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Giessbach Funicular

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The Giessbach Funicular with the World's First Abt Switch

Background on the Giessbach Funicular

Steel cable-pulled cars have been used for transportation on inclined slopes, with many system variations, since the 1820s. Among them the "funicular" system, which employed two passenger cars attached to the same cable with a pulley at the top end, was especially attractive. It allowed counterbalancing of the two moving cars, one moving up while the other moved down and vice versa. The driving force came either from one car's ballast or from a steam engine turning the pulley.

In Europe, the years from 1871 to 1914 were a period of unprecedented prosperity and peace, sometimes called the *Belle Epoque*. Railway systems were growing, making international travel easier. As a result, more and more tourists were discovering the natural wonders of the Alps. This generated business opportunities for entrepreneurs seeking to make these wonders accessible for those able to afford them. The impressive cascades of the Giessbach were considered one of these wonders. A hotel first opened beside the falls in 1857. The current hotel, the *Grandhotel Giessbach* with 150 rooms and with the appearance of a French baroque palace, opened in 1875 (Figure 1).

Figure 1: The Giessbach Hotel built by Hauser Frères. This is a project drawing dated May 1874

This hotel was situated 100 meters above the boat pier, too steep a walk for many of the guests. Therefore, in 1878, the Builder-Owner Karl Hauser-Blattmann (1824-1895) solicited bids for a funicular to connect the hotel with the pier.

Riggenbach and Abt Obtain a Commission for the Giessbach Funicular

The company IGB (Maschinenfabrik der Internationalen Gesellschaft für Bergbahnen) was owned by Niklaus Riggenbach (1817–1899), a Swiss engineer. His masterpiece was the installation of a cog wheel railway ascending Mount Rigi in 1873. In 1878, he hired a bright 28-year-old engineer Carl Roman Abt (1850–1933) as chief engineer to design a funicular for the Giessbach Hotel.

The funiculars of that time used two tracks (see figure 7) or a three-rail arrangement to solve the half-way passing problem of the two cars. Abt proposed a solution that employed a single track with a half-way turnout. This put IGB ahead of all its competitors because of the obvious economic advantage, and IGB got the commission. The technical equipment and the superstructure parts were built and preassembled in Aarau. The transport to Giessbach was made by railway and boat. The funicular opened on July 21, 1879. The erection time of less than a year for the whole installation was an impressive achievement, since only minor mechanical construction equipment was available on-site (figure 2).

But IGB's economic success was short-lived. Due to a lack of new orders, IGB went bankrupt shortly after the delivery of the Giessbach Funicular, leaving Carl Roman Abt unemployed.

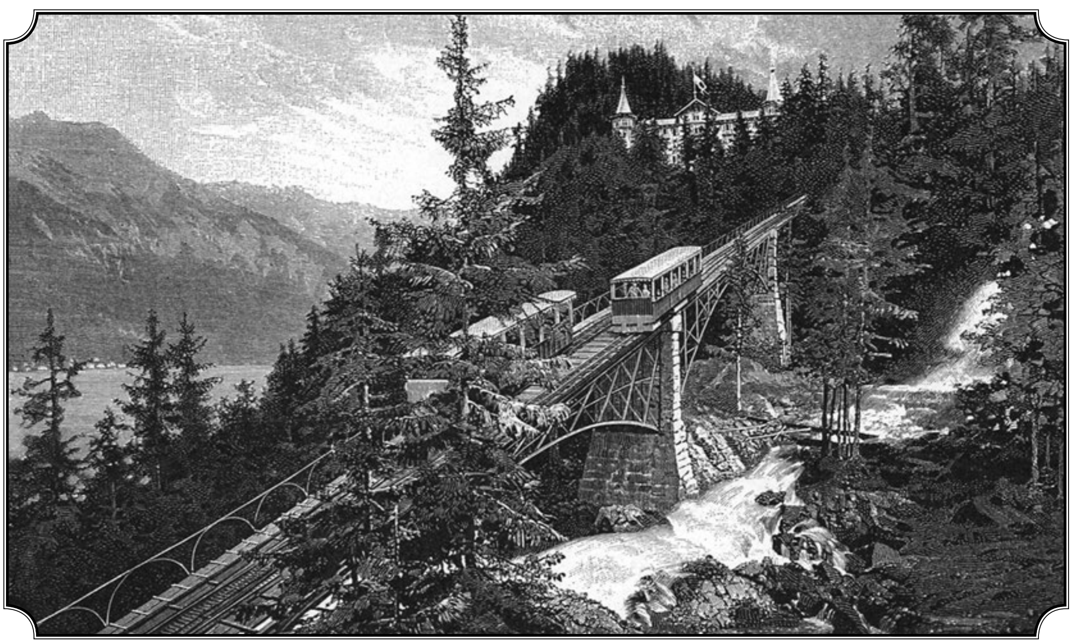
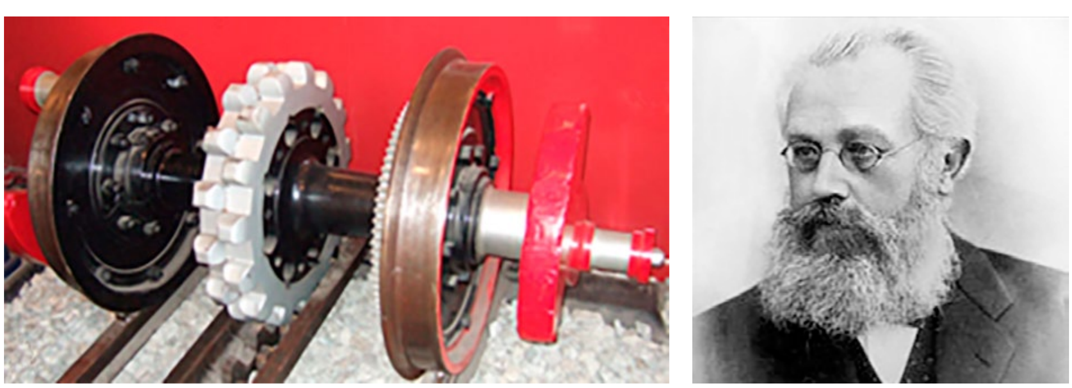


Figure 2: The two cars on the Abt automatic turnout in 1880.

Abt then worked for two years in the Swiss Federal Department of Railways, after which he became an independent engineer. He supervised the later maintenance of the Giessbach Funicular and the introduction of an improved Abt switch solution in other projects. Later he directed the construction of 72 mountain railways and became a wealthy man with an impressive record of successes, which included a cog rail design still known under his name (Figure 3).

Figure 3: Picture of Carl Roman Abt and Cog wheel "System Abt"





Technical Description

Carl Roman Abt described the “automatic turnout” solution he used at Giessbach in a sequence of very detailed articles published in 1879 [1]. His solution was characterized by abandoning the long-standing paradigm that railway car wheels must have the wheel flanges on the inside of the rails. At Giessbach one car was guided by external wheel flanges; the other car had internal wheel flanges like those of normal railway cars. This arrangement made passage over the turnout automatic. Abt's design also required additional guidance slips, and the upper and lower switches had to be different.

Abt's Giessbach design had some problems. The cars' passage over the switches was bumpy, and this frequently caused loose bolts on the rail at the rail connections. It is possible that there was friction in the cable passage, with the cable occasionally touching the wheel flanges. This likely caused frequent cable replacement. Contemporary reports simply mention “expensive and frequent maintenance.” Nevertheless, the Giessbach funicular was profitable because of the high passenger volume, earning an annual profit of 10%. While no correspondence is available from Abt on the subject, he soon found a better solution as shown in Figure 4. Because IGB was out of business, it was installed by Maschinenfabrik Bell, Kriens (the former competitor) under Abt's supervision.

Abt's improved solution employed two wheel flanges on the outer wheels on the outboard side of each passenger car as it traversed the turnout. This allowed for an uninterrupted guidance rail on the outside of the turnout and larger passages for the cable and the cog rail crossing the inner rails. The inner wheels were purely cylindrical without flanges, allowing for smooth passage over the turnout. This solution is what is still referred to as the “Abt Switch” – a short passing turnout track with no moving parts. It was first employed in the funicular of Citta-Stazione (Lugano Switzerland) in 1886. The Giessbach funicular was modified to this design in 1890 (or 1891, depending on the source) and still operates in this way.

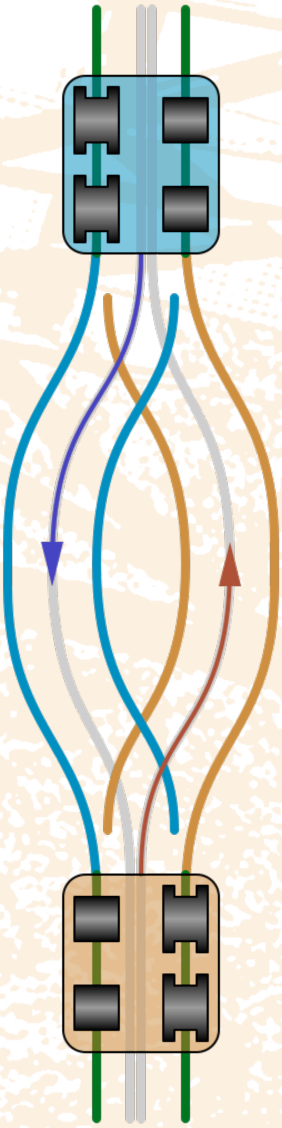


Figure 4: The improved and modern Abt switch principle. (image: Cmglee, WikiCommons)

This history clearly demonstrates that simple, ingenious solutions frequently are found after more complicated solutions fail.

Initial Configuration of the Giessbach Funicular

The Giessbach funicular was driven by weighting the descending car with a filled water tank. The speed was manually controlled by the driver with a brake, which acted on a toothed wheel that engaged a cog rail between the main rails. This cog rail used the Riggenbach system, and it still exists for use as an emergency brake system. The water came from Giessbach Falls via a reservoir in the upper station designed for filling the car tank. The required filling level was signalled by the driver of the lower car, according to the loading weight. Electric ringing signals communicated the required information. When the car reached the lower station, the car tank was emptied.

The upper station initially had no roof. For this reason, during the winter the upper car was stored under the roof of the lower station on a parallel rail. Moving this car down in autumn could be controlled with the brake, but moving it up in spring was an exhaustive muscle-driven exercise with an auxiliary hand car. [3]

The initial water tank operation required a nearly constant inclination to minimize changes in the speed control brake requirement. To secure the constant inclination, Abt designed a superstructure for the track with a high number of bridges, all still in use.

Subsequent Changes to the Giessbach Funicular

1912: The water weight drive was replaced by a new hydraulic drive that was powered by a Pelton turbine in a new engine building with a plain roof. The horizontal pulley was replaced by a vertical drive disk with three driving grooves and corresponding free turning disks. Both pinion and teething on the drive disk were made out of steel and are still used by the current electric drives (figures 5 and 6). Theodor Bell & Cie Kriens modified the car chassis to a 3 axis arrangement with the middle axis having no wheel flanges on either side. The initial chassis had the lower two axes in a pivoted bogie. The emergency drive was still operated by weight. The cog wheel was no longer used as a speed control device. The manual speed control was replaced by the speed governor of the turbine, which controlled the turbine's water nozzles.

Figure 7 (right): The earlier two track solutions (as an example, Budavári Sikló in Budapest, 1870) required almost twice the space and investment for the track superstructure.

Figure 5: The drive gear used since 1912 in the engine building at the top station. The three cable driving grooves on the large diameter wheel are made out of wood. They form a total deflection angle of more than 3 times 180 degrees (to be applied in the belt friction equation). At the bottom partly visible is the blue electric drive motor, from the intermediate gear only the green corner is visible. Both are from the 1998 restauration. (photo: Nicole Berra)

Figure 6: This is the drive shaft. From left to right visible is the service brake disk, the teethed pinion and the chain drive acting for the car position indicator. (photo: Nicole Berra)

1948: The hydraulic drive was replaced by an electric drive with a semi-automatic control. Speed was increased to 1.9 meters per second. The electric power came from a Pelton turbine near the lower station driven by water from Giessbach Falls. The old Pelton drive was disposed of in the lake. It was retrieved and is now on exhibit in the lower station.

1952: Both stations were renovated. The second track in the lower station was removed and the station building downsized correspondingly. The upper station was covered, which eliminated the need for storing both cars during the winter in the lower station. Other sources indicate that these changes occurred in 1948.

1958: A new electric motor from Maschinenfabrik Oerlikon (26hp) was installed.

1979: The hotel closed because of persistent low profitability. The intention was to replace it with a modern concrete building.

1983: A Swiss environmentalist named Franz Weber purchased the hotel, with help from his association, "Helvetia Nostra." The association's "Giessbach dem Schweizervolk" Trust now owns the hotel and has obtained landmark protection status for it. In the following years the hotel was gradually restored. We can assume that this supported the preservation of the funicular too.

1989: The track superstructure except the cog rail was renewed. (figure 8)

1998: A new 31 kW electric motor (thyristor controlled, direct current) and new brakes were installed in the station, and the cars received new chassis. The new controls allow driving the funicular either from one of the cars or from the station.

2007 and **2009:** The wooden upper car parts were restored according to the original configuration.

2010: Remote control system was updated.

The Abt switch rails still correspond to the 1891 design. The cog rails and the emergency brake (acting to the cog wheel) are reported to be original parts of 1879. The configuration as of 2014 is shown in figure 8.

Figure 8: The upper part of the Abt switch seen from below the bridge. The track superstructure is mainly on bridges like this.

The Current Status of the Giessbach Funicular

The Hotel and the funicular are owned by the Foundation "Giessbach dem Schweizer Volk" Trust.

Both Hotel and funicular are operated in the summer season. The funicular operates for public transport with a Swiss federal license. The time table is synchronized with the boat stops, which typically occur every 30 minutes. This configuration allows guests to reach the hotel the same way as in 1879. Today, there is also a road connection to the hotel with a bus stop nearby. The through going road traffic passes through a long tunnel below the hotel and is neither visible nor hearable from the hotel. This ensures that the landscape around the Giessbach remains as it was in the Belle Epoque.

There are two commemorative plaques in three languages located in the upper and in the lower station with the text shown in figure 10.

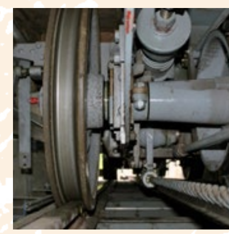
Figure 9: This is the view is from the descending car down over the turnout to the climbing car and to the lower station at the lake. The insert to the right show the wheel-flange arrangements used on the different rails. The lower car (visible) has the double flange wheels on the right side and the cylindrical wheels on the left side. The upper car (from which this picture is taken) has the opposite arrangement, and is guided by the left rail of the turnout. The cylindrical wheels passing over the inside rails of the turnout are supported by at least one rail in any position (without cut-outs). This allows a smooth passage. The cog rail between the rails is now only used for the emergency brake, which acts on the cog wheel. In most later funiculars the emergency brake function is fulfilled by clamp brakes acting directly on the rails. This makes the cog rail obsolete.

Cog rail system Riggenbach, initially used for speed control with a brake. Now used for the emergency brake in case of cable faillure.

Inner rails need interruptions for the cable and for the cog rail.

Cable passage to the car below between the rails. No rubbing to the rail allowed.

Outer guidance railis uninterrupted



The Significance of the Abt Automatic Turnout

The turnout solution with its Abt Switch is one of the few inventions which has been used without change for more than a century. Since 1879 more than one thousand installations have been built, some up to several kilometres long, according to a book published in 1975 [2]. Most of these have used the Abt turnout. In 2013, a new installation opened with a moving weight of more than 200 tons opened [5]. Nowadays aerial cable cars challenge funicular technology, especially because of their less expensive superstructure. But in some cases, especially for very heavy moving loads and in tunnels, funicular technology remains competitive. A large number of funiculars remain in operation and are continuously being updated with the latest drive and control technologies. Accidents have occurred on funiculars , but a malfunction of the Abt switch has never been the cause.

Designed by Carl Roman Abt, this was the first funicular to employ a single, two-rail track along its entire length, with a short passing track for the two cars to pass at mid-point. The passing track used turnouts with no moving parts, known as Abt Switches, for safe, reliable operation. Wheels with outside flanges on one car and inside flanges on the other routed the cars through the turnouts and around one another. Gaps in the rails allowed the flanges and haul cable to pass.

In 1891, Abt modified his design to place inside and outside flanges on only the outer wheels of both cars. This allowed continuous outer rails through the Abt Switches, providing a smoother ride and reducing wear. Still in service, Funicular Giessbach is 323 metres (1,191 ft.) long and rises 98 metres (322 ft.), and it was the model for many others.

Figure 10: English text of the commemorative plaque.

Acknowledgments

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References

[1] R. Abt: "Die Seilbahn am Giessbach", Journal DIE EISENBAHN (later renamed into "Bauzeitung"), 25. October 1879, Hefte 17…22. Available online: http://retro.seals.ch/digbib/voltoc?pid=sbz-001:1879:10:11. This article in 6 parts is very comprehensive, with drawings. It shows Abt's thinking, considerations with respect to design, construction process, operation, economics and safety, etc. The online version allows zooming into the drawings with a reasonable resolution.

[2] Walter Hefti 1975: "Schienenseilbahnen in aller Welt", Birkhäuser Verlag Basel, ISBN 3-7643-0726-9. This 300 page book in German is very comprehensive. The Giessbachbahn is mentioned several times and also shown in illustrations.

[3]Jürg Schweizer, Roger Rieker 2004: „Grandhotel Giessbach", Schweizer Kunstführer GSK. ISBN 3-85782-751-3, Serie 76, Nr. 751. This booklet shows both the historic and economic background and also contains a technical description and some historical facts of the Giessbachbahn.

[4] Adolf Wild 2014: „Die Standseilbahn am Giessbach - Die erste eingleisige Standseilbahn, erst eine Fehlkonstruktion, dann ein Welterfolg". This is a comprehensive summary of the history of the funicular with in-depth technical explanations. It was of great help for preparing this landmark description. It is available in the archive of the Giessbach Hotel.

[5] Axpo 2014: "Newsletter der Kraftwerke Linth-Limmern AG | Mai 2014", online accessible.

ASME SETTING THE STANDARD

The Giessbach Funicular,
added August 27th, 2015

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