runner need only be half the diameter, and could run at twice the speed.

Eric Crewdson (1888–1967) who was Managing Director of Gilbert Gilkes & Co Ltd., set out to design an impulse turbine which could use a very much larger jet, and in 1920 he was granted a patent for a type of turbine to which the trade name *Turgo Impulse* was given. Figure 16 shows the basic difference between the Pelton and Turgo Impulse designs, and figure 17 is cut-away view of a Turgo Impulse turbine. It will be seen that with the Turgo Impulse turbine the jet is set at an angle to the face of the runner and the water passes over the buckets in an axial direction before being discharged at the opposite side. The hydraulics of the flow through the runner are complex but it was found possible greatly to reduce the runner jet ratio as compared to a Pelton wheel, without appreciable loss in efficiency.

With the latest design of turbine a runner jet ratio of 4:1 can be obtained. The most powerful Turgo Impulse turbine develops 5,800 HP with a head of 178 metres and many hundreds are in use for the exploitation of medium heads and powers throughout the world.

Propeller, Kaplan and Deriaz Turbines

As reaction turbines increased in size they had, under any given operating head, to run at slower speeds. In many parts of the world huge rivers flowed over rapids, but it might only be possible to obtain an operating head of 10 or 20 metres. As Crewdson had set out to design a high speed impulse turbine, American and Continental designers looked for a higher speed type of reaction turbine. The first result was a turbine similar to a Francis turbine, but with a runner like a ship's propeller. An early design of runner had two blades. Later three, four or more blades were used. Fixed blade propeller turbines have certain grave disadvantages.

1. Their part-load efficiency is very low. This means that if a single turbine is installed on a river and the flow drops to half that required at full load, the turbines will develop less than half its maximum power.

2. The 'runaway speed' at which the turbine will run if full load is suddenly removed and the governor fails to control it is very high, which greatly increases the cost of the generator driven by the turbine.

3. 'Cavitation', which attacks the runner if it is not set sufficiently low relative to the tail water level, can be a serious problem.

The first problem was partly overcome in Canada and the United States by installing a number of units in one power station, and running as many as possible at full load. However, the cost of plant and civil engineering work led power station operators to demand larger turbines and fewer of