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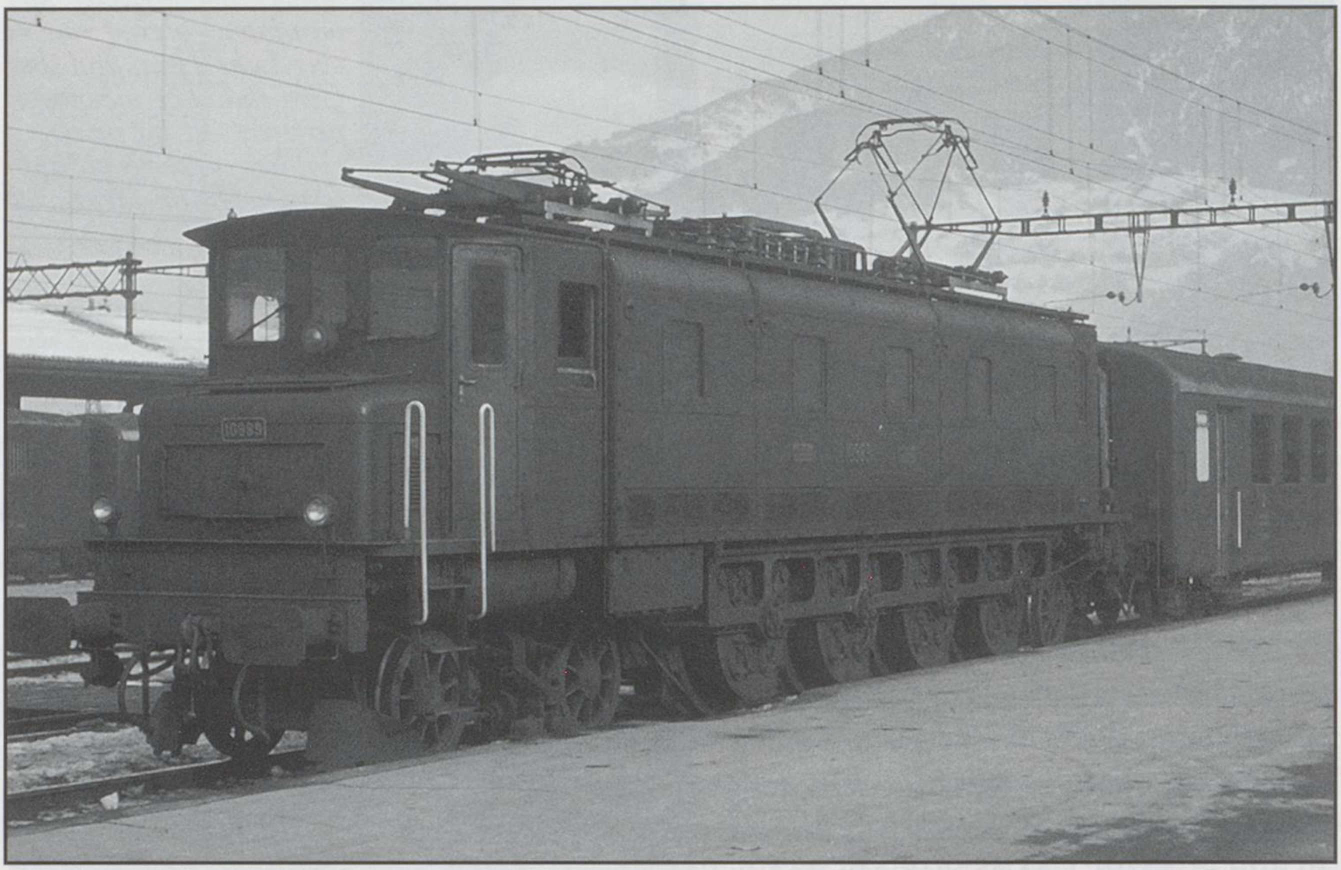
THE BROWN-BOVERI BUCHLI DRIVE



10989 at Brig, January 1969. *Photo: Paul Russenberger*

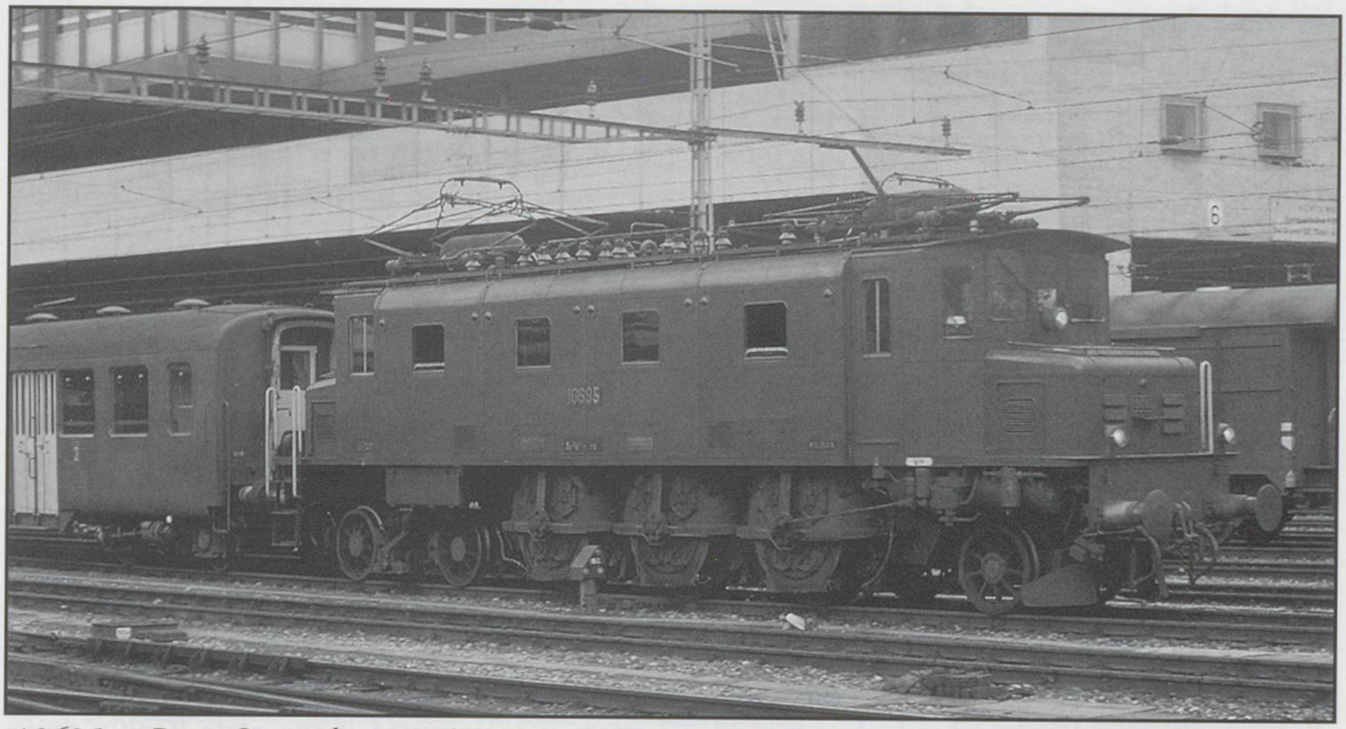
For years I gazed at Ae3/6^{I}s and Ae4/7s wondering just what was inside the boxes, which covered their massive driving wheels on one side only. And why was it necessary? A booklet published by Electric Railway Society indicated that it was the Brown-Boveri Buchli drive, but that did not really help. Years later an article in the French magazine *Voies Ferrèes* on some 2-Do-2 electric locomotives began to unlock the puzzle.

To understand why the drive was developed and how it fits into Swiss railway history, we need examine the locomotive engineering situation immediately after the First World War.

The classic predecessors of the Ae3/6^{I} are the Be6/8 *Krokodil* and the Be 4/6 bogie locomotives. The *Krokodil* is essentially an electric Garratt with two motors carried under each bonnet. These are geared to a lay shaft above the driving wheels, which drives them through coupling rods in a manner very similar to that of a steam locomotive. The Be4/6 also has pairs of motors mounted on each bogie driving a lay shaft, though at the same level as the coupling rods; unlike the *Krokodil*, the axis of the lay shaft is in the same plane as the axles of the driving wheels.

In each case the heavy motors are mounted on the locomotive frame (*Krokodil*) or the bogie (Be4/6). Their entire weight is carried through the springs on which the body or bogie itself rests. This gives the locomotive a better ride and reduces the dynamic forces imparted to the track whenever the locomotive encounters an irregularity, such as a rail joint or a crossing, by eliminating the dead weight of the traction motors. Unfortunately, the movement of the springs gives rise to the same movement between the wheels and the traction motors; a mechanism has to be provided which will allow this movement and still transmit power to the wheels. While the rod drive achieves this, it has fundamental disadvantages which cannot be eliminated.

Careful dynamic balancing of the rods minimises rotational forces, but cannot entirely prevent the bogie tending to yaw from side to side with each rotation of the wheels. More importantly, the transmission of the traction drive fluctuates. Rods can only transmit forces along their length. Consequently the full tractive force of the motor can only be transmitted when the rods are at their top or bottom positions. As the wheels turn, and the rods move away from their top or bottom positions, the torque applied to the driving wheels is reduced until after a quarter of a turn no force is transmitted. (This is the equivalent of a steam locomotive having the piston at the end of its stroke.) As the wheels turn further, the tractive force increases to the same maximum when the rod reaches the other (bottom or top) position. While the rise and fall in tractive effort can be compensated by placing the rods on one side of the locomotive at 90 degrees to those on the other side (quartering), so that one set is transmitting the maximum force when the other can transmit no force, the whole arrangement is mechanically inefficient.



10695 at Bern, September 1976. *Photo: Paul Russenberger*

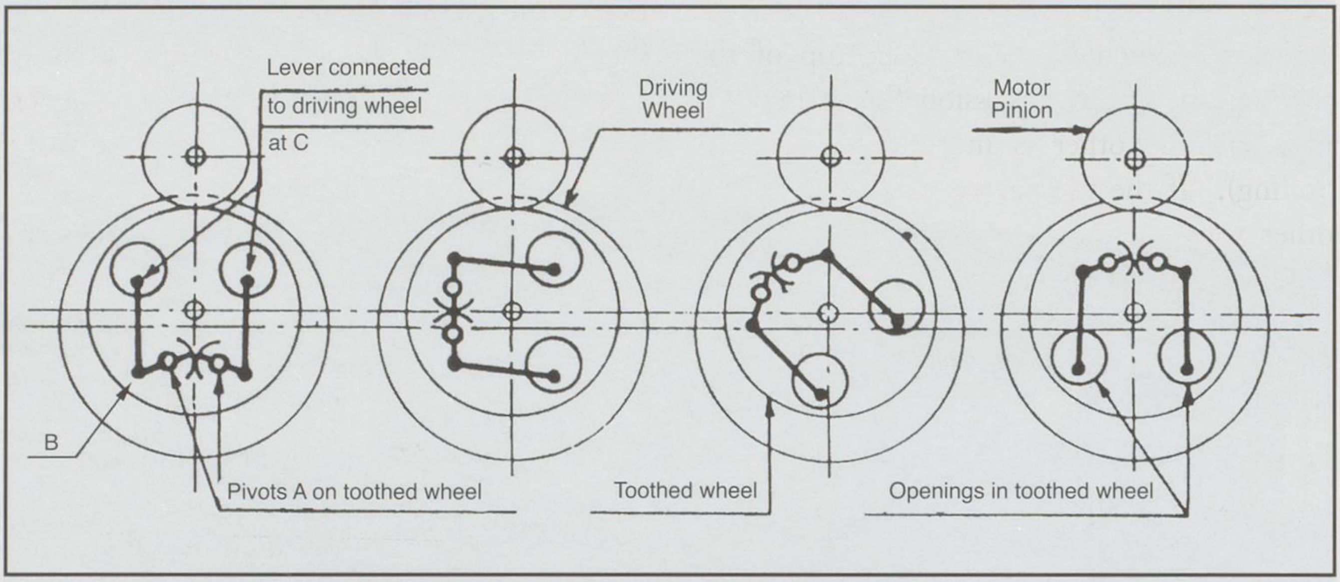
As increased traffic and train weights demanded more power from each locomotive, not only were larger traction motors required, but also the losses incurred by the rod drive became less and less acceptable. To achieve the 100 kph required by the A classification while keeping bearing speeds down, larger driving wheels were also needed. The size of adequately powerful, alternating current motors required them to be fully suspended. Even before the Be4/6 and Be6/8 were in service, it was clear that a drive would have to be developed which would meet these requirements.

In 1918 the unique Be2/5, number 11001, which had originally been built by Brown-Boveri for the 12,000 volt electrification from Perpignan to Villefranche in France and was returned as unsatisfactory, emerged from the BBC works equipped with two experimental drives. It was originally a 1-Co-1 with the driven wheels retained in the main frame; it was now a 1-Bo1-1. The outer driven axle was fitted with a Tschanz drive and the centre axle with a Buchli drive, the drives being named after the engineers who had developed them; Tschanz worked for the SBB and Buchli for BBC and SLM. The locomotive was allocated to Bern for use on the newly electrified line to Thun.

The results from ordinary running convinced SLM and BBC that the Buchli drive could be safely used on the Ae3/6 I then under development and introduced in 1921, initiating one of the classic Swiss locomotive schemes as a total of 231 units were ultimately built to this general layout. However, the SBB were not as convinced and had another experimental locomotive built in 1922, Ae4/8 number 11300. This was a cumbersome 1Bo1-1Bo1 machine. One bogie was equipped with Tschanz drives and the other with Buchli drives. It remained in service until 1964.

One end of each lever has a number of teeth, which engage in similar teeth on the other lever. The other end, B, is linked to another lever connected to the driving wheel at C. Because the two small levers engage with each other, they can only move together. (That is the key to the working of the mechanism.)

Suppose that the driving wheel was fixed so that its axle always coincided with the shaft of the toothed wheel. While this would make the drive unnecessary, it would enable the small levers to be replaced with a single lever solidly mounted on the pivots A, fixing the position of



How then, is the drive laid out and how does it work? A diagrammatic sketch is shown and the reader is strongly advised to look at it now!

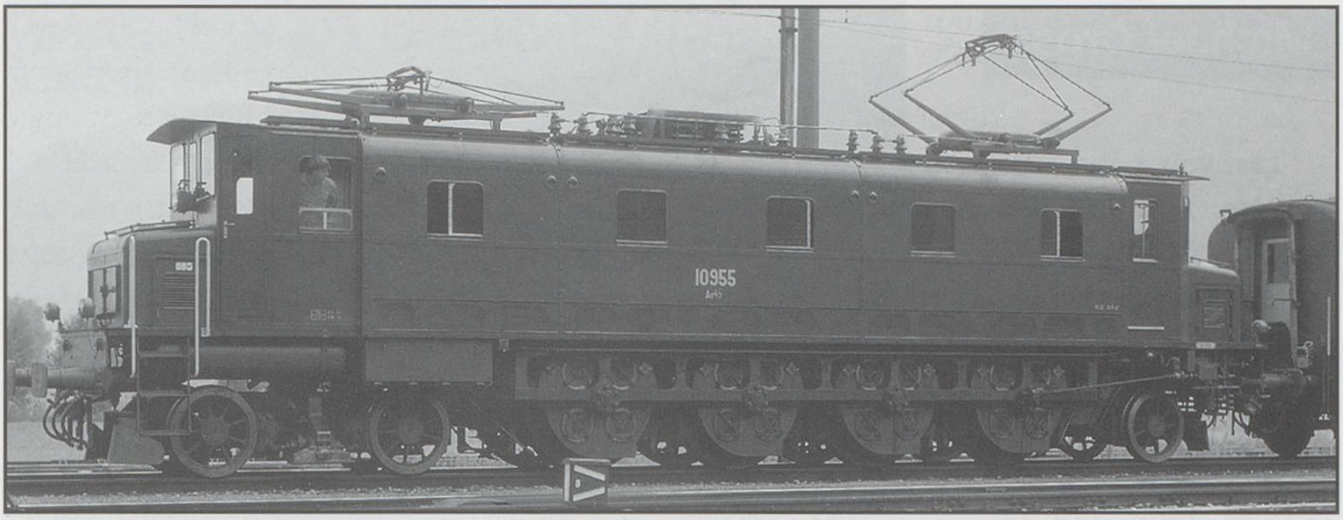
The traction motors are mounted directly above each driven wheel so that the motor shaft and the driving wheel axle are parallel and in the same vertical plane. The motor drives through its pinion wheel. This wheel engages with another toothed wheel, which turns on a shaft mounted on the locomotive body. This wheel is linked to the driving wheel by a series of levers that transmit the drive and allow the driving wheel to move vertically relative to the toothed wheel, thus permitting the required relative movement between the driving wheel and the body.

On the toothed wheel are two pivots, A, with a small lever mounted centrally on each.

the other end B. Because the positions B and C are fixed, turning B will also turn C. This effect is maintained if the ends B only move together. This simultaneous movement is achieved through the small levers engaging with each other. This movement allows the driving wheel to move relative to the toothed wheel and so relative to the locomotive body.

The levers BC are always acting together, one pushing and the other pulling the driving wheel round, regardless of their position. Hence, power is always transmitted from the motor regardless of the position of the mechanism.

As the sketch is drawn, the driving wheel has moved downwards from the central position in which the driving wheel axle passes exactly through the centre of the toothed wheel. The mechanism is shown turning



10955 at Nieder- und Oberurnen, 3 September 1987. Photo: Paul Russenberger

clockwise through 180 degrees or a half circle. The lever which passes over the top of the mechanism is in compression (i.e. it is pushing) and the other is in tension (i.e. it is pulling). If the mechanism were to turn the other way, these would be reversed, but, as indicated, power would always be transmitted.

The drive has the advantage of robust simplicity. Its disadvantage is that the teeth on the small levers have to be lubricated and lubrication cannot be achieved by passing through an oil bath, as can the teeth on the large wheel.

For over 75 years the drive gave good service on the SBB. It was also used extensively in France on 2-Do-2 locomotives built both for the Paris Orleans Railway, the Ètat Railway and the SNCF. Similar locomotives ran in Spain and the drive has also been used in Germany, Brazil, India and Japan.

Postscript: 11001 was withdrawn in 1937. By then its number must have been duplicated by an Ae4/7. Does anyone know the running number subsequently carried? The photograph in SBB Lokomotiven und Triebwagen shows no number and the text makes no reference to renumbering.

Does anyone know anything about the Tschanz drive?

The rod drive of the Krokodil in the Verkehrshaus. The vertical movement is achieved where the rod drive is attached to the leading axle furthest from the camera. Photo: Paul Russenberger