12.1 Security installations

12.1.1 Motivations

At the moment when more than one single train rolled on a network, it was necessary to define a method to avoid route conflicts between trains and to reduce the accident risk. First step was realized with visual signals, giving information at drivers if they can continue their route or not. This imposes a strict respect of signal and dispositions by the train personals. This ask also a strict choice of signal images – closed or open – by the ground personals who have to know if a way is free or not: it's the principle of *cantonment*. Signals had to present an image without ambiguity. They were first realized with mobile elements, then with colored lights.

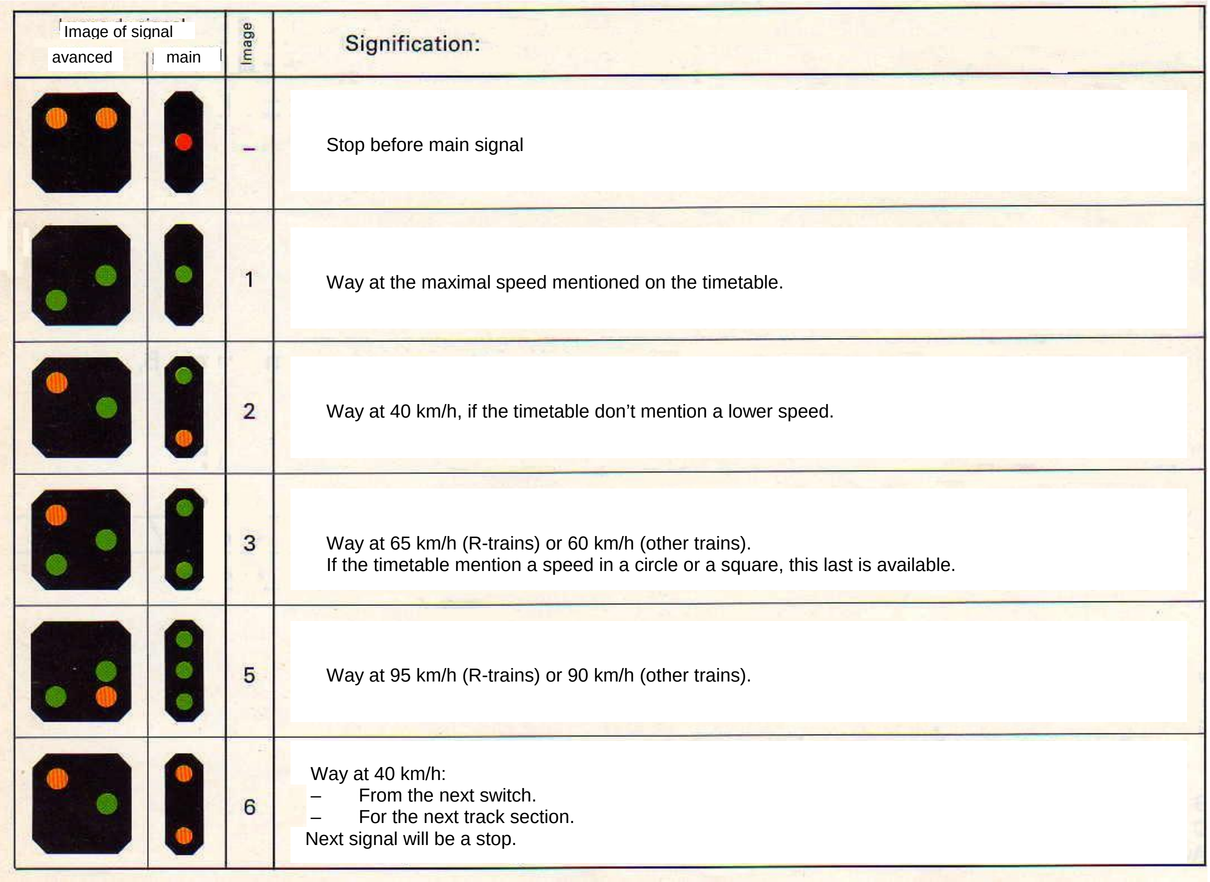
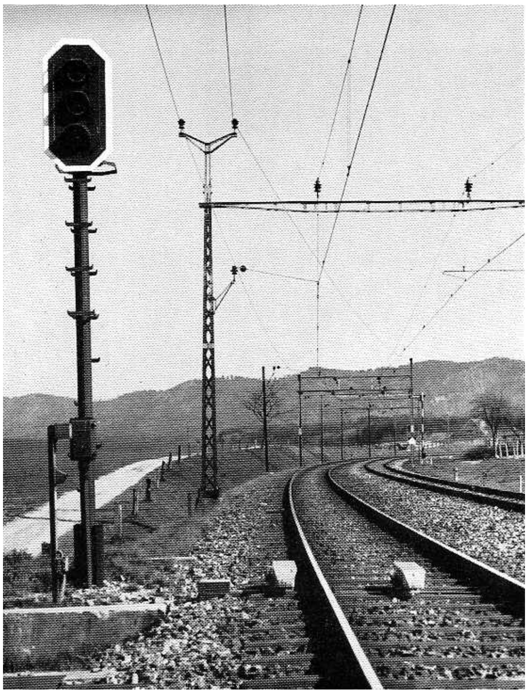


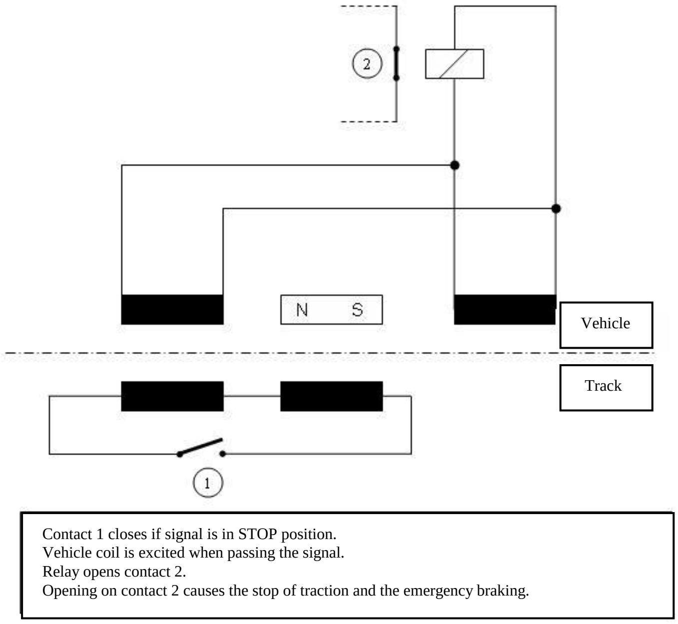
Image of signal avanced	main	Image	Signification:
		–	Stop before main signal
		1	Way at the maximal speed mentioned on the timetable.
		2	Way at 40 km/h, if the timetable don't mention a lower speed.
		3	Way at 65 km/h (R-trains) or 60 km/h (other trains). If the timetable mention a speed in a circle or a square, this last is available.
		5	Way at 95 km/h (R-trains) or 90 km/h (other trains).
		6	Way at 40 km/h: – From the next switch. – For the next track section. Next signal will be a stop.

Fig. 12.1 – Example of light signals: Switzerland about 1970.

12.1.2 Base developments

Accidents due to human failures had brought a second step: a floor device coupled with a signal give an emergency stop order to the train if it passes a closed signal after an error of the driver: the tractive effort is stopped and the main pipe of the brake is opened, causes a braking. To avoid errors of the ground personals, a system prevents the train access on a track section where another train is yet on the way: it is called *block system*. Most of railways are on this second step, with various sophistication levels. Principles are quite the same on all national networks, but are incompatibles between them, for historical reasons.





A Device at the track. **B** Functional principle.

Fig. 12.2 – Example of a supervision device for signal passing: *Signum*.

The systems in different networks are not totally safe: for example, the distance between signal and dangerous point is sometimes shorter than the emergency braking distance and do not avoid collision if the *incorrect* train runs at maximal allowed speed. Such systems can be classified in two categories: contact devices and induction devices. The increase of speeds induces the needs of advanced signals giving information at the driver if the next signal is closed or not; the sight distance became shorter than braking distance. In some cases, two steps of advanced signals were built. For high speed, trains were equipped with repetition of signals on driver's desk, in order to give enough time to read surely the signal.

12.1.3 Recent developments

The traffic growth and the gaps in different systems induced a third step at the end of the XXth century: an exchange of coded messages takes place at some points between track and train. The message is defined by image of the protection signal and the local topology. From received information: allowed speed at a defined distance, the computer calculates the limit profile for stop or deceleration, including the train parameters memorized at the beginning of the journey. This system allows also the supervision of the maximal speed. At the main signal, a message is sent to the board computer when the signals opens, giving the new allowed speed. In case of profile overtaking, the computers order an emergency braking. It is guaranteed that the train stops – by the driver or the computer – before the closed signal or will not arrived too fast on a section limited in speed. In different countries were built different systems with different technical solution not compatibles between them.

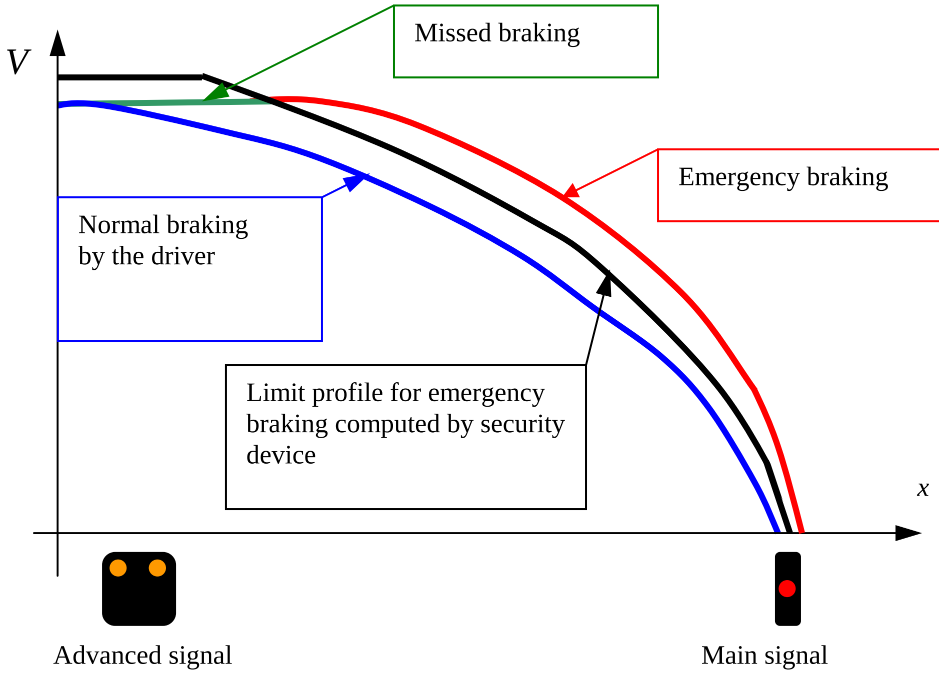


Fig. 12.3 – Real- and computed speed profiles.

A fourth step is on the way: an European standardization of ground-train transmission (wave type and dialogue protocol) with a larger function of speed monitoring, including the option of full automatic drive (ETCS : *European Train Control System*). At redaction time, such lines are in service, for passenger- freight- or mixed traffic. With such a system, the protected sections are not absolutely connected with the ground, but could be gliding defined by the preceding train: this system is called *mobile cantonment*. In this case, the ground signal can be avoided. The availability of ground-train dialog has to be guaranteed full time, the train position have to be known exactly so by the mobile computer than by the traffic control. The speed sensor on the axle axis give a sufficient precise measure for speed control but not for positioning, were accumulation of little errors could induce a malfunction. Satellite positioning will be used (GPS, Galileo) or at least sufficient points to reset the exact position on the embedded computer.

12.1.4 Interoperability

The will to operate locomotives and trains on diverse railway networks induce the installation of many security devices under the floor. It’s difficult to find enough space for all and one unused must not disturb other embedded or ground devices.

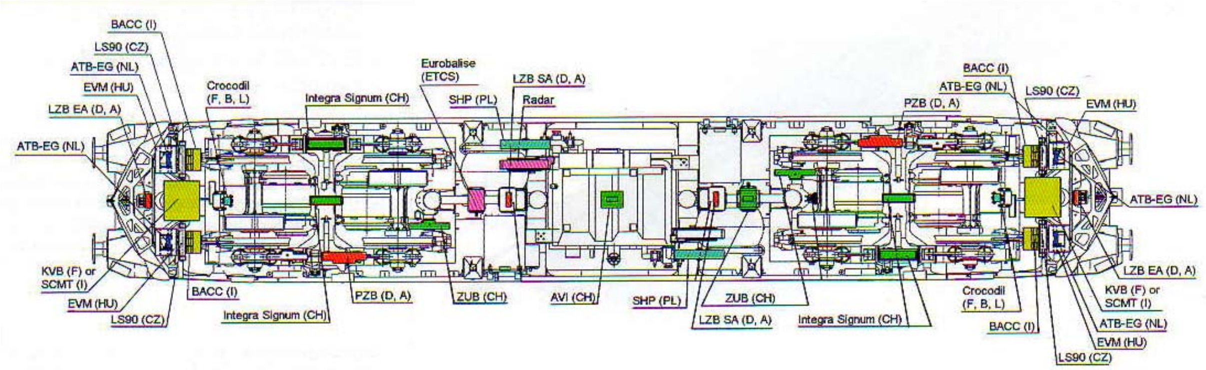


Fig. 12.4 – Security devices under a four-axle locomotive.