



18 *Model of an English Electric Kaplan turbine and generator developing 28,000 HP at Invergarry.*

them, particularly as the extreme reliability of well-built large turbines was proved throughout the world.

Professor Victor Kaplan (1876–1934), a German working at Brünn in Czechoslovakia, realised that if the propeller blade angle could be reduced as the quantity of water dropped, much better part-load efficiency would be obtained. He carried out experimental work from 1910 to 1924 and solved the difficult problem of fixing the blades in the hub and adjusting the blades and the guide vanes in unison so as always to run at maximum efficiency. There are now many very large Kaplan turbines in the world, but few in the United Kingdom. Only at some sites in Scotland has it been found economic to install reasonable large, low head units. Figure 18 shows a working model of a 28,000 HP English Electric Kaplan turbine installed at Invergarry.

The Kaplan turbine cannot normally be used for heads higher than about forty to fifty metres. But the combination of adjustable guide vanes and runner blades gave such a high efficiency that there was clearly need for a Francis type turbine which would have similar characteristics to the Kaplan but could be used for higher heads.

Such a machine was evolved by Paul Deriaz who was trained in Zurich and later became Chief Designer of the Water Turbine Department of The English Electric Co Ltd. Figure 19 shows a section through a Deriaz turbine and it will be seen that the runner blades are set at an angle around the rim of a conical hub. One of the difficulties with large Kaplan turbines lay in the provision of robust stubs and bearings to secure the blades to the hub which could only be of limited diameter. With the Deriaz design longer and stronger stubs with good bearings and reasonably long operating levers could be incorporated. This was an important mechanical feature while the hydraulic design gave excellent efficiency characteristics.

Deriaz turbines can be used for heads up to 300 metres and units of over 100,000 HP are in operation.

Reversible Pump Turbines

One of the problems in electricity supply is that the demand varies throughout the day but electricity can be generated most economically if a constant load is imposed on the power stations. Electrical energy cannot be stored, except in relatively small quantities in accumulators. There must therefore be sufficient generating capacity available to meet the greatest foreseeable demand, and inevitably some of this very expensive equipment will be in use for only a short period each day.

The Central Electricity Generating Board seek to alleviate this problem by using a number of pumped storage stations. These are essentially hydro-electric generating stations which are used to generate electricity at peak hours but which are operated in reverse and pump water up hill in