DOI: https://doi.org/10.30932/1992-3252-2020-18-212-232


Желѣзнодорожное Дѣло

ЖУРНАЛЪ

№ 1. Годъ XXIX.

The publication reproduces with some abridgement but keeping as far as possible author's lexical means and style the report of I. V. Shirman at the meeting of the 8th Department of Imperial Russian Technical Society on March 4, 1910, chaired by O. A. Struve. The meeting discussed engineering and economic issues of operation of transport vehicles using electric traction and the most promising at that time, the idea of autonomously powered passenger systems was also highlighted.

Keywords: *transport, history of transport, electric transport, railless systems.*

For the original Russian text of the article please see p. 212.

The editorial board expresses gratitude to the staff of the library of Russian University of Transport for the kind assistance in preparing the publication.

THE MOVEMENT OF PASSENGERS AND GOODS ALONG A RAILLESS TRACK

Carriages with electric batteries turned out to be more suitable for driving on a railless track and, despite the energy losses associated with the sequential charging and discharging of the battery and rapid wear of the electrodes, there are conditions when their use is fully justified, as we will see below.

Even more profitable, however, is the direct supply of electrical energy by means of the upper wire (double – for supply and return of energy) to electric motors suspended on the axles of the carriage, if the length of the lines is limited to 3–4 kilometres and the direction of movement is quite definite once and for all. In the future, we will move on to considering these 2 types, starting with a battery electric carriage, which has the advantage of freedom of movement in any direction for up to 75 kilometres without a new charge.

Carriages of this kind first appeared in 1898 with the Krieger systems in Paris (see Sieg's article in E. T. Z. 1908 No. 52 and 53). Since then, many improvements have been made to the design details, but the main element – *the battery* – still awaits final improvement.

The lead elements and sulfuric acid solution used so far represent a rather significant weight, namely 1 kilogram per 7,5 watt-hours of production; there is a construction weighing 1 kilogram for 30 watt-hours of performance (see J. C.), but such relief is achieved at the expense of durability, which is not great at all.

When battery vehicles move along a rail track, where there are fewer shocks, the plates serve no more than 100000 kilometres on average: positive ones 100–120000, negative ones – no more than 60000.

When driving on a railless track, the service life should undoubtedly decrease.

So-called alkaline batteries with zinc or iron-nickel electrodes have not yet come true; the electric motor force of such an element is only 1,2 volts, while acidic one [attains] 2 volts. The return rate is only 50 % in the former, while in the latter it reaches 75 %. Their cost is also higher. In America, Edison battery tests continue, it was very promising

Pic. 1.

at one time, but the final improvement is still far away.

As for motors, 2 types are used:

1. High-speed lightweight, suspended from a frame with a gear or chain drive to the drive axle...

It is preferable to have the rear axle as the driving axle – there is less chance of damage, and the front axle is then made with each wheel turning separately, as in gasoline cars.

2. Low-speed – 150–250 rpm, directly connected to the wheel.

Presenting some advantages due to the lack of transmission, motors of this design are large, easily damaged in a collision, and much heavier. The winding is sequential or shunt, i.e., excitation in the branching; the latter is justified in areas with intermittent inclines and rises.

We will not go into the details of the design, as the purpose of the post is to find out the cost of operation. This was determined in some cases of application of the described system by the following figures.

1. Fire-pump vehicle in Berlin, yearly run = 1500 km.

		Per 1 km
Costs of battery maintenance	31,50	28 Pfg.
Power recharging	391,73	
423,23 mark		
Motor, control gear maintenance, cable	30	2
Lubrication	12	0,8
Rubber tires	457	30,4
Device to avoid slipping	4	
(«Derapant»)	100	6,65
Body repair	45	3
Miscellaneous (including charge about		
600 kW h.)	137,77	9,15
Total	1205 mark	80 Pfg.
and for 4 pumps in total	4820 mark	
with steam traction	6920	
with horse traction	17281	

following insignificant yearly run but the need to keep the horses all-the-year-round.

The weight of such a coach is of 4,5 t, the speed on the dry asphalt road attained 36 km/h. The energy consumption was (68 A x 145 V) / (36 x 4,5) = 56,4 W-h/t • km and consumption per kilometre of run 56,4 x 4,5 = ∞ 254 c.-h., and charging current, counting the output coefficient = 75 % ∞ 340. «The vehicle could go 86 kilometres to complete exhaustion (counting 56,4: 0,75 = 76 watt-hours/ tonne • km, in reality, on average, 97 watt-hours/ tonne • km» (see article Sieg l.c.).

A similar carriage of a fire-fighting wagon train in Dusseldorf gave a consumption of 59,6 watt-hours on wet asphalt at υ = 36 km/h and strong winds.

At υ = 18 km/h energy consumption dropped to 41,5 watt-hours/tonne • km.

The carriage made a run of 108 km and the battery was not yet exhausted.

The carriage overcame slopes up to 100 ‰ at a speed of 18 km/h, did not stop in the snow, etc.

2. Carriages for transportation of patients.

In Cologne, the daily mileage is about 50 km;
annual maintenance .... 7200 marks;
with horse traction it was .... 9400 marks.
In Harlaching near Munich it overcomes a slope of 170 ‰ per 600 meters;
annual maintenance .... 4360 marks;
with horse traction .... 5548.

3. Carriages for collecting letters from mailboxes also proved to be profitable in operation.

We also provide data on operation of street carriages, with the pavements in good condition.

In Berlin, there is a large enterprise of this kind Bedag (Berliner-Elektromobil-Droschken A. G.) with a capital of 2 • 10^6 marks.

Revenues and expenses for this enterprise were expressed in the following figures: (E. T. *Z.* 08. No. 28):

Revenue: 5 months of 1907 ....5 months of 1908
390000 Marks (36,39) ....895000 (36,80 vehicle- day).
Costs ....-615000
....+280000

Due to the lack of exhaust odour, fire safety, less shaking from the electric motor and more convenient handling, such carriages, according to many, should replace gasoline cars in the field of traffic, but the decisive factor is the cost of operation.

Although maintenance of an electric motor is cheaper than maintenance of an internal combustion engine, consumption of the battery is still quite high, and the costs of charging current are high.

At first, when the maximum speed of movement was limited to 15 km-hours, the weight of the carriage did not exceed 1400 kilograms, including 3 riders, and the battery maintenance, current consumption and tires were less than now in carriages that could reach speeds of up to 25 km/h and weighing 2000 kilograms and more.

Solid rubber tires are unsuitable for this speed, pneumatic tires are needed; and this, in turn, increases consumption of work, as the table below shows:

*	Front wheels		Rear wheels	Consumption watt-hour carriage-km
1	Solid rubber	I	Pneumatic tire with «derapant»	179 watt-hour
2	Pneumatic tires			162 watt-hour
3	Solid rubber	I	Solid rubber II	148 watt-hour
4	« »	II	Pneumatic tires	131 watt-hour
5	« »	II	Solid rubber II	116 watt-hour

Ratio 1: 5 = 1,5.

Costs per carriage-kilometre is now identified in Germany by the figures that follow:

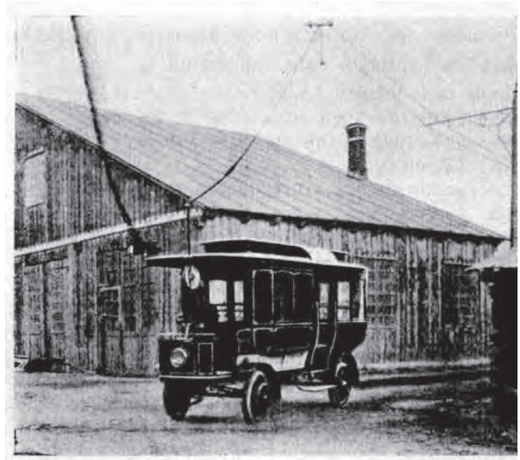
1. Rubber tires .... 10 Pfg.
2. Average battery (form 5 through 8) maintenance .... 6 Pfg.
3. Current for charging, counting 250–300 watt-hour and 8–12 Pfg. km/h.. 4 Pfg.
4. Motor and control gear maintenance, cables .... 1,5 Pfg.
5. Body and springs maintenance, etc... 1,5 Pfg.

Total carriage-km .... 23 Pfg.

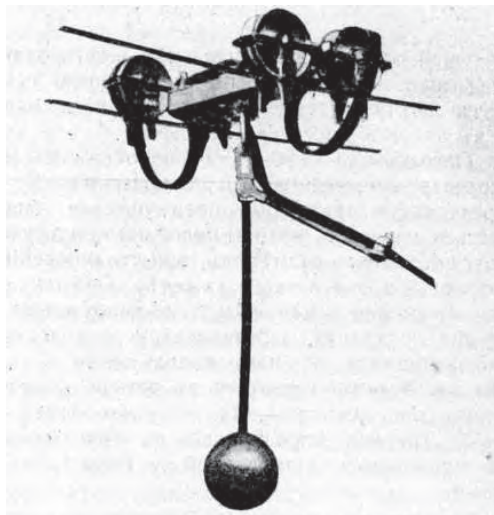
A driver receives 2 marks, or 1 mark and a certain % of the gross revenue, which can be up to 6 marks on average or, with a daily mileage of 60–70 kilometres, another 10 Pfg. So, it means the total of 33 pfennigs/carriage-km. To this figure must be added the costs of maintaining the garage, % of the capital spent, repayment, insurance, taxes.

Costs are generally not much higher than for petrol vehicles. The disadvantage is the dependence on the station where the charging takes place, and the loss of time for this charging. But, as we have seen, there are special cases when the use of such carriages is beneficial, although they are not as versatile as gasoline cars. The carriages, which receive energy from the overhead wire, are even more constrained, but their operation is so cheap that the use of such vehicles is justified in many cases, as experience has shown.

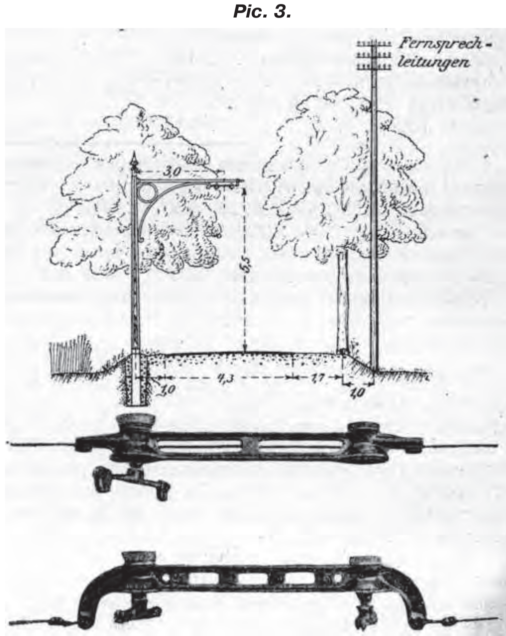
V. P. Shubersky first reported in the Russian literature about such carriages (see the Journal of the Ministry of Transport for 1902, No. 4 and 5). Since then, many improvements have been made, and the number of lines served by this system has also increased.



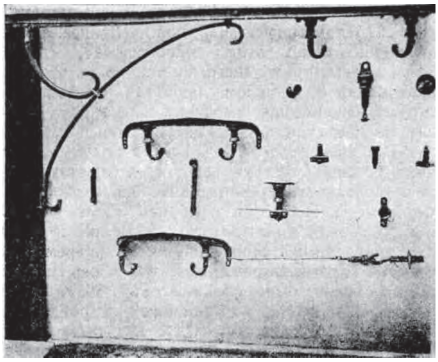
Pic. 2



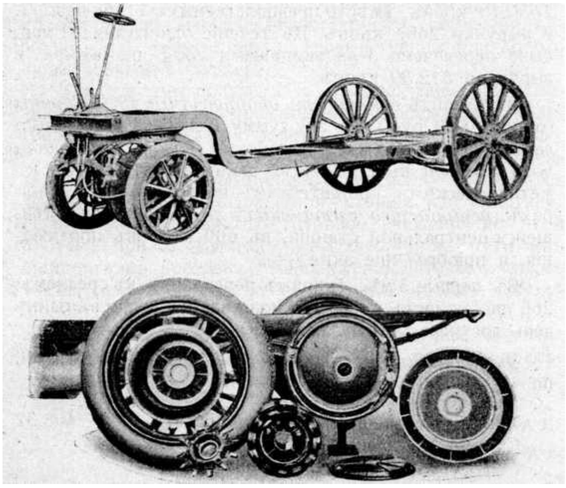
Pic. 3.



Pic. 4.



Pic. 5.



Pic. 6 a, b.

As for suspension of the current supply wire and the contact, 2 designs should be noted that are sharply different from each other.

1. Schiemann system (Max Schiemann, Pic. 1), – in it, the contact is pressed from below to the double working wire and through an insulated cord, enclosed in a hollow cane, energy is supplied to the motors. Reinforcement of the cane allows the carriage to deviate from the wire line.

2. Mercedes–Electric–Stoll system – a trolley on 4 wheels, connected to the carriage by means of an insulated cable, rolls along a double working wire (Pics. 2 and 3). A sufficient length of cable that can be wound and unwound from a drum attached to the carriage gives the carriage more freedom to deviate from the line of the working wire, which is important in case it is necessary to make detour of an obstacle on the way. This system has some advantages: when 2 similar carriages are crossing, moving towards each other, the carriages exchange trolley contacts, thanks to the cut cable and the contacts on the carriage, which is very quick and convenient.

With system 1 one contact is removed from the wire and again placed along the passage of the carriage continuing to move.

Due to the peculiarities of the contact, the suspension of the working wire is made in the 2nd system differently than in the 1st system (Pics. 4 and 5).

Both differ in the design and type of electric motors installed on the carriage.

In the 1st system, the electric motor is light, high-speed with a gear drive connected to the front axle (Pic. 6a). In the 2nd system, the electric motor is directly attached to the rear axle wheel (Pic. 6b). Each system has its own advantages and disadvantages, but both are inherent in: insignificant initial costs, in comparison with arrangement of railways with electric traction; low weight of the carriage and ease of management, and therefore low operating costs, as it is evident from the reports

Table 1

M. Schiemann System

	First operated	Length	Maximum slope (grade)	Road	Passenger and cargo	
Langenfeld–Mannheim (Rheinland)	May 1904	4 km	33 ‰	Highway	–	
Grevenbrück–Bilstein–Kirchveischede (Westfalen)	June 1904	9 km	57 ‰	Highway and cobblestone pavement	2 carriages, 24 places. Weight 4,8 tonnes. Speed 12 km/h. Tariff 5 Pfg./km	1 electric locomotive. 6 tonnes. 5 carts, 2 tonnes each. Speed 6–8 km/h
Charbonnières–les-Bains, Sud de France	August 1905	5 km	85 ‰	Highway with cobblestone base	2 wagons, 30 places Engines 15/22 r.l. Weight 3,4 tonnes. Speed 15 km/h	
Neuenahr–Ahrweiler–Walporzheim (Rheinland)	May 1906	5,5 km	Parallel to the line of Prussian state railway		3 wagons, 18 seats + 2 standing places. Engines 15/22 r.l. Weight 3,25 tonnes. Speed 22 km/h, 3 trailer wagons x 19 places. Weight 1,65 tonnes. Tariff 5 Pfg./km	
Mülhausen [now Mulhouse], Alsace	July 1907	1,7 km	83 ‰	Highway, asphalt, cobblestone pavement	4 wagons x 20 places. Engines 15/22 r.l. Weight 2,8 tonnes	
Pirano–Porto Rose in Italy [now Piran–Portorožin Slovenia]	October 1909	5,7 km	–	Dam road along the seacoast	3 wagons x 20 places. Engines 15/22 r.l. Weight 2,8 tonnes. 2 trailer wagons	

below. This explains the gradual spread of both systems.

The lines constructed according to the M. Schiemann system are indicated in Table [1], those built according to system Mercedes-Stoll – in the Table [2]. The results of operation of one of the lines of M. Schiemann system are given in Table [3].

No less interesting are the results of operation of the line in Gm nd, which operates according to the Mercedes-Stoll system. The communication of the town with the railway station is served. Initial length = 27 km, [there is] 1 vehicle with 16 seats and a post compartment. During the time from 15th July to 15th October 1907, 8030 carriage-km were made without repairs, making every day from 5:30 am to 9:30 pm 32 trips, from October 1 even 34 trips, and on Sundays up to 50 trips (2,7 km).

During this time, 24304 passengers were transported, which gives an average of 24304:8030 = 3 passengers per carriage-km. Assuming that the passenger completes the entire trip, the number of occupied seats = 3 x 2,7 = 8,1 on average out of the 16 available. The energy consumption per carriage-km was, with the total consumption of electricity energy for the specified time in 1234 kW-h, 1234000:8030 = 153,6 watt-hours, and per passenger-kilometre: 153,6:3 = 51 watt-hours.

A tram car, rolling on a rail track, consumes, on average, over 600 watt per car-kilometre (data from Russian cities without significant rises on the line; in Sevastopol, for example, this consumption reaches 800–900 watt).

Since the number of passengers per car-kilometre is 2–6, the energy consumption per passenger-kilometre in a more expensive tram is from 100–300 watt-hours, or from 2 to 6 times more. This is due to the significant weight of tram car, about 8 tonnes = 480 poods [pood = 16 kg]. Even with 18 passengers, their weight is 1/6 of the weight of the car.

A similar facility Klosterneuburg–Weidling, in Austria, with a line length of 3–8 km, with slopes on the part of the track of 30 ‰ and 60 ‰, gave a current consumption of 173 watt per carriage-kilometre, with a carriage weight of 2,44 tonnes and 21 seats for passengers. With a current price of 0,26 kronen (about 10 kopecks) per kW-h the cost of energy per carriage-kilometre is about 0,045 kronen (less than 2 kopecks). True, the consumption rate for rubber tires is much more significant than for wheel rims of a tram car, but in the Gmünd facility after 8000 kilometre run no noticeable wear was observed; manufacturers guarantee 15000 km, but there are known cases of replacement only after 24000 km. It all depends on the nature of the track, climatic conditions and driving conditions, that is, whether you have to stop often (when braking sliding is possible,

Table 2

Railless tram of Mercedes–Stoll system

	First operated	Capital invested	Length	Max. slope for freight transportation	Number of places in a carriage	Daily mileage of a carriage	Mileage till now	Yearly number of passengers	Max. number pf passengers /day	Transported before October 10, 1909	Per wagon/km	Revenue Gen.	Revenue Per wagon/verst	Subsidies from post office	Tariff	Per km	Price of current per kW-h	Current consumption per wagon/km
Gmünd city–railway station	July 1907	75000 Fr.	3,3 km	40 ‰	18	100 km	57000 km	90000	1200	160690 2 being invalid.	3	22815	0,40	2000 Fr.	0,20 children 0,10 workers 0,06	0,06	0,30 440 l.v.	0,30 kW-h
Weidling–railway station	May 1908	170000	3,7	70 ‰	22	120 190	105000	230000	2800 3 carriages 510 Fr. revenue	285000	2,75	54600	–	2200	0,30 segment 0,10/ 0,20	0,06	0,26 500 l.v.	0,29
Pötzleinsdorf–Salmannsdorf	October 1908	170000	2	90 ‰	24	summer 160 winter 100	61600	–	1950	151000	2,5	28890	0,47	–	0,20 children 0,10	0,10	0,15 580 l.v.	0,30
Kalksburg–station of Southern railway	July 1909	160000	3,8	13 ‰	22	220 110	30190	63000 during 3 мonths	2450 3 carriages 604 Fr.	60290	2	12285 during 3 months	0,40	600	segment 0,30 0,10 0,15 0,20	0,06	0,20 550 l.v.	0,26
Pressburg [now Bratislava]	July 1909	310000	5,8	80 ‰	24	–	35282	–	3050 (1200 Fr.)	55000	1,60	22275	0,63	–	segment 0,50 0,20 0,30	0,08	0,14 450 l.v.	0,33
Budweis [now České Budějovice] 1 carriage	–	–	–	–	24	–	–	–	–	–	–	–	–	–	–	–	–	–
Judenburg 1 carriage (4 wheels mov.)	–	–	2	160 ‰	18	–	–	–	–	–	–	–	–	–	–	–	–	–
	Base 3,5 m	Standard L of carriage 4,55 m, p = 2500 kg (22 m), p = 2700 kg (24 m)					υ = 25–30 km/h at horizontal segments υ = 14–15 km/h when rising the slope				Génie Civil 1910. 8.1. No. 10.							

Note: revenue, tariff, current price are presented in Francs, according to the source, current consumption is indicated larger than in documents published by construction companies.

moving from rest also requires a lot of effort). The initial costs are not high compared to a tram structure. While the installation of a rail tram in Klosterneuburg–Weidling was supposed to cost 380 000 kroons, the cost of purchasing 3 carriages, installation of wiring, a garage, etc. cost only 120 000 kronen. The service is nevertheless going quite satisfactorily: with the number of passengers at 90 000 with horse traction, with an improved traction 130 000–150 000 passengers per year and a revenue of 32 000 kronen were awaited. Meanwhile, within one month (May), 37 549 passengers were transported and 7 630,10 kronen were accounted, instead of the estimated 11 666 passengers and 2 666 kronen. During a single day (May 31), 2534 passengers were transported by 3 carriages and 512,30 kronen were raised.

In Gmünd, the cost of equipment is 42000 kronen (about 1900 rubles). This amount includes the construction of a shed for 4 carriages, the installation of an overhead working wire of 2,7 km of length suspended with metal brackets on wooden poles, the installation of supply wires from the existing central station, 600 meters in length, and acquisition of a vehicle.

In the first 3 months the carriage carried an average of 265 passengers per day; the maximum number during a single day reached 940 passengers.

Operating costs for the first 3 months (July 16–October 15 1907).

Drivers' salary (in kronen)	408,32
Cost of electricity current received from the existing central plant at the price 0,30 kronen / kW-h, including lighting of:	
the shed 1284,5 x0,30	385,36
Grease and lubricating material	18,02
Maintenance and repair of overhead lines	29,64
Tickets, advertising	21
Insurance in case of accidents with people	74,25
« « in case of fire	2
Health insurance premium payment	5,60
Total	944,19
Then written off:	
4 % for spent capital	420
10 % for spent capital on repayment of cost of the vehicle	412,50
5 % for spent capital regarding the shed, overhead lines	319
Wear of rubber tires, counting 0,06 kronen /km of run	480
Total	1631,50

and total expenses 2575,69 or 0,32 kronen per carriage-km.

Incomes were expressed as 3146,46, hence + 570,77 or 5,4 % on the capital spent in excess of the written off 4 %. In winter, movement is weaker, but still for 9 months 70000 passengers were transported; during construction they counted on 24000 passengers per year and a revenue of 7200 kronen.

The above figures show that such an enterprise pays off, being organized in the most modest size, therefore, within the power of a small city government.

Revenue for 3 months (July 16 – October 15, 1907) at Gmünd line of 2,7 km:

For announcement	45 kronen
From subscribers	30 kronen
12204 tickets, 0,10 each	1220.40
6500 tickets, 0,06 each (workers)	390
1240 tickets, 0,06 each (children)	74,90
4400 tickets, 0,20 each (non-residents)	880
500 pc. of luggage, 0,20 each	100
100 pc. of luggage, 0,40 each	40
For transportation of post	366,66
Total	3146,6 kronen

In addition, significant costs for the initial equipment are not required if there is an electric plant; the increasing demand is easily met by a gradual increase in the number of carriages. On the other hand, if it were found that the demand for movement is insufficient, the structure can be moved to other streets or roads without great expense.

The current can be obtained from an electrical installation in an existing industrial enterprise (mill, factory, railway workshops, etc.).

The described system enables an industrial enterprise to organize transportation of goods to the nearest railway station or pier. We had to see freight traffic on this system at st. Wurzen (in Saxony, on the way from Leipzig to Dresden). Track length = 4 km. There are 3 electric locomotives of 6 tonnes in weight,

Pic. 7. Line Langenfeld-Mannheim. A highway of crushed stone on a sandy mat; length 4 km; the highest rise is 33 ‰. Passenger and freight traffic was opened in May 1904. There are also high voltage wires from Solingen to Mannheim suspended from the poles.

Table 3

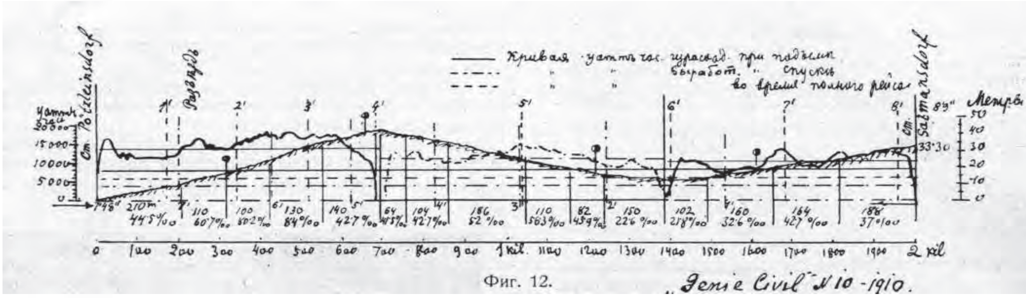
Results of operation of a line with M. Schiemann system
Neuenahr–Ahrweiler–Walporzheim (Rheinland)
Fixed capital 140000 German marks. Current of 550 V, at the price of 0,13 per kW-h. supplied from the owner of a sanatorium, distance between wires is of 0,50 m, q= 50 mm. The length of the line = 5,5 km.
3 motorised carriages with 18 sitting and 2 standing places; full weight is 3250 kg, 15/22 r.l. engine.
Max. speed is 22 km/h. 3 trailers with 19 seats each and full weight of 1650 kg.

	Carriage/km			Revenue		Current consumption		Operation costs during first 10 months and 7 days		Per carriage/ km
	Motorised	Trailers	Total	Total	Per carriage /km	Total	Per carriage /km			
1906					Marks	kW-h	kW-h		marks	Pfg.
May (7 days)	2187	670	2522	1114,00	0,45	979	0,39	1. Management, press works, etc.	2000	2,9
June	7668	4520	9928	3364,60	0,34	3223	0,325			
July	8117	5100	10667	3835,00	0,36	3389	0,320	2. Wages, uniform	8143,38	11,9
August	8510	5208	11114	4088,30	0,372	3421	0 308			
September	8231	2638	9550	2913,10	0,304	3515	0,370	3. Current 25943,5 x 0,13 =	3372,65	4,9
October	4525	–	4525	1174,10	0,26	1826	0,404	4. Repair and maintenance of carriages	904,31	1,3
November	4298	–	4298	946,15	0,22	1710,5	0,400			
December	3894	–	3894	892,00	0,230	1934	0,496	5. Lubrication, lighting, tools use, etc.	929,14	1,4
1907								6. Rubber tires	2319,90	3,4
January	3927	–	3927	900	0,235	1943	0,504	7. Insurance against fire and accidents	1371,22	2
February	3676	–	3676	866	0,236	1860	0,506		19031,60	27,8
March	4137	270	4272	1216,20	0,284	2132	0,498	With average revenue of 0,312 per carriage/km –0,278 +0,034 per carriage/km, and 68373 x 0,034 = 2320 marks		
	59170	18406	68373	21309,45	0,312 average	25943,5	0,380 average			

Table 4

	Suburban traffic, May–October, 5 carriages	Urban traffic, all-the-year-round, 60 carriages, 37 seats	Cargo 5 x 1000 kg and 2500 65 km daily mileage	Cargo, horse traction, 29,5 km daily mileage	Cart with battery, 3 riders, total weight 1400 kg, daily mileage 60–70 km, daily revenue 36 marks	Electric vehicle with air wire		Electric tram		Horse tram
						3 motorised, 3 trailers, 10 months	1 motorised, 3 months	8,4 on single track 120 versts, information of enterprises	5 on double track 148 versts, information of enterprises	10,5 on single track, 90 versts of daily mileage, Russia
Management	4,8	20	–	–	–	2,9	0	3,07[1] 41 %	5,50	5
Lease of premises	2,73	–	–	–	–	–	–			
Insurance, taxes	7,5	3	4,8	–	–	2	0,89			
Miscellaneous	1,07	–	1,6	5,4	–	–	–	–	–	–
Print works	1,05	–		–	–	–	0,226	–	–	–
Wages	11	11	11,2	18,4	2 months + 10 % 1 month + 15 % 10	11,9	4,45	7,35	8,25	8,55
Supervision	–	1	–	–	–	–	–	–	–	–
Petrol	9,3	8–13	5,2	–	–	–	–	–		\
Current	–	–		корм 12	4 250–300 W at 8–12 Pfg. Per kW-h.	4,9	4,20 maint.	5,33[1] (41 %) air	5,82 cables	18,60 stable
Battery maintenance	–	–	–	–	5–8	–	0,322	0,16	0,4	–
Lubrication, light	1,44	3	–	–	–	–	0,195	–	–	–
Depot service	–	1	–	–	–	1,4	–	–	–	–
Repair and maintenance, spare parts	J 10,37	12	8,8	7,6	motor 1,5 body 1,5 3	1,3	?	3,56	4,52	1,86
Track maintenance	–	–	–	–	–	–	–	1,62	1,78	1,05
Tires	10	10–9	–	–	10	3,4	5,22	–	–	–
Operation costs, carriage/km	59,26	51	31,6	43,4	32–35	27,8	15,493	08/09 years: 21,09 09/10 years: 20	26,27 23,5	– 35,06[2]
Year mileage, carriage/km	58487	2,000,000	15000	–	18000–20000	68373/10 months	–	626,231/2,5	979,406/5,45	727,000/4,4
Written-off, 20 %	29,1	10	3	–	10	17,5	14,3	–	–	–
Equipment, 10 %	0,555	–	–	–	–	8				

1) Station also provides lighting, so 59 % of management and energy generation costs are referred as being used for lighting.
2) Gr. Ber. Str. (Berlin): 1890 horse traction –34,5 costs +59 revenue, 58,5 % operation rate.
1906 electric traction –22,9 5 costs. +42,5 revenue, 53,95 %.
3) Figures separated by a slash show number of passengers per carriage-verst.



Pic. 8. [The original picture is reproduced as illustration].

biaxial; on each axle there is an electric motor of 25; metal tires of 150–200 mm width; pressure on tires is 100–75 kilogram-centimetres, i.e. within the limits of the norms established in Russia.

With rises of 40 ‰ and 50 ‰, such an electric locomotive pulls 3 carts of 5 tonnes of coal or flour carrying capacity.

The speed of movement is 6–8 km/hour.

See 23–27 pfennig/tonne-km, or about 0,2 kopecks for pood-verst [16 kg-1/0668 km].

With the help of 3 electric locomotives, 10 coal wagons and 27 wagons for flour are transported; daily transportation, on average, is about 300 tonnes, i.e., it is a standard freightage that can justify the laying of rail track, but it is not always possible to receive permission to lay rail track on the highway of general use. Simultaneous servicing of passenger and freight traffic is possible (Pic. 7).

In conclusion, possibility should be noted of saving electrical energy when driving on mountain lines, that is, with significant ups and downs.

It is enough to install an electric motor with shunt excitation on the carriage, so that the energy obtained when driving on an incline, when the motor starts to work as a generator, is sent into the overhead wires and utilized for the movement of the carriage going up the ascent. Pic. 8 depicts maintenance of electric energy on a site of 2 kilometres.

Summarizing all of the above, we have the right to assert that transportation, by means of electric vehicles with an overhead wire, over short distances (2–4 kilometres) is the cheapest in terms of operation and requires the lowest costs for initial equipment, and therefore wherever there is a more or less good road, it deserves full attention for transportation of both passengers and goods.

Chairman. Let me thank the speaker (applause). Maybe someone present would like to receive some clarification, in which case I would ask those who wish to ask questions or get some additional information, contact the speaker.

If there are no volunteers, then let me adhere to the wishes expressed by the speaker, and, perhaps, expand it. The most important and desirable thing is that the carriage, with the help of this or that energy, could circulate completely freely, so that all the conditions of its circulation are contained in the carriage itself. It was the internal combustion carriages that made a step in this direction.

We were familiarized with the conditions of movement of the carriage, so to speak, not along the rail, but along the wire track located on top of the road along which the carriage is rolling.

It seems to me that in the end one should wish that the carriages, as a means of transport, were not connected either with special devices under them, of course, without touching the arranged road, or with special devices above them to obtain driving force, but that they were independent carriers of energy. I think that experiments with internal combustion devices cannot be considered complete. Now they are trying to supply electrical energy to vehicles from the outside, using wires. The Italians very aptly called the roads equipped with this method – *filovia*, as opposed to railways – *ferrovia*.

I think in the future no *filovia* will be needed to supply energy. It seems to me that this is the further task of electrical engineering, and it will undoubtedly receive its solution, and only then the means of transportation will circulate freely along the roads with their own energy.

I declare this meeting closed.

(Zheleznodorozhnoe Delo [Railway Business], 1910, No. 43, pp. 171–185) ●