The electric railway. Part 7, The post war developments of the classic electrical concept

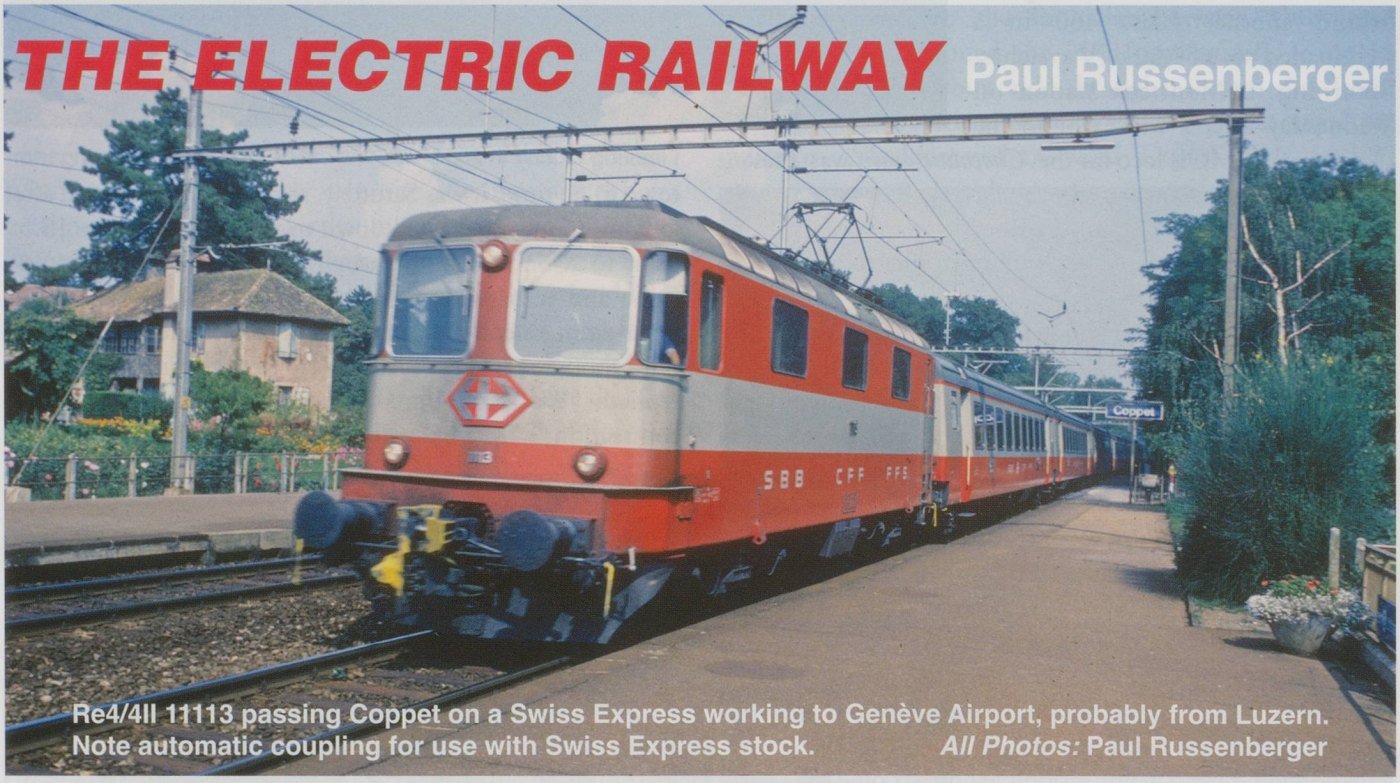
and, as is inevitable when you are in a hurry, was required to stop at every request halt along the way, so no time was made up. At Montbovon we were relieved to see the MOB train waiting for us. Shortly after departure the Train Manager came through checking tickets, and we thanked her for waiting - "Yes, but I have passengers for Geneva Airport" she commented. Fortunately we did not stop at many request halts and arrived in Montreux just three minutes late, and before the Genève train. Seeing the Train Manager on the platform she greeted us with a broad smile saying "We have made the connection, so everyone is happy." She must have gone home that night pleased that she had made the right decision. A nice end to our stay in Montreux, our Swiss Passes yet again seeing much use and proving excellent value for money. After a week of good weather it was time to move on to Grindelwald where it rained, but that is another story.

Changing trains at Montbovon on 7.9.2013.

TPF No. 226 at Gruyères on 7.9.2013. *Photos:* David Carpenter

THE ELECTRIC RAILWAY

Paul Russenberger



Re4/4II 11113 passing Coppet on a Swiss Express working to Genève Airport, probably from Luzern. Note automatic coupling for use with Swiss Express stock. *All Photos:* Paul Russenberger

Part 7 – The Post War Developments of the Classic Electrical Concept

The first Leichstahlwagen – 'Light Steel Coach' – appeared in 1937 and series production began that year. The concept achieved a reduction in weight from at least 35t to 29t for the same carrying capacity by building the strength into the body itself. The heavy underframe is replaced by constructing the whole coach body as a tube. This is sometimes referred to as 'monocoque' construction, though railway parlance usually describes it as 'integral'. A locomotive is a rolling stock vehicle in the same way as a coach, albeit with traction equipment rather than passenger accommodation. It follows that the same principles of construction can be applied. Because the locomotive has to carry a greater weight – transformers weigh more than people – a greater reduction in weight can be gained. There are numerous advantages. Less material is used in construction; the vehicle

potentially behaves better in accidents; the reduction in mass means that less energy is used in accelerating the train; for the same installed power a higher maximum speed can be attained because of the reduction in rolling resistance which is related to weight. The body has to be designed carefully since the body skin itself carries some of the structural strength and is therefore under stress.

In 1940 three motor luggage vans were delivered to the SBB, Nos. 601-3 and classified RFe4/4. They were rated at 1,340hp, but weighed only 50.5t. This compares with the earlier De4/4 luggage van of 1927, which weighed 59t and was rated at 1,100hp. While there had clearly been some development of the traction motors in the intervening years, the figures show a 14% reduction in weight and a 21% increase in power output. The 'R'[1] classification acknowledged their maximum speed of 125kph. Although the SBB probably only had a limited use for such vehicles, they were essentially experimental and proved the practical viability of the concept. In 1944 the Bodensee – Toggenburg and Sudostbahnen bought them and altered the gearing of the transmission to suit their steeply graded lines. This reduced the maximum speed to 90kph. They survived into the 1990s. The principle of integral construction was a significant breakthrough in locomotive development. It can be applied to both electric and diesel traction. By the 1960s it had become the standard principle in the design of locomotive and coach bodies throughout the world and is possibly the most significant development given to rolling stock engineering by Switzerland.

Building on the experience with the RFe4/4, SBB took delivery of a production series of Bo-Bo locomotives in 1946-8. Their body design clearly followed the RFe4/4, though they were rather more powerful at 2,470hp and heavier at 57t. Nevertheless, this brought the maximum axle load below 15t and provided a power to weight ratio of 43.4hp/t compared with 26.0hp/t of the Ae4/7. Initially Nos. 401 – 426, they were fitted with end corridor connections so that they could be marshalled in the centre of a train, and the internal corridor was laid out so that passengers could walk through the locomotive[2]. They were put to work on lightweight express trains on the Zürich – Bern – Genève axis, replacing class Ae3/6I; the difference in weight was the equivalent of one heavy-weight coach, together with an additional 360hp. Delivery of a further series of 24 without the corridor connections took place in 1950-51.

The post-war economic recovery was to reactivate the problem of motive power for the Gotthard. The pre-war Ae8/14 twin-units had proved to be operationally cumbersome. While they could deliver the necessary power for the heaviest of trains, it was excessive for use elsewhere

1. Originally SBB RFe4/4 No. 602 of 1940, this locomotive became 22 when transferred to the SOB. The strong resemblance to the RE4/4I arising from the integral construction is apparent.

2. Re4/4I 10005 enters Zürich HB on 31 August 1974. The corridor connection and the windows lighting the through passenger corridor on one side can be clearly seen.

3. Re4/4I 10050 enters Bern with the Geneva portion of the northbound Rheingold in September 1976. Note the lack of corridor connections and the different bodyside louvres.

4. Ae6/6 11406 'Obwalden' entering Zürich HB on 6 June 1977. The first 25 of the class named after cantons carried chrome decoration.

when they were built, yet a single Ae4/7 was bound to prove inadequate. An intermediate development had taken place with the Ae4/6, which had been ordered from SLM in 1939. However, their concept was akin to the Ae8/14 rather than the Re4/4³. Consequently the SBB developed a specification for a six-axle, bogie unit capable of delivering approaching 6,000hp over one hour and constructed according to the principles of the Re4/4. The Ae6/6, which first appeared in 1952 and went into series production from 1955-66 to a total of 120 machines, was the result. The body rested on inverted leaf springs placed outside the 3-axle bogies, the middle motor preventing the simple arrangement of the body resting on an internal, transverse girder. While it was 10t heavier than the Ae4/7, because the whole weight of the locomotive was carried by the bogies with all axles powered, the Ae6/6 could haul five times its own weight of 128t over the Gotthard compared with 2.6 times of the Ae4/7. Aesthetically, the slightly raked ends with two large cab windows of the Ae6/6 set the genre for the general external appearance for the next generation of SBB locomotives. They were also the first class to carry names together with the badge of the appropriate canton or town.

By the 1960s much of the SBB fleet had been in service for 40 years and was becoming due for replacement. The wide use of Bo-Bo electric locomotives throughout Europe showed that it was a suitable layout for widespread use, and was appropriate for a design for general purposes on the SBB. In 1963-4 a short production run of six locomotives appeared, classified Re4/4II. Full series production began in 1967 and continued until 1985, by which time nearly 300 had been delivered. For a weight of 80t, they can deliver 6,200 hp over an hour and have a maximum speed of 140kph. There are detailed differences between the three production tranches, including no fewer than 11 different overall lengths! Twenty of the final series were fitted with a lower gearing between the traction motors and the rail wheels and classified Re4/4III. This reduced the maximum speed to 125kph and increased the maximum tractive effort from 255kN to 280kN⁴. A smaller variation applied to seven units of the second series enabled them to work to Lindau. They were equipped with one pantograph suitable for the Austrian and German overhead wire. To even out the wear on the pantograph head the wire is not placed directly over the centre of the running rails, but is deliberately moved from side to side. In Switzerland this 'stagger' is narrower and the mechanical tension in the overhead line is greater, making it stiffer, so that a wider pantograph head and a lower contact force are needed on the ÖBB or DB.

The logical development from here was to expand the Re4/4II Bo-Bo into a Bo-Bo-Bo, or 'Tri-Bo', and this led to the Re6/6. The advantage of the Tri-Bo over the Co-Co is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1. Re4/4II 11111 during shunting movements at Basel SBB in August 1978, seen from the corridor connection of the Chur – Amsterdam car of the Rheingold.
2. Re6/6 11612 *'Regensdorf'* in March 1981 at Bellinzona following the author's footplate ride mentioned in the text.
3. Re4/4I 10036 and Re4/4II 11221 at Winterthur in March 1984. The second tranche of the Re4/4I did not have the corridor connections and had a different layout of windows and louvres in the bodysides.
4. Ae6/6 11513 *'Walisellen'* manoeuvring light engine to the west of Bern station on 1 November 1987.

1. Re4/4II 11243 at Thun on a working to Interlaken on 28 January 1989.
2. Re6/6 11688 Linthal approaching Brunnen on a Chiasso – Schafhausen working on 6 September 1989. At this point the southbound track is in tunnel while the northbound one uses the original single track.
3. Re4/4I 10016 on the former turntable at Luzern shed. Note the 'blank' bodyside on the non-corridor side of the locomotive.

that the twin axle bogies can follow the track more easily and the transfer of weight between axles is reduced, thus maintaining better contact with the rail. This is important when exerting a high tractive effort. The smaller bogie has a naturally lower resistance to being rotated either laterally or in pitching, thereby reducing the dynamic forces applied to the track[5]. The centre bogie can move laterally. Four prototypes appeared in 1972 to test the mechanical layouts, the body of the first two being made in two sections connected by a horizontal hinge. The purpose of the hinge being horizontal was to assist the locomotive in following vertical curvature. Experience showed that the simpler construction using a single body was adequate and this was followed in the production series introduced in 1975. The class is effectively an Re4/4II stretched by 50%, since it uses the same bogies, wheelsets and traction motors and can work in multiple with the Re4/4II and Re4/4III. The advantage over the Ae6/6 is indicated by the higher hourly rated power output of 7,850kW, compared with 4,300kW, for virtually the same tractive effort. This enables a higher speed to be reached before the maximum tractive effort can no longer be sustained.

All the designs described followed the original concept of taking the 15kV ac from the overhead line and transforming it down to a voltage acceptable to the traction motors, controlled by varying the ratio of the windings on the transformer. The Re4/4II and the Re6/6 together became as iconic of SBB locomotives as the Ae3/6I and Ae4/7 had before them. They had also taken the original system to what may be its technical limit. Developments in 'semi-conductors' by the late 1970s were to enable traction engineers to move seriously towards their ultimate goal of a motor which operates satisfactorily over a wide range of speeds, is compact and requires limited running maintenance. This would lead to a step change in electric traction technology across the world – Switzerland included.

REFERENCES

1 The 'R' originated with the 'Rotepfeil' – Red Arrow – railcars which were the first vehicles authorised to run at over 110 km/hr, the maximum speed for an 'A' classified vehicle.

2 Photographs exist of this corridor connection (Platform 5 Swiss Railways, 1st edition), but has any member experienced it in use?

3 A very thorough article on these locomotives by John Jesson appeared in the September 1992 Swiss Express.

4 To help comparison with contemporary British locomotives, 255kN equates to approximately 57,300 lb-force and 280 kN with 63,000 lb-force.

5 I have been fortunate enough to have travelled on an Re6/6 – it rode like a passenger coach.

Swiss Tips: Good ideas and information about Switzerland from travellers.

Fancy a walk with a difference? The SBB has recently completed a major overhaul of the great reinforced concrete viaduct over the valley of l'Orbe on the line between Vallorbe and Le Day. For those with a head for heights there is a public footpath suspended underneath the tracks between the arches of the viaduct. Enjoy!

Do you have some good information about Switzerland? Why not share it with other members by sending it to ther editor of *Swiss Express* so it can become a **Swiss Tip**?