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Nineteenth-century Hydro-electric Railways in the U.K.

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We still have with us some Victorian water-powered railways in the shape of cliff tramways operated on the water-balance principle, but I believe we no longer have any railways using water power through the medium of electrical transmission. Of course, a good deal of hydro-electric power nowadays gets fed into the electricity grid system, and may thus contribute to electric traction; and there have been cases of hydro-electricity being mixed with thermally-generated electricity and contributing to the supply for electric tramways in the more distant past, as at Worcester after 1902. However, at the end of the nineteenth century there were at least five railways in the U.K. which used water power for electric traction, on an exclusive basis for at least part of the year. These were, in order of opening of the hydro-electric supply,

- Portrush to Bushmills (Northern Ireland) – later extended to the Giant's Causeway
- Bessbrook to Newry (Northern Ireland)
- Carstairs Junction to Carstairs House (Scotland)
- Greenside Lead Mine, near Ullswater (England)
- Douglas to Ramsey (Isle of Man)

The object of this article is to draw attention to these systems as a group, to set them in their historical background, and to list some basic literature from which full information can be obtained.

During the nineteenth century the application of water power was greatly improved by the development of the water turbine, and during the same period the generation and use of electricity progressed from Volta's pile in 1800 to public supply in 1881. Simple electrical machines were made from the early 1830s, and in 1841–3 Robert Davidson experimented with a battery-powered electric locomotive which actually ran successfully on the Edinburgh & Glasgow Railway; it used simple axle-mounted magneto-electric rotary motors, but had little power or endurance.[1] In 1851 an American, Charles G. Page, demonstrated an electric battery locomotive on the Baltimore & Ohio Railroad; it used reciprocating electric engines analogous to a steam engine, and was not a success.[2] Nothing more of importance was done in electric traction until Siemens and Halske demonstrated a short electric railway at Berlin in 1879 in which a rotary electric motor on a small locomotive was supplied from a special centre rail with current return through the running rails. On 12 May 1881 the first commercial electric tramway was opened at Lichterfeld in Berlin; it had a length of 2 km, used the running rails as conductors with a voltage of 100, had an electric motor mounted under each car, driving the axles by pulleys and steel ropes, and had a steam-driven power station of 12 H.P.[3] Electric street tramways of the more familiar kind began with Sprague's tramway at Richmond, Virginia, in 1887.[4]

Water power was widely used in industry, and it is perhaps surprising that it does not appear to have been used for generating electricity until 1880. In November of that year it was reported[5] that an experiment had been tried at Turin in Italy in which water power had successfully been used to drive an electric railway in which the electricity had been transmitted by means of two parallel cables along the route. Unfortunately no further information on this important matter has yet been found.

In the U.K. the first application of hydro-electricity seems to have been to the illumination of Sir W. G. Armstrong's house, Cragside, at Rothbury in Northumberland, in December 1880;[6] and this was followed by the public lighting of Godalming in Surrey in September 1881, also using water power.[7] After that, with Swan's incandescent-filament lamp commercially available, public electricity supply began to develop, and among the numerous generating stations that had been built by the end of the century, about a dozen in Britain were water-powered, with some more in Ireland.[8] Hydro-electric development was, of course, much greater in America and in many countries in Europe because of their better supply of suitable rivers. Hydro-electricity was also used for numerous private and industrial applications, in the U.K. as elsewhere, and one early example in a remote place was in Mull in 1882.[9]

Against this background we can now consider the beginnings of the five hydro-electric railways.

The Portrush – Bushmills – Giant's Causeway tramway

The six-mile section of this line between Portrush and Bushmills was laid by the end of 1882 and inspected by the Board of Trade's Inspector on 12 January 1883. At this stage steam locomotives were being used, with electric traction on a purely experimental basis using steam-driven generators. The electrical design was in the hands of Siemens Bros. and Dr. John Hopkinson, and was set out in their paper in April[10]; they decided that an outside conductor rail carrying 225 volts would be suitable, in spite of the fact that the line ran beside a public road. A fatal accident in 1895 led to the replacement of this system by an overhead trolley system. The hydro-electric generating station was completed in September 1883.[11] It was on the river Bush near Bushmills, where natural falls provided a head of about 25 ft. Two 50 H.P. turbines were provided; this would have been ample as each tramcar was fitted with motors of about 4 H.P. The regular electric service opened on 5 November 1883.

Traffic was quite considerable, over 62,000 passengers being carried in 1887, and it was in this year that the 2-mile extension to the Giant's Causeway was opened, with additional generating capacity at the hydro station. Steam locomotives were also used on the line for goods and exceptional traffic.

The tramway continued in service until 1949, with the hydro-electric station functioning until the end. Its jubilee was noticed in 1933,[12] a short history with excellent illustrations was given by Lee[13] in 1936, and an account of the line after dismantling was given by Dickinson.[14] A full history of the line has been given (unfortunately without references) by McGuigan,[15] and he has included descriptions of the generating station and of its various stages of expansion.

The gauge of the line was the standard Irish narrow gauge of 3 ft. The electricity supply was supplemented from 1925 by an oil engined power plant of 132 H.P. at Portrush.

The Bessbrook & Newry tramway

This too was of 3 ft gauge, used a third rail system at 250 volts (but centrally-placed), and had John Hopkinson as its electrical designer, but there were some important differences from the Portrush line. Firstly, the Bessbrook & Newry tramway was essentially an industrial one, being constructed for a manufacturing firm primarily for its own use and being required to transport up to 200 tons of minerals and goods in addition to passengers (who were mainly its own employees).[16,17] Secondly, it had its own route independent of public roads. Thirdly, the goods wagons had flangeless wheels so that they could also be hauled by horses on ordinary roads; these wheels ran on lighter rails laid outside and nearly an inch lower than the main tram rails, so that the latter acted as guides. Fourthly, the line was entirely dependent on water power, having no steam or other auxiliary power. Fifthly, the tramcars were of bogie type, with the leading bogie carrying an electric motor of about 20 H.P., and these cars (initially two in number) were used as locomotives as well as passenger carriers. There were reversal loops at each terminus. The line, connecting geographically but not physically with the main line at Newry, was just over 3 miles in length with maximum gradient 1 in 50. It was opened for traffic in October 1885, although the first sod had been cut as early as September 1883.[15]

The hydro-electric generating station was on the Camlough river at Millvale, where the tramway crossed it, about a mile from Bessbrook. The head was 28 ft and a single turbine of 62 H.P. was provided, with two dynamos.

Where the line crossed a public road, it was necessary to interrupt the third rail, and instead of relying on contact shoes at each end of the car to bridge the gap, as on the Portrush line, the gap was spanned by an overhead conductor which made contact with a transverse iron bar above the roof of the tramcar.

Hopkinson's paper of 1888 gave a very detailed description of the line and its equipment,[18] and a well-illustrated account was given by Frayle over 50 years later.[19]

The tramway had quite a long life, not closing until 10 January 1948.[20] An early tramcar from the line which incorporated one of the original motor-bogies of 1885 has been preserved in the Belfast Tramway Museum.[21]

The Carstairs House tramway

This small tramway, of 2 ft 6 in gauge and one and a quarter miles long, linked Carstairs House (grid reference NS 942 443) to Carstairs Junction, on the then Caledonian Railway; it was a private line, opened in May 1889, with one motor-car. Two more were obtained soon afterwards. There were two conductor rails, one at each side of the track.[22]

The hydro-electric generating station was at a waterfall some three miles from the house, equipped with a turbine and dynamo of about 16 kW rating. The generator voltage was kept at a value which maintained about 250 volts between the conductor rails. There was no earth connexion (!) The generator had also to supply the house lighting system. Batteries were used for storage of electricity, so that the system could be run for limited periods without the generator.

Electric traction ceased in 1905 after the electrocution of the owner; horses were then used until final closure in about 1935.[23]

An illustration of one of the electric cars is given by Brotchie.[24]

The Greenside Lead Mine tramway

This was an underground tramway in the Lucy level of this large mine, about one and a half miles long, and of gauge of about 2 ft. It was provided with electric traction in the shape of one small locomotive of 14 H.P., weighing 2½ tons, in about 1892, as part of a major modernization of the mine involving electric power started in 1890.[25] The lead industry at this time was in decline, but by this bold programme of electrification and other improvements the mine was able to survive another 70 years.[26,27] The electrical supply was generated by water power. In contrast with the systems already described, which had convenient falls on sizeable streams, this installation involved considerable

construction of watercourses up in the mountains and a length of pipeline.[28] The generating station itself was very much in the wilds of the mountains at grid reference NY 358 168. The initial equipment comprised one 100 H.P. reaction turbine and one dynamo, but in the early 1900s a Pelton wheel and another dynamo were added, and in 1911 the original turbine was replaced by a 300 H.P. Pelton wheel driving a high-voltage alternator. The head was about 400 ft.

The locomotive collected its current by means of two pairs of contact pulleys running on two bare phosphor-bronze conductors attached to the roof of the level (or tunnel). Seeing that the voltage was 250 volts, this seemed somewhat hazardous in a damp situation, but no accidents seem to have been reported. The locomotive was still running in 1921 according to an inventory of plant which is held in the Westmorland (now Cumbria) Record Office. Shaw[27] says it ran for 40 years; he also says it was of 30 H.P., but the inventory clearly says 14, as does Borlase.[25] Its normal train, according to the inventory, was 12 wagons. It was said to be able to haul this load of about 18 tons over the 1½ miles in about 20 minutes.

The Douglas to Ramsey tramway

This electric tramway was constructed in two sections; that from Douglas to Laxey, about 8 miles, was opened in July 1894,[29] and that from Laxey to Ramsey, about 10½ miles, in August 1898.[30] The electricity was thermally generated. However, as the winter traffic was light, it was thought that it would be a very substantial economy to provide water-generated electricity during perhaps seven months of the year when ample water was available in the Laxey river, the steam stations being started up only for the summer when the traffic was heavy and the water scarce. A hydro-electric generating station was therefore built at Laxey, very near the steam station there, from which it was remotely controlled. It was put into service at the end of 1899.[31,32] Unfortunately it soon proved necessary to augment the water power from time to time during the winters as the river flow was not always adequate.

A head race or leat was built to take water from the river below the famous lead mine. It comprised 1300 ft of open channel and 820 ft of steel pipe-line of 3 ft diameter. After providing a head of about 40 ft for the turbines, the water was led to Laxey Harbour by a tail race of 624 ft. Because the intake water contained so much suspended matter from the mine washings, special settling tanks had to be provided in the head race. The two turbines were in the same casing, but either could be worked independently; the total power was 140 H.P. An 80 kW dynamo was provided, together with a 160-amp booster.

The tramway had three battery stations, and these were used continuously to help smooth the load fluctuations for the dynamos.

Like the two Irish lines, this line had John Hopkinson as its electrical advisor; it also had the same gauge of 3 ft. However, instead of a third rail it had an overhead conductor, with a contact bar on the roof of the tramcars somewhat as used for road crossings on the Bessbrook & Newry line.[33] This enabled it to work with a 500 volt supply. The contact bars were replaced by trolleys early in 1898.

In April 1935 the tramway went over to the public electricity supply, and the hydro-electric plant was used no more.

A recent book by Pearson[34] gives a detailed history of the line.

Discussion.

It may well be asked why I should have grouped these five hydro-electric tramways together. Were they not just electric tramways, with hydro-electric supply as an incidental? I think the answer to this last question is 'No'. The first four would almost certainly not have been electric tramways at all if there had not been the possibility of getting cheap hydro-electric power. The availability of water power was the reason for their electrification. There was no doubt that in all cases the use of hydro-electric power was very much cheaper than thermal power of any kind. It was indeed the general nineteenth century experience in industry generally that water power was cheaper than steam. Public electricity-supply stations that used water power were able to generate electricity at a lower cost per unit than thermal stations at the end of the nineteenth century. The situation in Britain nowadays is quite different; with the massive capital costs of the civil engineering work required for a large hydro-electric scheme in Scotland or Wales, not to mention the long transmission lines required to take the electricity to where it is wanted, and present rates of interest, thermal generation is now cheaper than hydro-generation. But none of this applied before 1900; the civil engineering works were very modest, the power was used where it was generated, and interest rates were low.

The five lines were geographically and technically very diverse. They showed a marked degree of originality and innovation, and were in many ways pioneers.

References

What I have tried to do here is to list a careful selection of references, some contemporary with the opening of the lines, some more recent, to give a good detailed overall coverage (technical, operational, and photographic) for those who want to go deeply into the story of these lines. All are readily accessible in the larger reference libraries.

Contemporary reports were very numerous, and hundreds can be found by searching the indexes of the relevant journals; but these are needed only for specialized research, and cannot be listed here.

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