An Introduction to Railway Signalling and Equipment

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Aim: I aim to provide a general overview of the concepts and terminology used in railway signalling.

Overview:

1. The history of railway signalling
2. The key components of a signalling system
3. Trackwork: Rails, sleepers, ballast etc
Police men would provide signals to trains.
Coloured flags were used during the day.
Lights were used at night.
And how did they know where the trains were?

There was no system to track train location.

Once the train went out of sight there was no way to tell its location.

Clocks timed a delay in-between trains.
The first major advance in railway signalling was the introduction of **Fixed Signals**.

These essentially were wooden boards mounted on rotating posts

- **Board visible**  Stop!, Do not proceed
- **Board not visible**  Track ahead is clear, Proceed
More Fixed Signals

One improvement on the basic fixed signal is the disc and crossbar.

Either the disc or the crossbar is visible at any given time.

Disc visible  Proceed Aspect
Crossbar visible  Stop Aspect

The term aspect refers to the different modes or visible state of a signal.
Disc and Crossbar
A new signal called the **semaphore** was introduced in 1841. Used a signal arm which could be positioned at different angles. With an oil lamp for night operation.
A Bright Idea!

Up to this point **one policeman** controlled **one signal**

Then someone had an amazing idea!

Connect signals to a central point called **a signal box** with cables
A **signaller** set the signals using levers.
This allowed for the development of the **interlocking**:  
- Prevents the signalling system entering an **unsafe state**.  
- Physically **locks** levers in the signal box.  
- Levers can only be moved if it is safe to do so.

By 1890 an interlocking was a legal requirement for every train station in the UK.
An Old Interlocking
Further Advances

Communications between railway stations was enabled around the same time.

Originally this was using Morse code transmitted along telegraph lines.

Another major advance was the introduction of the absolute block system.
A piece of track between two signal boxes was called a block. This track could be in one of 3 states:

- Line blocked (Default/ Failsafe state)
- Line clear
- Train on line

A simple device was used to communicate the state of the track between the two signal boxes.
The History of Railway Signalling

Human Error

The interlocking and the absolute block system created a much safer railway.

However it was still susceptible to human error.

For instance a signaller may forget that a train has been waiting at a signal for a long period of time.

This resulted in the infamous **Rule 55**:

"If a train is stopped at a signal for more than 3 minutes then either the fireman or the guard must walk to the signal box and formally remind the signaller of the presence of the train"
This problem with human error was solved at the end of the 19th century.

Electric **track circuits** enabled the detection of trains automatically.

Track circuits were installed along whole segments of track.
This in turn made **automatic signalling** possible.

A signal would automatically display a stop aspect if the track it controlled was occupied.

This type of signalling was called **track circuit block** signalling.
Electric Point Machines

Following the general trend of electrification in the railways points were electrified.

Electric point machines enabled points to be controlled remotely.

A point could be moved at the flick of a switch.

A modern electric point.
Electromechanical interlockings

This electrification called for the introduction of electromechanical interlockings.

These made use of relays.

Old style mechanical interlockings could take up a 2 storey building.

These interlockings were much smaller.
In 1923 the first coloured light signals were introduced. These gave the same indications day and night. Brighter than oil lamps

Red  Stop aspect.
Yellow Proceed with caution. (Not called Amber!!!)
Green Proceed aspect.
Coloured Light Signals
Now that both the points and the lights were electrified the big levers of the early railways became redundant.

Electric switches could now control both points and lights.

**Power Frames**: Contain some mechanical locking

**Control Panels**: Fully electric
An illuminated diagram used lamps to indicate the position of trains.

A panel with coloured lamps was introduced to display the descriptor of a train.
The introduction of switches over levers allowed for the introduction of **Routes**.

Instead of setting all points and signals, an entrance and exit signal are selected.

The control system automatically sets all points and signals in-between.
Up to this point railway signalling was very cable intensive.

2 pairs of cable for every point and signal.

Remote controlled systems could control a remote junction with just two pairs of cable.

A **signalling centre** was connected to an on-site interlocking.

Signalling centres controlled a large numbers of trains.

Train numbers consisting of 4 characters were introduced e.g. 2P22.
Solid State Interlocking

Up until the 1980s the use of electronics for any safety critical system was forbidden.

- The behaviour of relays was well understood by engineers at the time.
- The behaviour of electronics was not.

The advent of microprocessors caused a review of this situation. A new generation of solid state interlockings was designed. These were as least as safe or safer than their relay counterparts. Allowed for automatic route setting.
More recently it has been possible to pass signalling information from the track to a train. This has led to the development of:

**Automatic Warning System**
- Provides a warning if the train approaches a non-proceed aspect.
- Applies the breaks if the warning is not acknowledged.

**Automatic Train Protection**
- System constantly calculates the maximum safe speed of the train.
- Applies the breaks if the train exceeds the safe speed.
Where is the interlocking?

- Control Systems
- Railway Interlocking
- Physical Railway
Signalling Centre

Diagram showing connections between
- Control Device
- Telecomms.
- Power Cubicle
- Interlocking
- Train Describer
- Trackside Equipment

Connections marked with 'C' and 'I' for current and information flow.
Cables are housed in a **cable route** alongside the railway. This is typically a concrete trough with a loose lid.

If the cable route has to cross the railway then an **undertrack crossing** is used.

These consist of two man hole covers and a small tunnel.

The final interface to any track side equipment is stored in an **Apparatus Case** also called a **Location Case**.
Rail Types

There are currently two different types of rail used in the UK.

**Bullhead**  Older design, placed in chairs.

**Flat-Bottom**  Modern design, easier to install, attached with clips.
Bullhead Rail

Key

Sleeper

Ballast

Chair

Coach Screw
Flat Bottom Rail