Zeitschrift: Swiss express : the Swiss Railways Society journal
Herausgeber: Swiss Railways Society
Band: 6 (2000-2002)
Heft: 4

Artikel: Tooth by tooth. Part 3, Electric power on the rack
Autor: Hauser-Gubser, A.
DOI: https://doi.org/10.5169/seals-854885

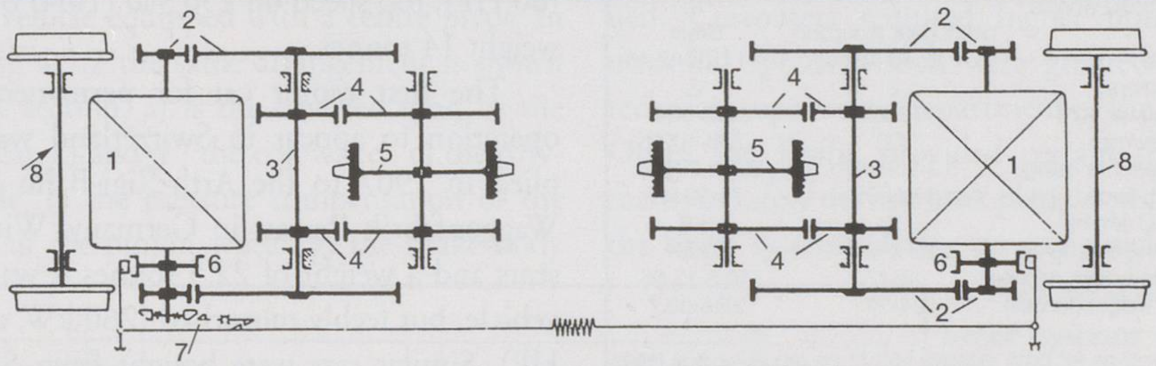
A. Hauser-Gubser

TOOTH BY TOOTH
Part 3 - Electric power on the Rack

4.3 Electric locomotives and motor cars for permanent rack operation.

I know our members are well informed by contributions made in the past regarding the electrification of our alpine transit lines. Even in Switzerland few people interested in railways realise that both the Jungfrau and the Gornergrat lines were electrified right from the start in 1898, some 15 years earlier than the adhesion operated lines. It is, of course, correct that the electrification uses three-phase current, a system hardly convenient for the great standard gauge lines with complicated track layouts and the need to operate trains efficiently at varying speeds.

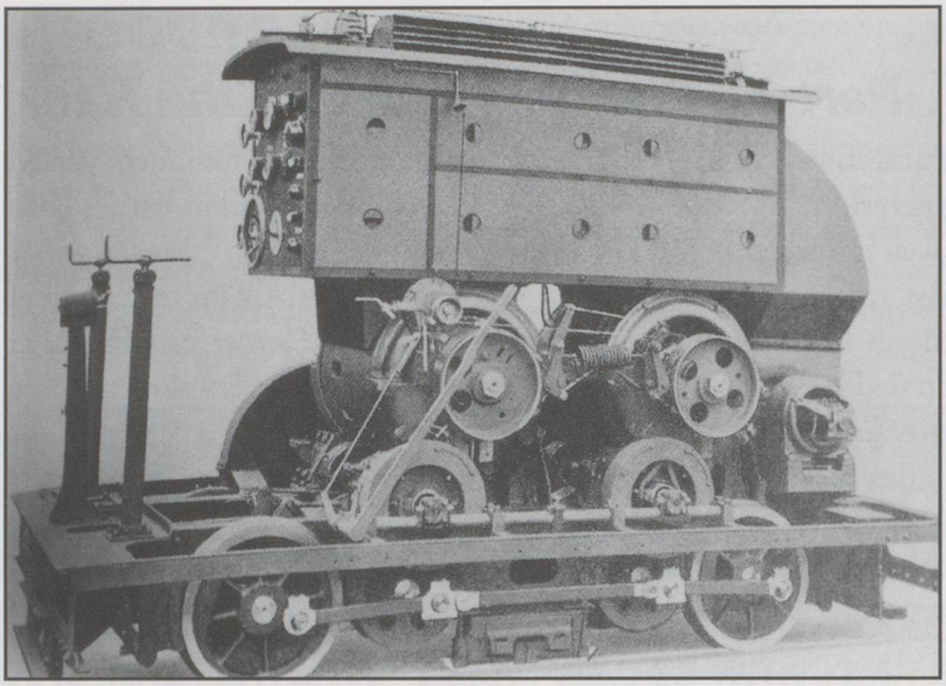
During the following decades Switzerland's rack lines were electrified with direct current of various voltages and with single phase alternating current of 11000 and 15000 Volt, 16 2/3 Hertz. The Monte Generoso railway in particular experienced steam, diesel and electric traction.



4.3.1 Drive arrangement for the first Jungfraubahn locomotive. See text for explanation of numbers. (Courtesy Sulzer/SLM archives)

It is easy to understand that the design of steam engines initially had an enormous influence on electric traction vehicles. In 1895 and the following years, the evolution of new drive mechanisms seemed to be problematic, the more so as available electric motors were very large. The locomotives of the Jungfrau and the Gornergrat lines were fitted with 2 motors (1) in my diagram 4.3.1 which ran a toothed wheel transmission (2) on a first backgear (3). The latter drove over two parallel mounted geared wheels (4) and one of the pinion wheels each (5). Hence there were two transmissions totalling a gear ratio of 1:12.4 on the Jungfrau line and 1:12.96 on the Gornergrat. The high reduction ratio is due to the very slow running speed compared with that of the motors. The brake discs (6) on the axles of the electric motors are wound up by special brake springs. A conical pendulum (7) was automatically actuated when the maximum speed was exceeded. The cars downhill ends were supported by the locomotive over a sprung pendulum stanchion. This is the famous Rowan composition invented by the British engineer William Robert Rowan, head designer of the Danish passenger car producer Scania, who obtained excellent results with steam driven tramway engines. Two rotary current slip ring motors of 90 kW (ca 120 HP) power output each were fed by the overhead. When starting the locomotive, the driver placed resistors in series with the slip rings. On the downhill trip the motors worked as asynchronous generators feeding the overhead and acting as a retarding brake, a principle taken up again for the modern asynchronous motors of locomotives such as classes 460 and 465 in the 1990s.(see photo 4.3.2, technical data 4.3.3)

Soon, even though conversion was very costly, tourist line managers realised the returns



4.3.2 The first Jungfrau locomotive's drive mechanism with motors and resistors. (photo courtesy SLM, collection Hauser)

reported substantial increases in passenger numbers which they attributed to the cleanliness of the new mode of transportation.

The line managements were irritated by the high proportion of the locomotive weight in relation to the train weight and as a result the idea of motor coaches was soon discussed. But there was quite a dilemma to solve in that the number of available passenger seats had to be as high as possible thus needing a powerful motor and which, in turn at that time, was big and difficult to install. Only low powered motors could be fitted, for example 90 kW (120 HP) in the case of the car supplied 1894 by Siemens & Halske to the Barmen-Tolleturm line. The first rack car appeared 1893 on the Mont Salève line near Geneva, power output 45 kW (60 HP), top speed on 250 %o (1in4) 6 km/h, weight 14 tonnes.

4.3.3 - Electric Locos of the Jungfrau and Gornergrat Rlwys

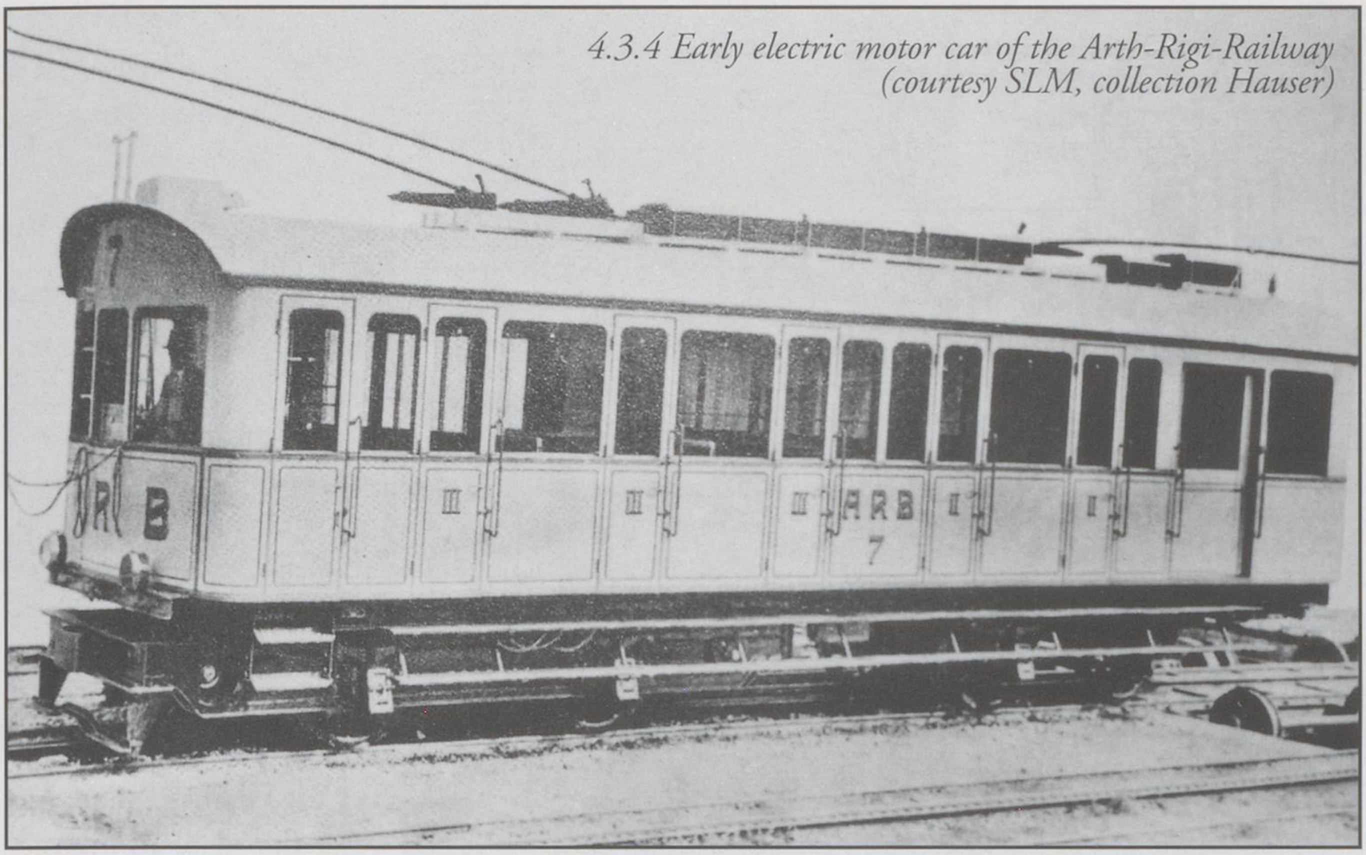
	JB	GGB
Axle configuration	He 2/2	He 2/2
Numbers	7	5
Built	1898-1904	1898-1930
Overall length (mm)	4376-4466	4130
Wheelbase (mm)	2450-2650	2140
Running wheel dia. (mm)	600	706-726
Cog wheel dia (mm)	700	510
Number of cog wheels	2	2
Drive	direct gear reduction	direct
Gear ratios	1:12.40-12.66	1:11.76-12.40
Electric motors	2	2
Nominal power (kW)	176-220	130-184
Nominal rev/min	800	785-1000
Nom. speed-1 hr rating	8.3-9.2 km/h	6.4-8.7 km/h
Nom. tract. force (1 hr)	ca 69kN-91 kN	71-89 kN
Max. speed (km/h)	9	8-9
Max. starting trac. force	88.3 kN	93 kN
Locomotive weight (tonnes)	14-17	10.5-12.66
Total train weight (tonnes)	34-37	28.5-30.7

The locomotives for both railways had to be rebuilt several times mainly due to voltage changes, but also the elimination of short adhesion sections.

to be gained through electrification. Both infrastructure (overhead, tunnel profiles, feeders, transformer substations and workshops) and rolling stock had to be adapted. But the uncertainty of coal prices with its heavy price fluctuations could be eliminated and it was possible to negotiate long lasting current supplies with several suppliers. The locomotives proved not only to be more powerful but much cheaper to maintain. Finally various lines

The first motor car for permanent rack operation to appear in Switzerland was supplied in 1907 to the Arth-Rigi-Bahn by the Waggonfabrik Rastatt in Germany. With 100 seats and a weight of 22.5 tonnes it was a big vehicle, but feebly motorised (260 kW, ca. 350 HP). Similar cars were bought from SLM in 1911, 1925 and 1949 (see photo 4.3.4)

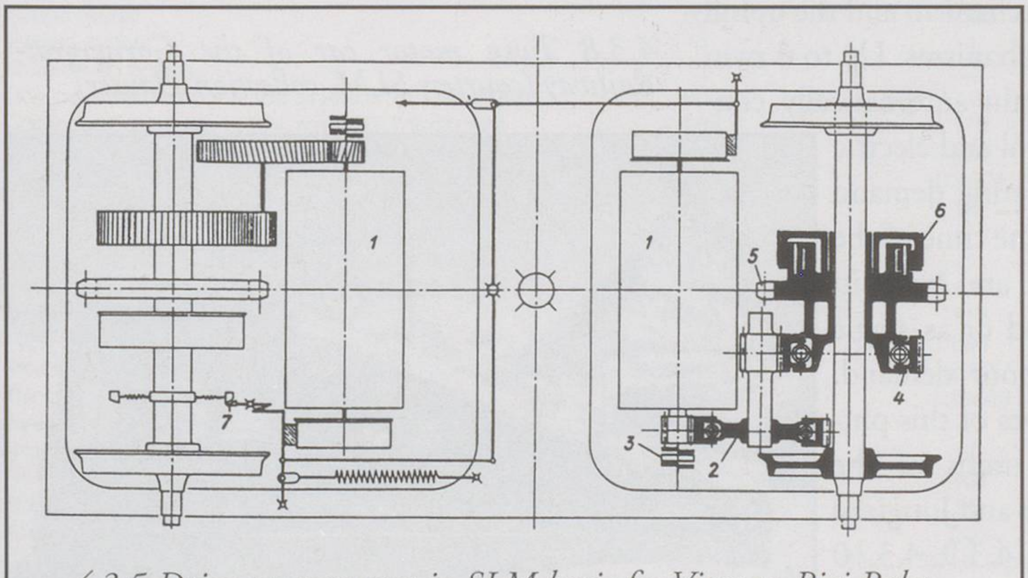
The collaboration between SLM and the various producers of electric equipment resulted in new solutions for this problem some of which are still valid and available today. SLM devised sophisticated bogies in which it was possible to place one or two motors. (See drawings 4.3.5 and 4.3.6). The latter (next page - top) shows the drive arrangement of the Wengernalp Bahn motor cars. The two motors (1) in each bogie drive through a friction clutch (2) and a cardan shaft (3), a bevelled gear which



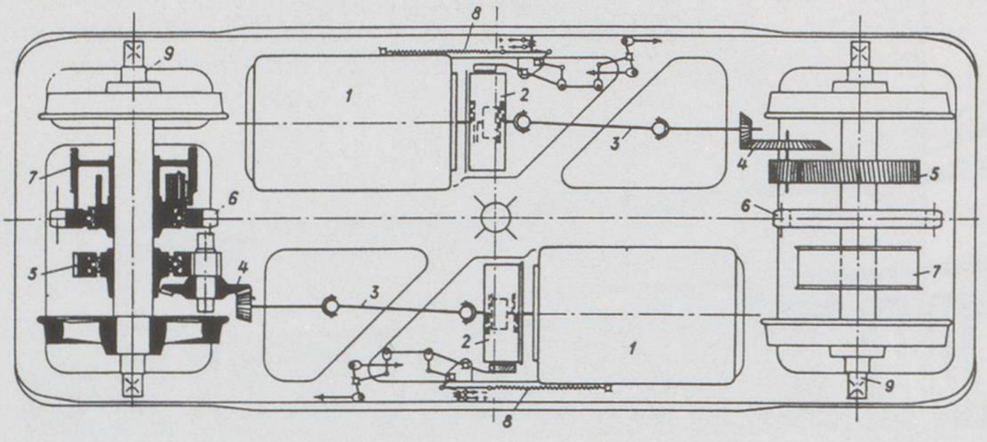
4.3.4 Early electric motor car of the Arth-Rigi-Railway (courtesy SLM, collection Hauser)

engages the spur gear (5) sitting on the driving axle with the pinion wheel (6). A ratchet brake (7) working on the driving axle is one of the five independent brake systems. The whole is mounted in the bogie frame (9) for an 800 mm gauge vehicle equipped with a centre pivot. In drawing 4.3.7 the same arrangement is shown by axle section, a) is the bevelled gear, b) the spur gear, c) and d) the cog wheel, e) the driving axle, f) the pressure compensation of the spring of the pinion wheel, g) the brake body with installed ratchet brake mechanism, i) the ratchet brake and finally j) the brake band. This basic arrangement was widely accepted both by Swiss and foreign customers.

Nevertheless technical evolution continued. Customers required higher uphill and downhill speeds, which were granted by the technical supervision department of the Federal Office for Traffic provided certain improvements in safety devices took place, especially for the brake systems. Today on some rack motor cars up to 6 different brake systems are fitted, each independent of the others. SLM studied first the idea of twin cars forming one train each car being motorised. In one single stroke not only the higher speeds, but a much higher seating capacity could be realised. The downhill bogies are usually fitted with the electric

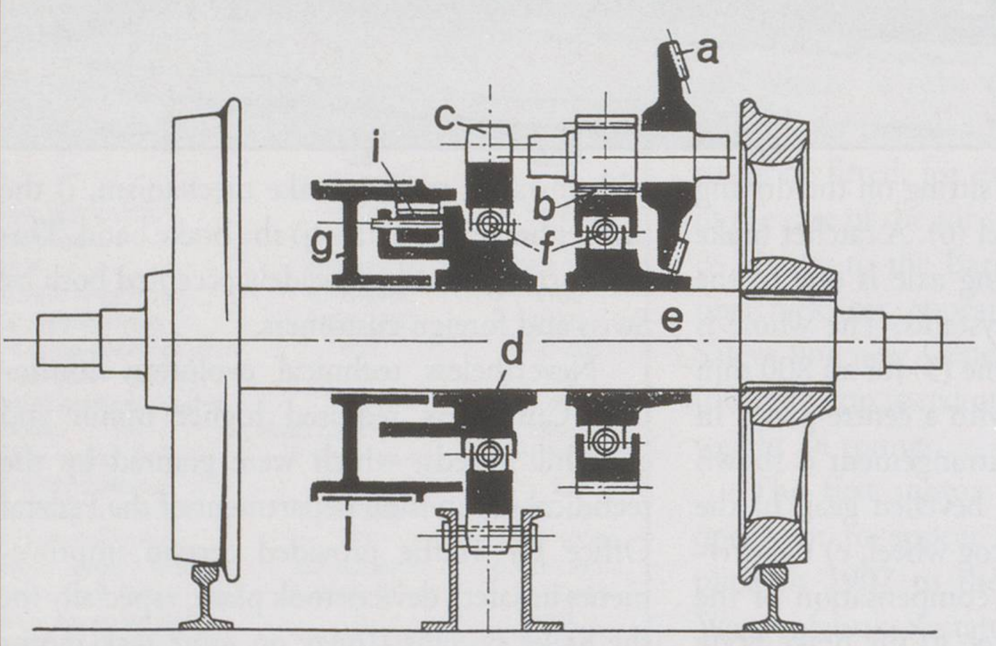


4.3.5 Drive arrangement in SLM bogie for Vitznau-Rigi Bahn (Courtesy Sulzer/SLM archives)



4.3.6 Bogie drive arrangement for Wengernalpbahn (800mm gauge)(Courtesy Sulzer/SLM archives)

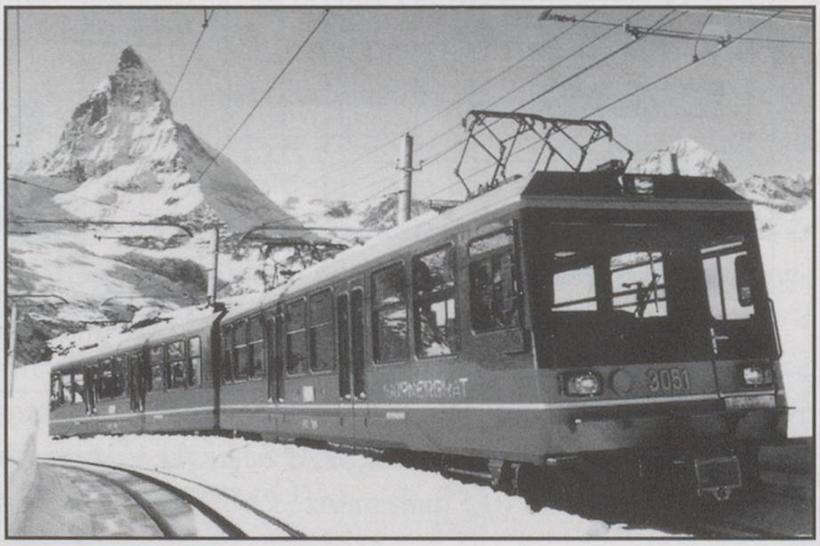
4.3.7 Axle section of 4.3.6 (Courtesy SLM)



motors and the drive mechanism and the uphill ones with the brake mechanisms. Up to 6 twin units may form one train automatically coupling the braking, control and electric systems and in turn offering demand flexibility according to the time of the day. The older units are kept in reserve for peak demand or as single car runs in times of poor demand. Prominent representatives of this philosophy are the new trains of the Gornergrat, Wengernalp and Jungfrau Bahnen.(Photos 4.3.8, 4.3.9, 4.3.10 and the corresponding technical data 4.3.11.) In the case of the Wengernalpbahn it is even possible to push an additional passenger car on the 190 % ascent from Lauterbrunnen to Kleine Scheidegg.

Once again the Pilatus Bahn provides one of the highlights of light vehicle construction with its railway car weighing a mere 9.6 tonnes for 40 passengers. The travelling time from Alpnachstad to Pilatus Kulm was reduced to 28 minutes instead of 75 by steam (photo 4.3.12, technical data 4.3.13 and drawing 4.3.14).

4.3.8 Twin motor car of the Gornergrat-Railway (courtesy SLM, collection Hauser)



4.3.9. WAB twin car unit 131 at the new station at Wengen in February 1999
Photo: Paul Russenberger

4.3.10. JB twin car unit no. 211 pictured at Eigergletscher in August 2000
Photo: Paul Russenberger

4.3.11. Technical data for the twin motor cars of the Wengernalp, the Jungfrau and the Gornergrat Railways

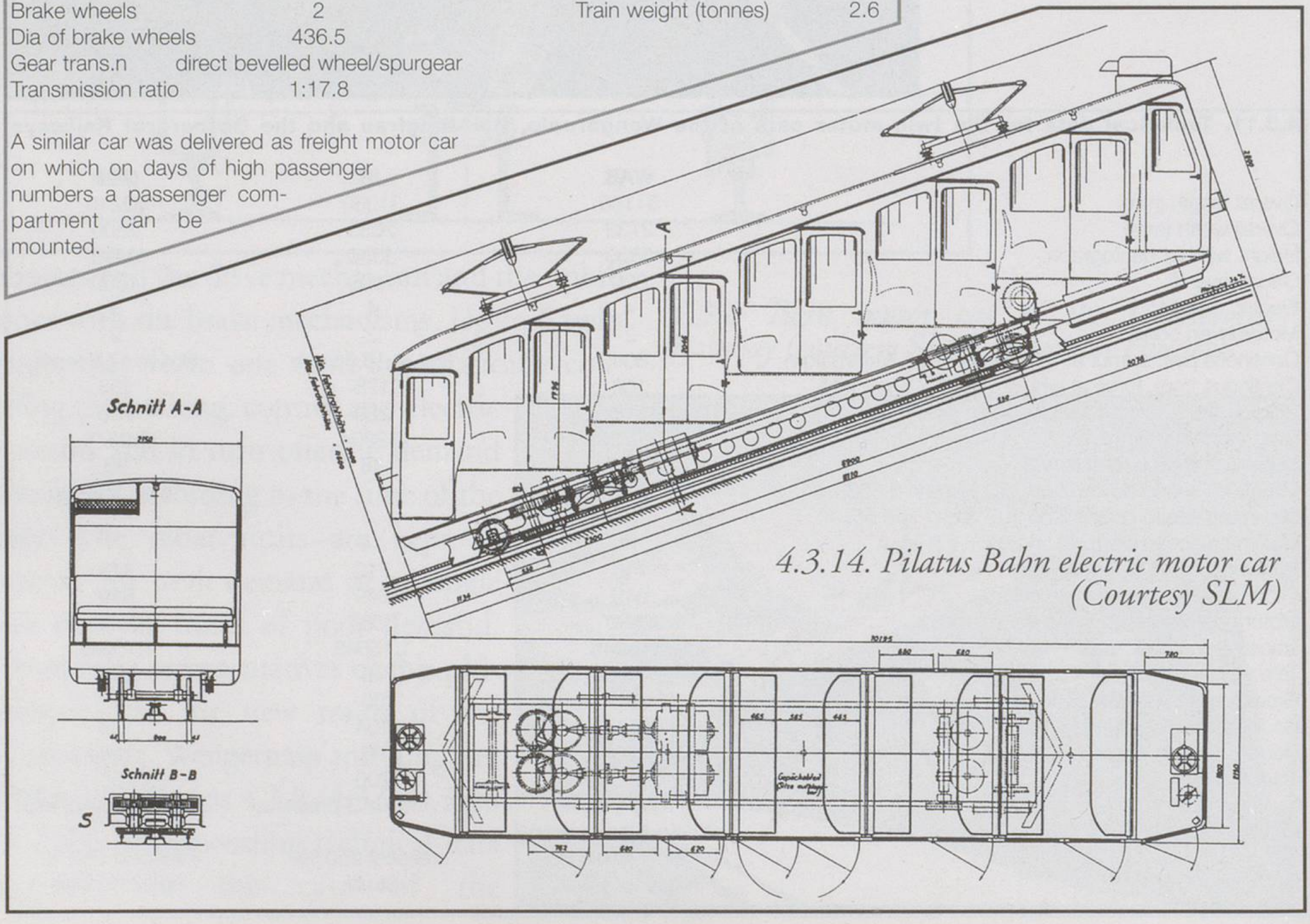
	WAB	JB	GGB
Overall length (mm)	31160	31350	32210
Overall width (mm)	2133	2633	2600
Height without pantograph	3500	3350	3600
Gauge overall	800	1000	1000
Electric motors	4	4	4
Motordriven bogies	2	2	2
Continous pwr. output at mtr. shafts at 17.7 km/h (kW)	804	804 at 16.6 km/h	804 at 17.7 km/h
Continous tract. force at whl. rim at 17.7 km/h (kN)	168	178	158
Starting tractive force (electrically limited) (kN)	216	220	220
Gear efficiency factor	0.9733	0.9804	0.9678
Maximum speed uphill (km/h)	28	28	28
Maximum speed downhill on 120 %o (1in 8.333)	21.5		16 on 200 %o
Maximum speed downhill on 180 %o (1 in 5.55)	17		
Maximum speed downhill on 250 %o (1 in 4)	14	14	
Running wheels diameter (mm)	713	713	713
Pitch diameter of cog wheels (mm)	649	649	649
Motors-nominal revolutions per minute	3580	3580	3580
Transmission gear ratio	1:15645	1:15645	1:15645
Tare weight in tonnes	43.1	45	49.5
Gross weight fully loaded in tonnes	58.1	60	68.7
No. of seated passengers	80	104	128
No. of standing passengers	120	96	128
Total capacity	200	200	256
Current system	1500 v dc	1125 v 50 Hz 3-phase ac	725v 50Hz 3-phase
Incline	190 %o (L'brun. side) 250 %o (G'wald side)	steepest 250 %	steepest 250 %
Rack system	Riggenb.-Pauli	Strub	Abt-2 lamellas

4.3.12. Pilatusbahn car no.22 awaits the descending car at a passing loop. July 1993.
Photo: Steve Horobin

4.3.13 - The Pilatus motor cars, technical data.

Numbers built	9	Electric motors	2
Years built	1947/1954	Total power output (kW)	154,5
Builder	SLM/MFO	Revolutions per minute	1750
Overall length (mm)	11500	Speed uphill (km/h)	8
Wheelbase (mm)	6900	Tractive force (kN)	64
Dia. running wheels (mm)	420/400	Max. speed-uphill (km/h)	12
No. of cog wheels	2	Max. speed-downhill (km/h)	9
Dia. of cog wheels (mm)	436.5	Starting tractive force (kN)	123
Brake wheels	2	Train weight (tonnes)	2.6
Dia of brake wheels	436.5		
Gear trans.n	direct bevelled wheel/spurgear		
Transmission ratio	1:17.8		

A similar car was delivered as freight motor car on which on days of high passenger numbers a passenger compartment can be mounted.



4.3.14. Pilatus Bahn electric motor car (Courtesy SLM)