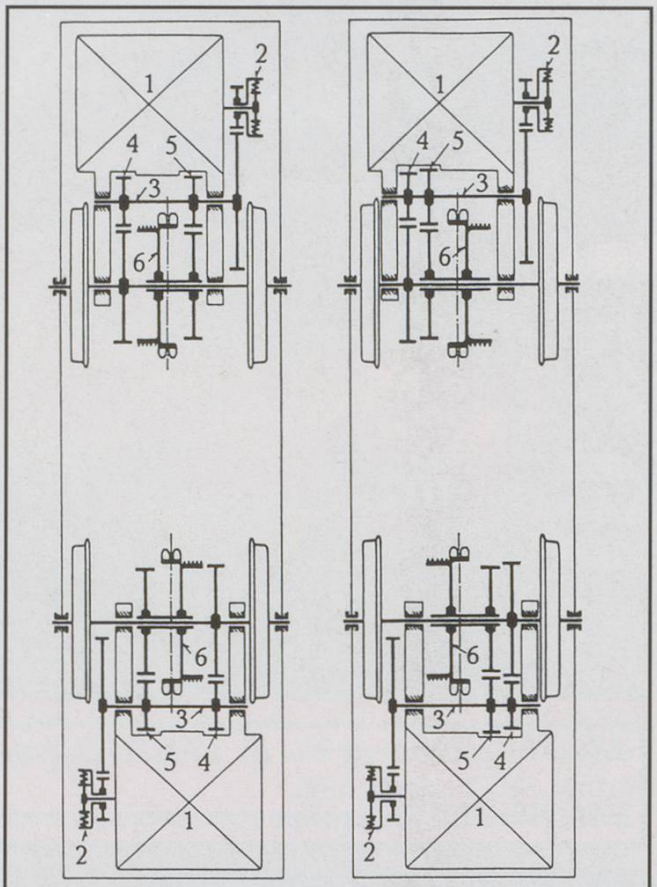
Zeitschrift: Swiss express : the Swiss Railways Society journal
Herausgeber: Swiss Railways Society
Band: 6 (2000-2002)
Heft: 5

Artikel: Tooth by tooth. Part 3, Electric power on the rack
Autor: Hauser-Gubser, A.
DOI: https://doi.org/10.5169/seals-854902

4.4 Electric Locomotives and Motor Cars for Mixed Operation.

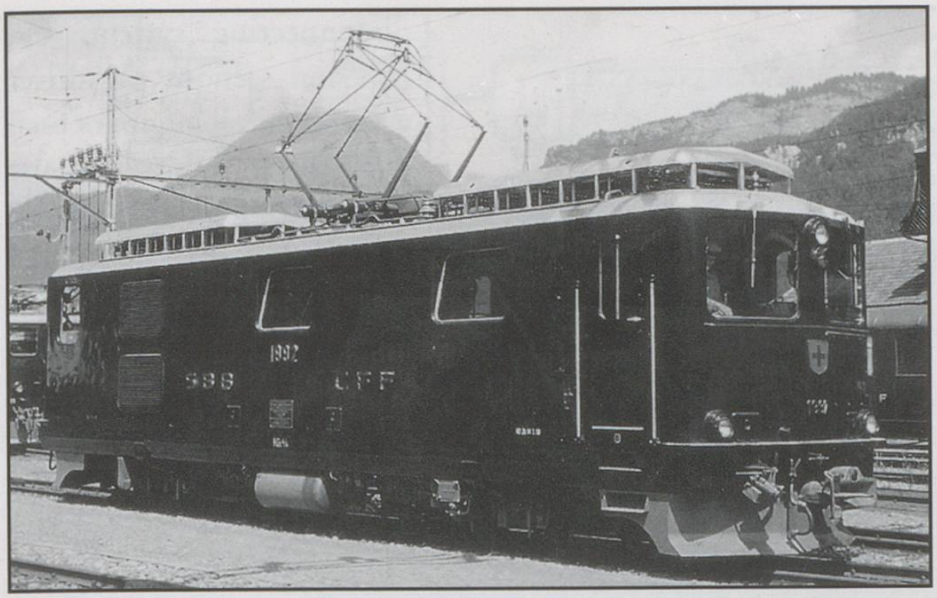
The evolution of these traction vehicles was not very different from those for rack operations from end to end. However there is a fundamental difference in drive mechanisms. There exists a) the permanently coupled drive, b) the system where the adhesion drive can be disconnected on rack sections, c) completely separated drives and d) the vehicles fitted with differential gears. This latest development brings the advantage of an adjustable distribution of available tractive force between rack and adhesion sections.

Well known examples for type a) are the locomotives of the Furka Oberalp and Brig-Visp-Zermatt Railways. In drawing 4.4.1 the drive mechanism is shown. Each of the two motors (1) in one bogie drives through a sprung pinion (2) the large toothed wheel (3) of the backshaft. This pair forms the first gear reduction. The backshaft is fitted with the gear wheels (4) and (5). (4) engages the toothed wheel on the driving axle. This is the adhesion drive. (5) engages another toothed wheel sitting on a bush which is equipped with the pinion wheel (6) and the brake drum. Through the geared wheel pairs 4 and 5 which form the second gear reduction both the adhesion and the rack drive are permanently coupled. On adhesion sections the pinion wheels are revolving without engagement since there is no rack bar and the entire torque produced by the motors is directed to the adhesion wheels. On rack sections the torque is divided between cog wheel and adhesion wheels. As explained in the chapter on steam locomotives, it is important that the pitch diameter of the pinion wheels is about the same as the one of the adhesion wheels. There is a slight loss of about 1.5 % of tractive force which the owners of the vehicles have to put up with. This drive has found wide acceptance due to the comparatively low price *(see photo 4.4.2)*. Further engines of this type were

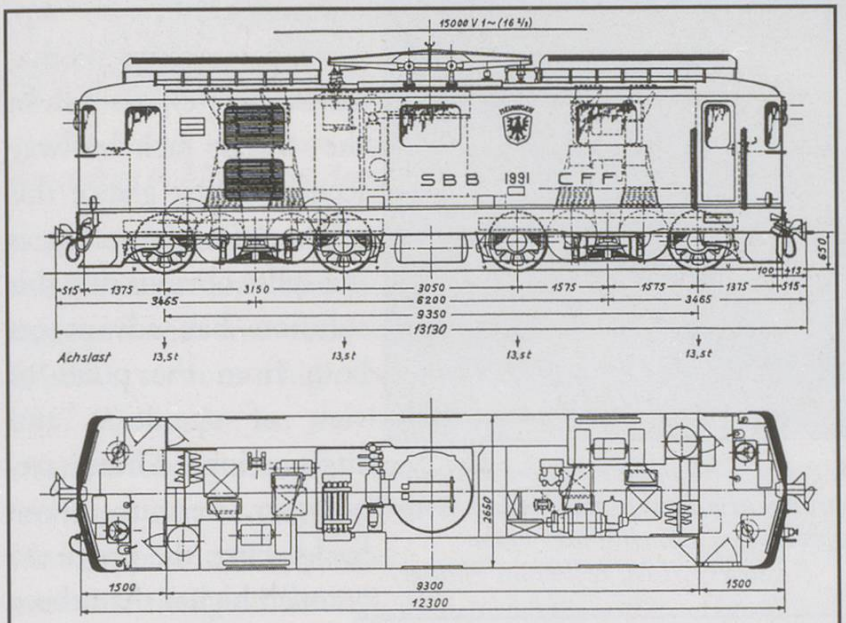


4.4.1 FO & BVZ locomotive drive arrangement (permanently coupled) *(Courtesy SLM)*

4.4.2 Furka Oberalp train on the 110‰ (1 in 9,1) ramp between Gletsch and the Furka Tunnel on the last day of official operation over the mountain route 11th October 1981 *Photo: Hauser*



4.4.3 Brünig Locomotive no 1992 at Meiringen, 07/09/1965 *Photo: Hauser*



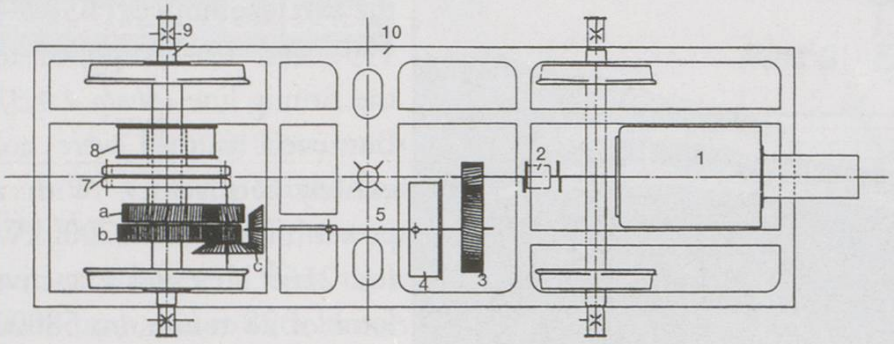
4.4.4 Brünig HGe4/4[1] nos. 1991/2 *(Courtesy SBB)*

4.4.5 - Technical data on Brünig line locomotives

Numbers	2	8
Builders	SLM/BBC/MFO	SLM/ABB
Built	1952	1987/1988
Overall length (mm)	13130	14800
Wheelbase (mm)	9350	7360
Rigid wheelbase (mm)	3150	2980
Dia. adhesion wheels	1028	965
Cog wheels	4	4
Cog wheels diameter (mm)	891	828
Drive mechanism	perm. coupled	differential drive
Gear ratio: adhesion	1:6.05	1:5.164
Gear ratio: rack drive	1:5.702	1:4.47
Electric motors	4	4
One hour power rating (kW)	1630	1932
Revolutions per min. at 31 (km/h)	1050	1311/45.6 (km/h)
Tractive force at 31 (km/h)	187 kN	141.9 kN@45.6 (km/h)
Max. speed-adhesion (km/h)	55	100
Max. speed-rack (km/h)	33	40
Starting tractive force (kN)	275	300
Locomotive weight (tonnes)	54	62.3
Max.train weight-	120	120
On 120 ‰ (1 in 8.33)		

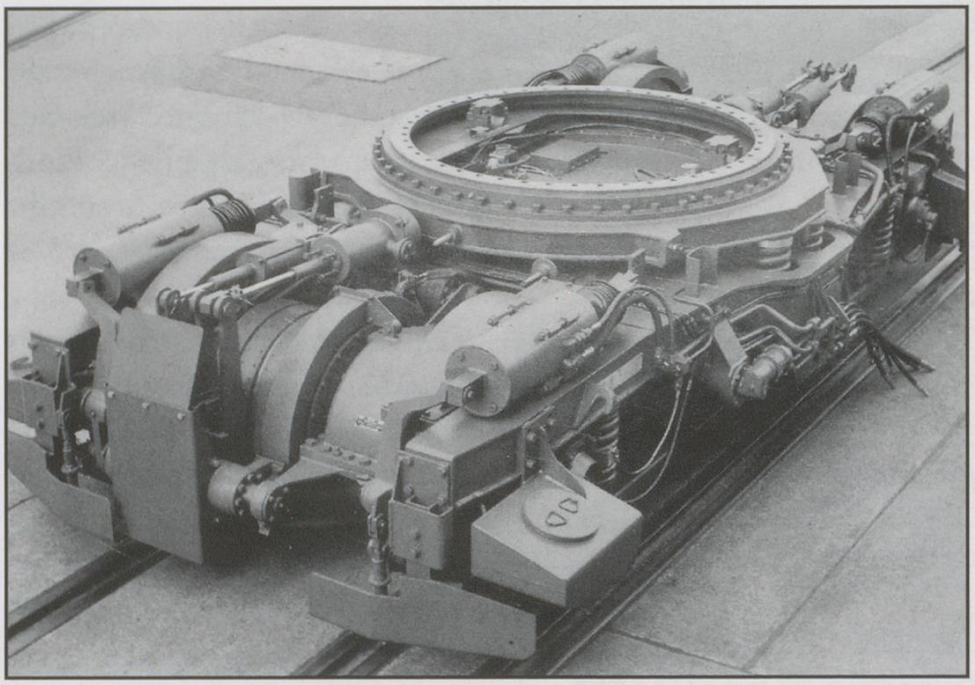
the two locomotives HGe 4/4 1991 and 1992 supplied to the Brünig line *(photo 4.4.3)*. But even so they were not entirely satisfactory. With a power output of 1700 kW (ca. 2160 HP) and a tractive force of 28 tonnes (ca.58000 lbs) the permanently coupled drive was over-strained. Broken teeth on the pinion wheels and transmission gears and even deformed rack bars were frequent. Despite various improvements the drive was still the weakest part *(diagram 4.4.4, technical data 4.4.5)*.

Drive mechanism arrangements for type b) where the adhesion part is disconnected in rack sections are found usually on lines with a very short adhesion section. On rack sections, the adhesion wheels have a carrying function only, the entire tractive force being transmitted over the pinion wheel to the rack bar. A typical representative is the motor car series ABFhe 2/4 supplied in 1946 to the Aigle-Leysin line. Usually these cars are running light, but their power reserve is sufficient to push a passenger coach of 6 tonnes increasing the train's gross weight to 36.5 tonnes. The travelling time was reduced from 56 minutes to 34 minutes. The speed on the 230 ‰ (1 in 4.3) incline rose from 7 to 14.5 km/h. Drawing 4.4.6 illustrates the drive arrangement in the bogies. Each bogie is fitted with a motor (1) which drives, through a friction clutch (2), the gear wheel (3) from where the torque is transmitted via a cardan shaft (5) to a double bevel geared transmission (6) driving two spur gear transmissions, of which a) serves to drive the axle with the pinion wheel (7) and b) the adhesion axle. The latter is fitted with a hydraulic



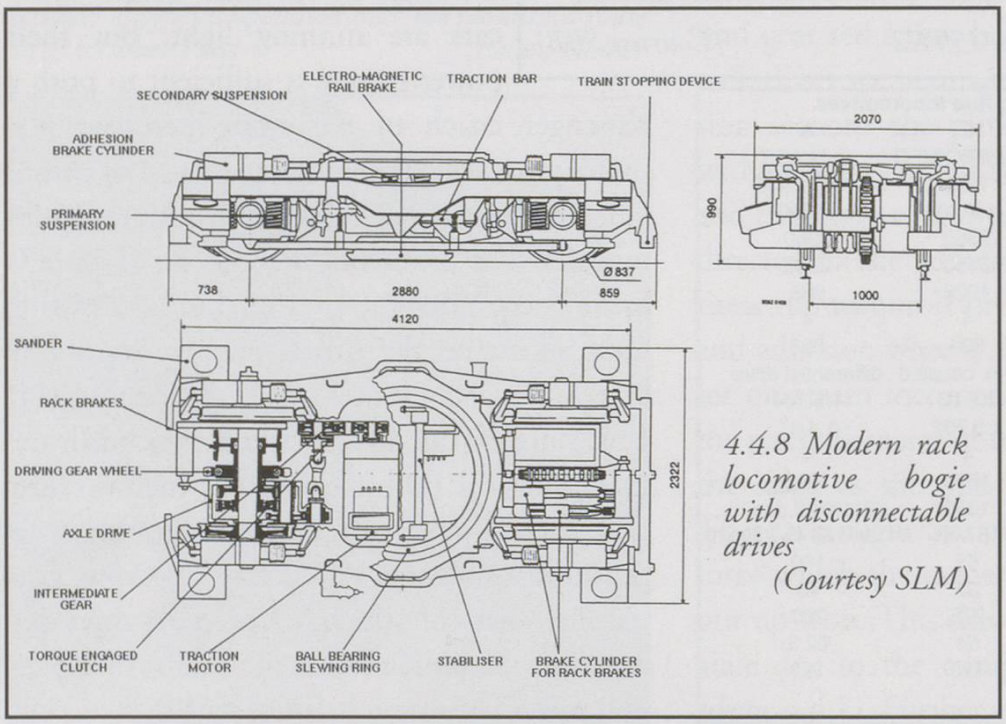
4.4.6 Aigle-Leysin motor car bogie (Courtesy SLM)

disconnecting system. On adhesion sections the driver actuates the oil pumps of each bogie driven by small electric motors. As soon as the needed pressure is available the adhesion drive is thrown in. In 1988 the TPC (Transports Publicques du Chablais) group to which the Aigle-Leysin line now belongs received further motor cars. A modern representative of this kind of drive is shown in photo 4.4.7 and drawing 4.4.8.

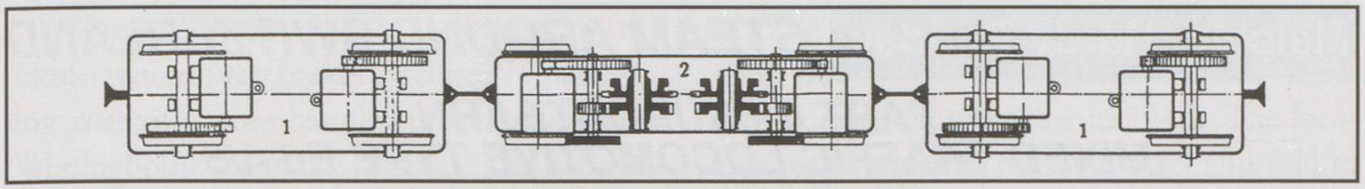


4.4.7 Modern bogie for meter or 800 mm gauge with disconnectable adhesion drive, four independent brake systems, electronic axle load compensation, automatic lubrication system, low level traction bars, two asynchronous motors (Courtesy SLM, collection Hauser)

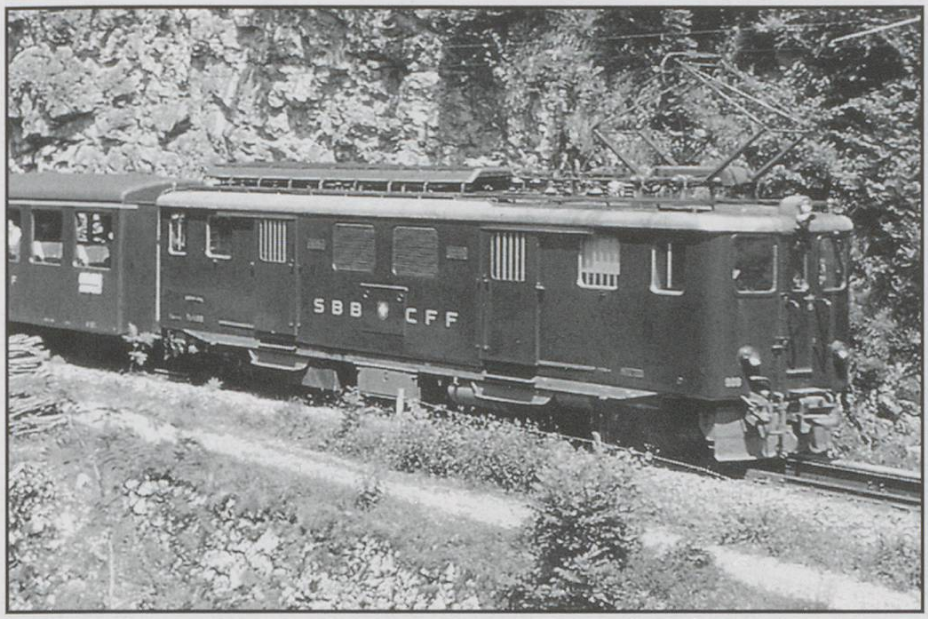
Separate drive mechanisms, type c), are rare in the Swiss rack railway scene. At first glance this might seem surprising as it is quite obvious that this solution has advantages both from the point of view of operation and engineering. There are, however, serious drawbacks. First: the prices are much higher than those for the combined drives described before. Second: separate rack drives add significant and additional weight which is of no use on the relatively long adhesion sections. Separate rack drives were applied to the Brünig motor cars supplied in 1941 on the occasion of the electrification. This line has two long adhesion sections with fairly wide curve radii (Luzern-



4.4.8 Modern rack locomotive bogie with disconnectable drives (Courtesy SLM)



4.4.9 Brünig motor cars drive arrangement (Courtesy SLM)



4.4.10 Brünig motor car with two adhesion bogies and one rack bogie descending to Meiringen, August 5th1974. Photo: Hauser

Giswil and Interlaken-Ost-Meiringen), whereas the mountain line from Giswil to Meiringen is equipped with four rack sections. For the level adhesion sections a high speed was required (in 1941 75 km/h); on the inclines however the traction force had to be very high, a requirement not easy to meet at that time. SLM proposed motor cars with three bogies of which two were designed for adhesion operation, the middle one contained the rack drive. It is possible for the driver to fix the percentage of tractive force assisting the rack drive on the inclines. *(See sketch 4.4.9 and photo 4.4.10.)*

During the 1970s and 1980s traffic rose steadily. The rolling stock of many lines, especially the Furka Oberalp, Brig-Visp-Zermatt and the Brünig, had been in use for 40 or more years. Maintaining the locomotives and motors became more and more difficult because the industry was no longer willing to manufacture outmoded electric motors except at very high prices. Furthermore, the modernisation of the flagship trains, like the Glacier Express, was inevitable. It was the Furka Oberalp, which contacted the industry first, closely observed by the Federal Traffic Office and the SBB, who wanted, if possible, a design which could be used on all lines, except for the equipment needed due to the two different current systems, in other words type d). The locomotives were required to haul 110-120 tonnes on inclines of 110-120 ‰ (1 in 9 - 1 in 8.3) with an ascending top speed of 40 km/h and with 90-100 km/h on adhesion sections from 10-40 ‰ (1 in 100 to 1 in 25). The available tractive force, limited for safety reasons to 300 kN (ca 67400 lbs) and thus too high for the Abt rack bar with two lamellas, was required to be controllable in that about 2/3 needed to be transmitted to the rack and the remaining 100 kN had to be transferred to the adhesion rails. SLM/ABB subsequently supplied 21 HGe 4/4 engines in all to the Brünig, Furka Oberalp and Brig-Visp-Zermatt lines. As I have discussed quite a variety of drives in this instalment and I want to avoid glazing the eyes of our members I am going to postpone the explanation of the differential to a detailed description of the locomotive in the context of an engine portrait. The one hour rating is 1932 kW(2590 HP), and the continuous power output 1836 kW (2460HP), top speed in rack sections of 120 ‰(1 in 8.33) is 40 km/h and 100 km/h on adhesion sections up to 40 ‰ incline. (See photo by Stuart Frost in Swiss Express June 2000, page 34, volume 6/2.)

The next chapter will be devoted to outstanding rack lines inside and outside Switzerland.