# Signalling Systems

Contents



## Signalling systems

### Q. Why are multiple aspect signalling systems used? What was wrong with the older systems which had two aspects?

Multiple aspect signals, by providing several intermediate speed stages between 'clear' and 'on', allow high-speed trains sufficient time to brake safely if required. This becomes very important as train speeds rise. Without multiple-aspect signals, the stop signals have to be placed very far apart to allow sufficient braking distance, and this reduces track utilization. At the same time, slower trains can also be run closer together on track with multiple aspect signals.

### Q. What kinds of signals (semaphores, lamps, etc.) does IR use?

IR uses several kinds of signals. Semaphore signals have generally given way to colour-light signals although there are still many places with semaphore signalling in use. [1/02]

**Semaphore** signals are the older style signals seen widely throughout the country, where each signal has an assembly with an *arm* mounted on a mast, where the arm can move through two or three different positions at different angles, each position providing a distinct signalling aspect. Very early in India's railway history, two-position lower-quadrant semaphore signals were the most prevalent. Around the 1930s, however, the introduction of American style power signalling equipment in some areas resulted in three-position upper-quadrant signalling being introduced as well, although both systems continued in use for many decades afterwards. It is not clear when distant signals were introduced.

**Colour-light** signals are assemblies of lamps that indicate different aspects by means of different colours of lamps that are lit. Colour-light signals were introduced in 1928 but were slow to take off. In recent years many older semaphore signals have been replaced by colour-light signals.

**Position-light**signals are assemblies of lamps where the signal aspect is indicated not by colour but rather by the combination of the lamps that are lit.

**Disc** signals are in the form of a vertical disc with a pattern such as a bar painted on it, which rotates about its centre to different positions to indicate different signal aspects. These are usually mounted on poles but may be close to ground level.

**Target signals** have a vertical disc (or two parallel vertical discs) which can rotate about a vertical axis so as to present the disc either face-on or edge-on to an observer along the track. Usually a lamp is provided behind the disc (or between the parallel discs) which is visible only when the discs are oriented edge-on. The centres of the discs usually also have lamps. The two aspects of this type of signal are indicated by the two orientations of the discs. This type of signal is almost always at ground level.

*In the following, 'on' refers to that position of a signal which shows its most restrictive indication (in accordance with IR's terminology). However, we use 'clear' for the position that shows the least restrictive indication instead of the word 'off' because the latter is used by IR to refer to any signal position other than the on position.*

## Q. What types of signalling systems are used on IR?

R uses several forms of signalling. In IR manuals reference is made usually only to 4 main types of systems, Lower Quadrant semaphore, Modified Lower Quadrant semaphore, Multiple Aspect Upper Quadrant semaphore, and multiple-aspect colour-light signalling. But in practice there are some variations in the kinds of colour-light signalling seen, so for ease of analysis, the following classification is used here. (Abbreviations in parentheses given for ease of reference in the text that follows.)

- Two-aspect Lower Quadrant semaphore signalling (2LQ)
- Modified Lower Quadrant semaphore signalling (MLQ)
- Multiple Aspect Upper Quadrant semaphore signalling (MAUQ)
- Two-aspect Colour-Light signalling (2CL)
- Three-aspect Colour-Light signalling (3CL)
- Four-aspect Colour-Light signalling, normally known just as Multiple Aspect Colour-Light signalling (MACL)

These are explained in detail in the section on aspects and indications of signals.

In addition to these, there are some in-cab warning systems (AWS), and of course flag/lamp/hand signals for emergency use.

## Semaphore Signals

### Q. What are the systems of semaphore signalling used by IR?

**Lower Quadrant**

In IR's lower quadrant system (**Two-aspect Lower Quadrant**) the semaphore arm can only be in two positions. The horizontal *on* position shows the most restrictive indication (requiring the train to stop or slow down or proceed with caution depending on the kind of signal), and a lowered position where the semaphore arm is at about 60 degrees or more from the horizontal shows the clear or proceed indication allowing a train to go past the signal.

The 2-aspect Lower Quadrant system suffers from a couple of disadvantages. The principal disadvantage is that the driver of a train must be prepared to bring the train to a full stop when the warner is at caution and the home signal is at danger. To address this, often warner signals are moved further back to provide sufficient distance from the home signal for braking the train to a full stop. The second disadvantage with the 2LQ system is that the indication of the warner signal is not explicit. When the warner is at caution, it may indicate that the home signal is at danger, or that the train will be received on a loop line, or that there is a speed restriction of some sort ahead. These disadvantages are addressed with the **Modified Lower Quadrant**system. In this, warners and distant signals (as in MAUQ, see below) are both used. The distant signals have only two aspects, Proceed and Caution. The distant signal is provided at an adequate distance to the rear of the Home signal, and a combination Home and Warner signal is provided 180m from where the block section ends. There is no difference in the placement or nature of the last stop signal. MLQ is found in the Kharagpur-Vishakhapatnam and a few other sections. It was not widely adopted as it is complex in working and provides no advantages over the competing multiple-aspect upper quadrant signalling system (see below) which also came into use and became far more commonly used on all important sections of IR.

Early versions of semaphores used in the lower quadrant system suffered from a potentially dangerous flaw, which is that in case of a mechanical failure, the semaphore arm was likely to drop by gravity into the clear position. This was guarded against in later versions by having the spectacle end of the semaphore be coniderably heavier to provide a counterweight to the arm. Generally speaking, fail-safe operation to ensure the signal shows its most restrictive aspect when the signal wire is broken is ensured by arranging counter-weights or adjusting the balance of weights between the semaphore arm and the spectacle appropriately, in both lower-quadrant and upper-quadrant signalling.

**Upper Quadrant**

Properly, **Multiple Aspect Upper Quadrant**, in this system there are three signal positions. The 12 o'clock position is *clear* or *proceed*, which gives a train permission to go past the signal without stopping. An intermediate position (at 45 degrees to the vertical) is the *attention* or *caution* indication; the meaning depends on the kind of signal. The horizontal position, where the semaphore arm is horizontal, the *on*position, is the most restrictive indication of the signal; it may require the train to stop, or to proceed with caution, etc., depending on the kind of signal.

**More notes**: In all semaphore systems, as the semaphore arm moves from one aspect to another, the end that is close to the signal mast and which has coloured glass disks ('spectacles') fixed to it moves in front of a lamp, changing the colour of the lamp seen at night. Today most of these lamps are electric lamps, but oil lamps were common earlier.

Semaphore signals are set up so that when viewed from the part of the track for which the signal is intended, the semaphore arm extends to the left of the mast on which it mounted. This, in addition to the colours of the semaphore arm (which are different on the front and back), provides a visual cue to distinguish between the signals meant for different directions of the track.

Assemblies of 2 or 3 or more semaphore signals on the same mast structure occur to indicate divergent routes. Usually, one of the signals is placed higher than the others, to indicate the 'main' line; the signals to its left or right are somewhat lower, and apply to signals to branches diverging to the left and right. Signals may be at the same height if the divergent routes are all of the same importance. Such multiple signal assemblies are seen for stop signals (home, starter, etc.) and also for distant signals (pre-warners).

## What are 'single-wire' and 'double-wire' signalling?

'Single-wire' apparatus, as the name implies, utilizes a single wire or cable connecting the signal lever at the cabin or elsewhere where the signal frame is located, to the actual semaphore mechanism on the signal post. Operating the signal lever to take the signal off causes the transmission wire to be pulled, moving the semaphore arm to the required aspect. To reverse this and change the signal aspect to a more restrictive one the signal lever is moved back, and the semaphore arm moves back because of gravity acting on the semaphore mechanism (in some cases there may be appropriate counter-weights for this). In single-wire transmission, a signal can be pulled for up to 900m. A gain stroke wheel may be inserted at the foot of the signal lever to increase the lever stroke, or a so-called 'facile stroke lever' may be provided. In these cases the distance over which the signal can be pulled may be as high as 1080m.

In 'double-wire' transmission, the wire that operates the semaphore loops around a drum or pulley at either end. Therefore, when the signal lever is moved in either direction, it exerts a positive pulling force to move the semaphore arm. Counter-weights are not necessary in this case. Signals can be pulled over a distance of 1600m in this case.

### What are drooping signals?

In single-wire transmission, heat causes the transmission wire to stretch or shrink, and this can result in an incorrect indication of the signal aspect. For instance, the most restrictive aspect may end up being below the horizontal in upper-quadrant signalling on a hot day - this is termed a drooping signal when the angle is more than 5 degrees. Wire adjusters are provided to compensate for temperature variations. The problem is minimized in double-wire transmission as there is positive movement of the wire in each direction and the wire remains in tension at all times.

## Colour-light Signals

### Q. What are the systems of colour-light signalling used by IR?

There are three systems of colour-light signalling in use. (In IR terminology, the term *Multiple-Aspect Colour-Light* signalling includes both 3- and 4-aspect signalling, and 2-aspect signalling is usually treated as a variant of 2-aspect semaphore signalling. Hence the classification below is not the same as IR's.)

- **Two-aspect colour-light signalling** – In this, each signal has two lamps (one above the other). The higher of the two is a green lamp, and the lower one is a red lamp. The green lamp when lit indicates*clear* (the proceed indication), and when the red lamp is lit, the signal is said to be in the on position, displaying its most restrictive indication.
- **Three-aspect colour-light signalling** – In this, each signal has three lamps arranged vertically. The top one is green, the middle one yellow, and the bottom one is red. The red and green lamps indicate indications as in the 2-aspect system, and the yellow lamp shows the *caution* indication.
- **Four-aspect colour-light signalling** – This is also known just as Multiple-aspect colour-light signalling (MACL or MACLS) and adds another yellow lamp to the 3-aspect system. The additional yellow lamp can be placed above the green lamp in a 4-lamp signal. In this case, the lower yellow lamp alone is lit to show the *caution* indication, and both yellow lamps are lit to show the *attention* indication. Alternatively, a different kind of 3-lamp signal may be used (e.g., for distant signals), where the top and bottom lamps are yellow and the middle one is green. Again, both yellow lamps light up to indicate the *attention*indication.

Special signals such as repeaters may have other combinations, e.g., two lamps, green above yellow.

The obvious advantage of colour-light signalling over semaphore signalling is the higher reliability of electrical control over the signals compared to the mechanical means for operating semaphore signals. Colour-light signals do not suffer from distance limitations as semaphore signalling does (exception: powered semaphore signalling), allowing signal controls to be placed conveniently together even if the signals themselves are far away. In addition, the electrical circuitry naturally allows for monitoring, interlocking, and detection of failure conditions, all of which are achievable but far less reliably with mechanical means in semaphore signalling.

## Signal Indications

### Q. What indications do signals show and what do they mean?

The most common indications shown by various signals are the following:

- **Stop** This requires a train to stop dead and not pass the signal except under special instructions or emergency procedures. (Stop signals may be passed after halting and waiting in automatic block territory – usually 1 min. during the day & 2 min. during the night.) This indication is also known as **Danger**.
- **Caution** This allows a train to proceed past the signal with caution (at reduced speed), being prepared to stop at the next signal. It can mean that the next signal is at Danger, or that the track ahead has speed restrictions.
- **Attention** This allows a train to proceed past the signal, being prepared to slow down to an appropriate speed for the next signal. It means that the next signal may be at Caution, or may guard a divergence which requires reduced speed (in which case a stop signal at the divergence will indicate the route for which points are set).
- **Proceed** This allows the train to proceed past the signal without slowing down or stopping.
- **Proceed Slow** This indication, shown only by calling-on signals, allows a train to pass the signal at slow speed after stopping, being prepared to stop short of another train or an obstruction on the same track.
- **Proceed Slow for Shunting** This indication, shown by shunting signals, allows movement past past the signal with caution for the purposes of shunting. This is the most common indication used when a shunt signal is pulled off, and in fact most shunt signals can only show this indication (other than Stop).
- **Proceed for Shunting** This indication, shown by shunting signals, allows movement past past the signal for the purposes of shunting, at speeds higher than allowed with the indication *Proceed slow for shunting*. This indication is not widely used, and appears in 3-aspect position light shunt signals.

# Miscellaneous

## Q. What are running signals and subsidiary signals?

Running signals are the normal signals that control the movement of regular trains. Subsidiary signals are those that control other movements such as shunting, or which provide additional information (repeater signals, points indicators, etc.).

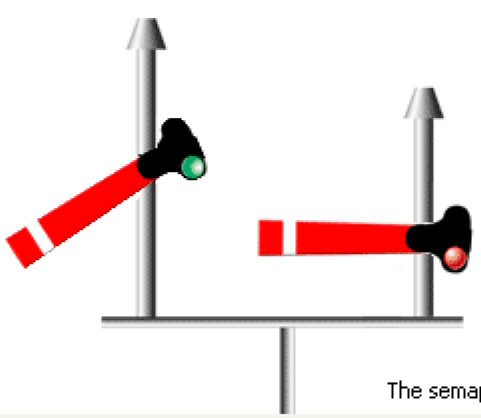
## Q. How do signals refer to specific lines in the case of diverging and converging routes?

Multiple signals may be mounted on a signal assembly (bracket post, signal gantry, etc.) to provide signal indications for diverging routes. The signals from left to right correspond to the diverging routes from left to right. If one of the routes is the main line, the signal for it is usually placed higher than the others (the maximum permissible speed applies for running through on it; speeds must be lowered for the divergences).

For instance, a very common combination is for three stop signals to be mounted together, with the middle one being placed higher and providing the indication for the main route, whereas the signals on the left and right of it provide indications for the branches on either side. If all routes are of equal importance, all signals are at the same height. ('Equal importance' in practice means all the routes allow the maximum permissible speed for the section.)

In rare circumstances, one can find multiple signals placed on the same mast one above the other; in such a case, the convention is that the highest one refers to the leftmost divergence, and successive signals below it refer to successive routes to the right.

The same convention applies for converging routes (top-to-bottom is left-to-right). Although diverging routes can share a single signal (with a route indicator in colour-light signalling), converging routes never share signals; a separate signal is provided for each line.

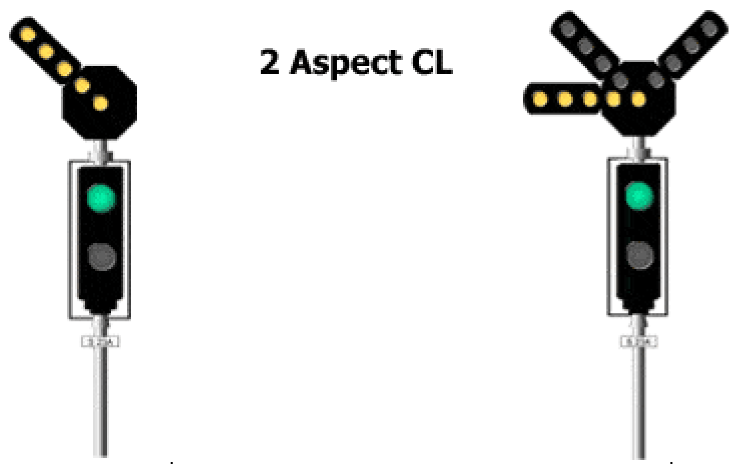


**2LQ , MLQ**

Multiple signals (lower quadrant).
The semaphore on the left is for the main line.

For colour-light signals, a **junction route indicator** or **directional type route indicator** is commonly used to indicate diverging routes. This consists of an additional set of 5 lunar white lamps in a row at an angle, attached to the main signal. The angle of the junction route indicator corresponds in a rough manner to the angle made by the diverging route. When these additional lamps are lit, they indicate that the signal applies to a diverging route. Otherwise, the signal is taken to apply to the main route.

More than one junction route indicator may be attached to a signal, in the case of facing points where more than two routes diverge, although it is rare to see more than 3 or 4 such indicators (6 is the maximum). The junction route indicator corresponds to a 'feather' in UK railway terminology. Junction route indicators are used where the number of diverging routes is smaller and where high visibility is a requirement.




Junction Route Indicator, choosing one among two routes. The indication is for the tracks to the left

Junction Route Indicator, choosing one among four routes. The indication is for the tracks to the left

In some cases, especially for home signals at stations that have many platforms, or at routing signals guarding approach to a lot of diverging routes, a **theatre route indicator** may be provided. This usually indicates the route (or road as it is sometimes termed) with a numeric display. The numerals may be formed using a 7x5 dot-matrix lamp assembly (the **multi-lamp route indicator**, MLRI), or with lamps lit behind stencils indicating route numbers (the **stencil type route indicator**, STRI).

There are also **projector type route indicators** which project the numeral on to an illuminated screen or plate. For all of these, a route indication is always provided, even for the main line, in contrast to the directional route indicators which remain unlit for the main line.

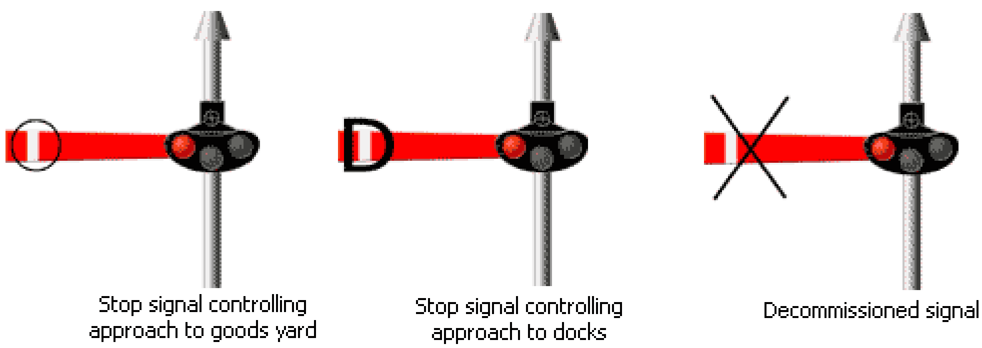
For a signal guarding departure from a station, a theatre route indicator may rarely have 'M' or 'ML' to indicate 'main line', and 'B' or 'BL' to indicate a 'branch line'; similarly 'L' or 'LL' for 'loop line'. The visibility of these is not as good as that of junction route indicators, hence they are used mainly near or within station limits where speeds are not high, but where the number of diverging routes may be large.

Normally, signals for multiple converging routes are placed on separate posts, and in some cases on a bracket post or signal gantry or bridge. In rare cases more than one signal may be placed on the same post, in which case the topmost refers to the leftmost route, and successive signals below it refer to successive routes to the right.

## Q. What do the rings, bars, etc. found on some signals mean?

Stop signals controlling the approach to goods yards or goods-only lines have a black ring fixed to the end of the semaphore arm. No corresponding indication is provided in colour-light territory. Similarly, semaphore signals controlling lines for dock platforms have a black semicircle (in the shape of a 'D') fixed to the end of the semaphore arm. Again, no corresponding indication is provided for a colour-light signal.

Two crossed bars in the form of a large 'X' attached to a signal of any kind (stop signals, shunt signals, etc.) indicate that the signal is not in use. The cross is often white for signals that have not yet been commissioned.




## Q. What does it mean when a colour-light signal does not face along the tracks but points away?

Colour-light signals that are not in use (just set up but not yet commissioned, or in the process of being decommissioned) are often turned to point away from the tracks, so that it is clear to all locomotive drivers that the signal is not in service. Otherwise, it would be treated as an active signal that is malfunctioning (lamps burnt out), which would require trains to follow special procedures for passing malfunctioning signals.

## Q. What is the purpose of the white lamps fitted to the rear of signals?

Signals that face away from the signal cabin are provided with **back lights** to enable the signal operator to see the aspect of the signal. Normally a single white lamp is lit when the signal is *on*, and no lamp is lit otherwise. For stop signals that can show the *Attention* indication, two white lamps are visible in the *on* aspect and no lamps otherwise (distant signals that can show *Attention* have only a single back light).

## Q. Sometimes a signal pole is observed to carry one signal at normal height and another much higher up; what are those? Or, what are Co-acting Signals?

A co-acting signal is a duplicate signal provided on the same mast as a stop signal, which always shows the same indication as that stop signal. The purpose of such a co-acting signal is to allow a continuous unobstructed view of the signal indication from all positions where a driver might need to observe it, in cases where an overbridge or other obstruction might block the view of a signal from some locations if there were only one instance of the signal provided on the mast.

Typically, one of the signals is fixed very high up on a mast and the other one much lower down, so that one or the other is always in view from all positions along the tracks as it is approached. Although theoretically more than two such co-acting signals could be provided on a single pole, this is never seen in practice.

## Q. What does 'ahead' or 'behind', 'advanced' or 'retarded', or 'front' or 'rear' mean when referring to a track or signals?

All orientation terms used when talking about track, points, signals, stations, etc. are given from the point of view of the driver of a train looking in the direction that the train is moving. Thus, a signal may be ahead of him or behind him. A signal or station that he is approaching is referred to as being in front, and one that he has passed is said to be in the rear. An 'advanced' starter signal is one that is further ahead than the starter signal, and so on.

## Q. What is a 'fixed signal'?

A **fixed signal** is any signal that is permanently erected at a location. The term is used to distinguish normal signals and indicators from hand or lamp and flag signals, detonators, flares, bells, and other special-purpose methods of signalling.

## Q. How is failure of signals guarded against?

Signal installations are designed as far as possible for fail-safe operation, which means that any failure should leave the system in a state where dangerous train movements are not allowed. For instance, in case of a failure detected at a panel interlocking installation, all signals controlled by it are designed to revert to On. Similarly, a failure detected in the block control circuit at the Starter signal causes all signals to the rear guarding the approach to the block section switch to On, and notification is sent automatically to the control centre or signal cabin.

The signals themselves have two-filament bulbs, or two-bulb assemblies for each lamp, to provide redundancy in case of a filament burning out. Where incandescent bulbs are used, the filaments are kept warm even when the lamp is off, through the passage of a small current which prevents thermal shocks on switching on the lamp and thereby reduces the chances of failure. The signals are also frequently examined and bulbs replaced in a pre-emptive manner.

There is also a trend towards using LED panels instead of incandescent bulbs for the greater safety they afford (since several LEDs on a panel can fail without compromising the safety of the signal) as well as for the power savings involved. Normally, a current relay also detects the current flowing in the signal lamp in its different states, and this allows detection of a failed lamp. (Even in the days of kerosene lamps for signals, a bimetallic thermal contact strip was used to detect the heat of the lamp and notify the signalman if the lamp was extinguished.)

Back lights for electric signals today (and small slits in the rear of kerosene-lamp signals in days gone by) allow the signalman or stationmaster to see the states of the signals at a station. Where visibility limits the use of back lights, the signal aspect is repeated in the signal cabin or (at small stations) in the station master's office.

In the latest instances of signalling control by means of interlinked stations (e.g., Chennai - Washermanpet), failure-detection circuits are provided for each track circuit and signal circuit with notification to the signal control centres in case of problems.

Signal installations are usually powered by independent power supplies (DC) that are driven by battery installations that are charged from the regional grid (state electricity board's supply). All the failsafe equpment and the signals themselves also have emergency fail-over to backup battery sets that keep the signals and points working in case of power failure. Most stations also have diesel generator sets to continue charging the batteries in case of power failure.

# Signal Aspects and Indications — Principal Running Signals

Contents

General information on signalling systems is found in another section. This section focuses on the main running signals and the aspects they display.

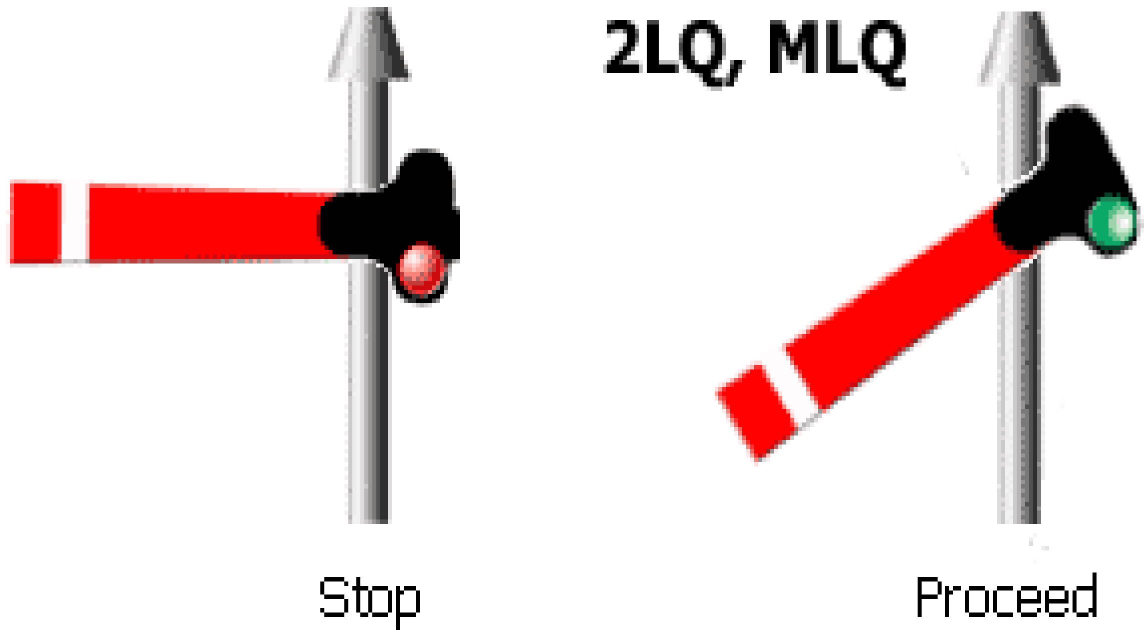
## Stop signals

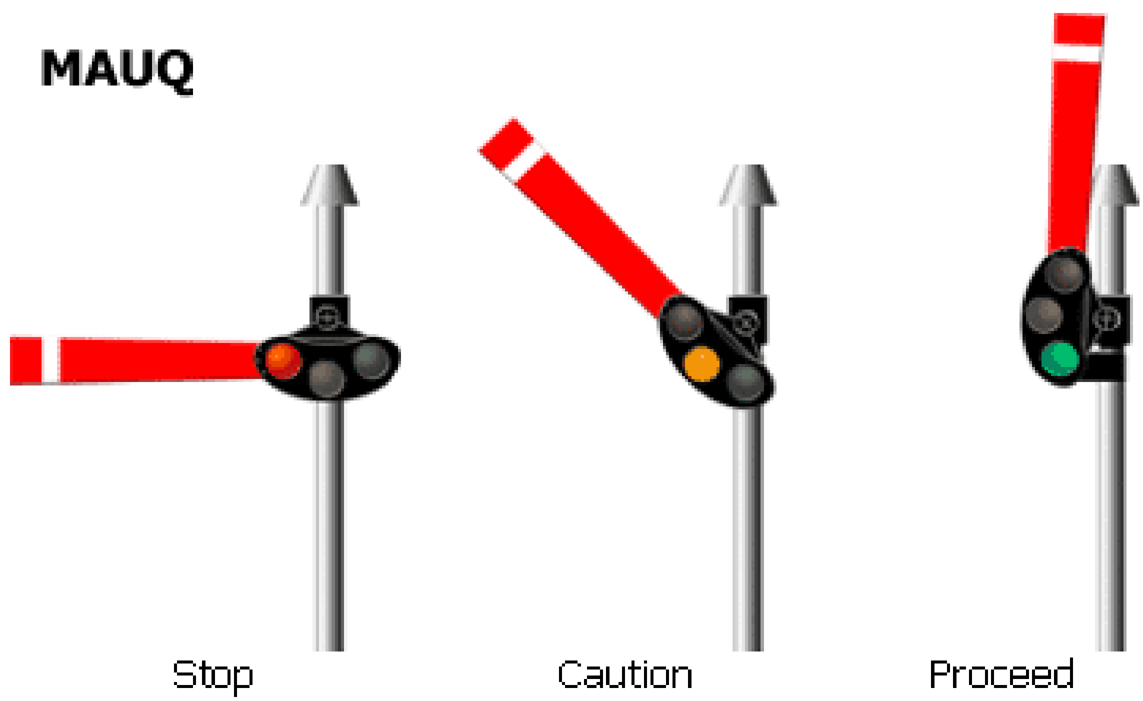
A stop signal governs access to a block section and ordinarily may not be passed when it is at its most restrictive indication (the *on* position, which shows the *stop* or *danger* indication for these signals). That is to say, when on, its interpretation is 'stop dead'.

Under some special circumstances, a stop signal may be passed at slow speed after the train has been brought to a standstill at the rear of the signal. This is commonly allowed in automatic block territory where the driver can proceed after waiting for a minute or two. In most other cases, the driver must obtain permission to proceed over a telephone callbox at the signal, or must have written authorization to ignore or pass the signal.

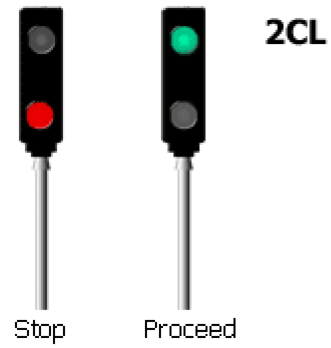
Automatic stop signals and delayed stop signals (see the section on block working) are provided with a circular plate marked 'A' (black on white)

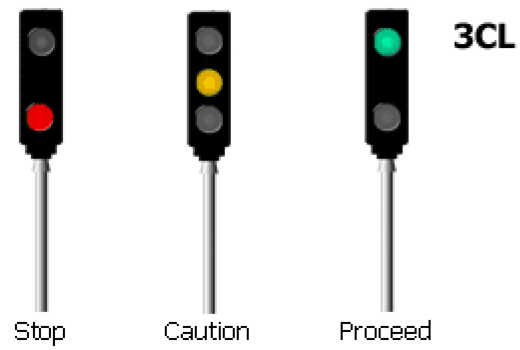
**Semaphore**: The semaphore arm of a stop signal is red in front with a white stripe near the end, and white in the back with a black stripe near the end. The arm is square-ended. Signal aspects are as shown below.

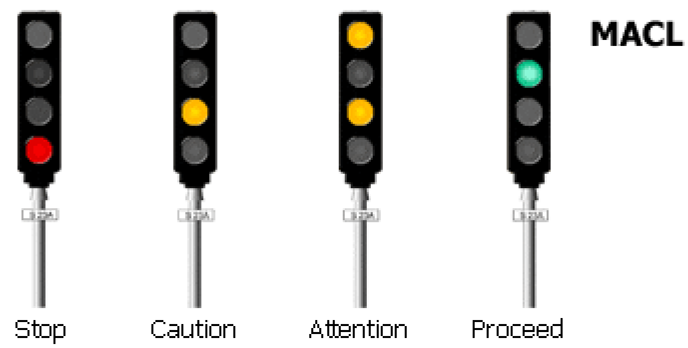



**Colour-light**: The stop signal may have two (green above red), three (green-yellow-red), or four lamps (yellow-green-yellow-red) as described above. Aspects are as shown below.




Stop signal indication summary:

- **2LQ, MLQ, 2CL**: Stop, Proceed
- **MAUQ, 3CL**: Stop, Caution, Proceed
- **MACL**: Stop, Caution, Attention, Proceed

Usually the signals are set up at sufficient distances so that, for instance, a train arriving at a Caution signal at the maximum speed for the section can safely brake to a halt before the next signal which is at Stop. Older locos especially hauling vacuum-braked rakes or long freight rakes should be able to slow down sufficiently when they reach a signal at Attention so as to be able to halt after reaching the next signal at Caution; but the newer locos hauling air-braked rakes can reach a signal at Attention at the maximum speed for the section and proceed through it without slowing down and still brake safely if the next signal is at Caution.

If the distance between the signal at Caution and the signal at danger is less than the safe braking distance, the signal to the rear displaying Attention also serves to alert the driver that the train may have to be slowed to restricted speed when it reaches the next signal.

A signal that is to the rear of a signal protecting a divergence cannot show an indication less restrictive than Caution or Attention when the points are set at the divergence for any line other than the main line. (The divergence should normally also be indicated by the use of a route indicator.) This Caution or Attention indication may be repeated further in the rear if the distance to the divergence is insufficient to permit a train to slow down to the appropriate speed for the divergence. The Caution indication is also used to indicate track sections with speed restrictions. The Attention indication may correspondingly be displayed by the signal to the rear of the signal guarding the approach to a curve or a divergence or section with speed restrictions.

The starter signal (see below) may show Attention or Caution to provide permission for a train to leave a station, instead of the Proceed indication.

Stop signals are of the following types:

**Home**

This is the first stop signal on approach to a station without an outer home signal. It is not optional. The signal guards entry to the station limits ahead from the block section in the rear and appears before all connections to the line (branches, loops, etc.) at the station.

A home signal at Caution indicates that the train may have to stop on the line before leaving the block, or that the train has to slow down to a particular speed in order for the starter signal at the entrance to the next block to shift to Proceed. A home signal is also set at Caution for temporary or permanent speed restrictions within station limits. An optional (electric) numeric display on the post of this signal is usually an indication of the platform to which the train will be routed.

Signal with 'feathers' (route indicators)
(Click for a larger view.)

For stations with multiple lines where a train may be received (i.e., main running line and loop lines), normally home signals are provided either in sets in semaphore signalling (as many as the number of receiving lines), or with route indicators ('feathers') in colour-light signalling, just before the diverging points to the various lines, to indicate for which line the points have been set for the train to be received. In semaphore signalling, the main line home signal is placed above any others; the lower signals refer to lines diverging to the left or right of the main line according to their position with respect to the main signal. Such signal arrangements are also referred to as **bracketed home** signals. Bracketed homes require interlocking between points and signals.

**Outer (Outer Home)**

To increase track utilization, or to provide better control over approach to station limits, additional signals may be provided to the rear of the Home signal. An Outer Home signal (also known simply as an Outer), to the rear of the home signal, is very common. The outer may be at Caution to indicate speed restrictions further ahead, or if the home signal is at Stop.

**Intermediate home**

Intermediate home signals may be provided between the outer and home in some cases to provide finer control over train movements on approach to station limits.

**Intermediate block**

his stop signal is provided on intermediate block sections which are block sections created by subdividing a long block section between stations; there isn't necessarily a separate station or route junction at the point. (If there is a station, it is an intermediate block post or halt station.) An intermediate block signal simply protects the block section ahead of it in a manner similar to a starter signal. A circular marker with 'IB' (black on white) is fixed to the post below the signal. The signal is controlled by the cabin of the station to the rear if the intermediate block post is not manned.

**Routing**

This indicates which of two or more diverging routes have been set, especially in cases where the corresponding Home or Outer or other stop signals before the facing points do not provide such indication.

**Starter**

This governs exit from the most advanced section within station limits, and entrance to the block section ahead. It marks the limit up to which a normal train can stand at a station. (Shunting movements can go beyond the starter when intermediate or advanced starters are provided.) Normally it is the last stop signal on departing from a station unless an advanced starter is present. If an advanced starter is provided, the starter may protect facing points to another running line at the same station. Starter signals are provided at most stations, but there are some without them. If the starter is not provided station working rules prescribe when trains may proceed to the next block section; usually tangible authority to proceed such as a Neale's ball token or paper line clear ticket are needed.

If there are several converging lines exiting a station, each is usually provided with a starter so as to protect each line from fouling the adjacent lines. If a single starter is provided for several converging lines exiting a station (this is rare), it is placed beyond the trailing points of the convergences. In some areas, a starter signal may be set up so that it does not shift to the Proceed indication unless the train slows down to a particular speed (or stops) before reaching it (in such cases the home signal at the entrance to the block is usually at Caution). Shunting cannot take place without special instructions beyond the starter if it is the last stop signal at the station.

Normally the starter signal shows a 'Proceed' indication (green signal) to indicate that a train may leave the station, but in some cases an 'Attention' or 'Caution' indication (double yellow / yellow) may be used to allow the train to leave the station (and make the platform available for another train) but at a reduced speed. On Konkan Railway lines it has been observed [4/01] that the 'Attention' indication (double yellow) is routinely used for the starter signal.

A starter signal may have additional lamps or signs such as 'M', 'B', etc. to indicate which tracks the train will depart on (mainline, branch line, etc.), in the case of diverging lines beyond the starter. Multiple semaphores or colour-light signals may also be used (*bracketed starters*), or route indicators.

**Advanced Starter**

This is an optional signal. It is a stop signal provided ahead of the starter signal, and therefore if present it is the last stop signal on departing station limits. The advanced starter allows shunting operations beyond the starter. Normally shunting may not take place beyond the advanced starter. Otherwise the advanced starter, if present, functions just like the starter signal to control exit from station limits and entrance to the block section ahead. It is placed ahead of all trailing points for converging lines exiting the station, and therefore, there is usually just one advanced starter for all the lines at the station.

**Intermediate starter**

Intermediate starters may be provided between the starter and advanced starter to split up the section into smaller sub-sections and provide finer control over train movements and shunting operations. Intermediate starters are placed to the rear of the fouling points of the points they protect.

**Gate**

A gate stop signal guards interlocked (or sometimes non-interlocked) gates at level crossings. A circular plate marked 'G' (black on yellow) is fixed on the post below the signal. A gate signal may be passed after the train comes to a standstill to the rear of the signal and after waiting for a minute or two. The train may then proceed slowly up to the level crossing, and must then wait for the gateman to direct the train across the level crossing with hand signals.

A gate signal may be placed on the same post as an outer signal, or the two may be combined. If an outer signal is ahead of the gate signal and there is insufficient visibility of the outer signal, the gate signal and the outer signal can be slotted to work together so that the gate signal is never pulled off when the outer is on. In such situations, the distant signal pertaining to the outer home acts as the gate distant.

*Note*: In very rare instances, if the distance between stations is really short, and the station to the rear needs an advanced starter which would appear in about the same place that the outer home for the station ahead, the two may be combined into one stop signal controlled from both stations. Thus the train effectively moves directly from the station limits of one station into the station limits of the next.

*Note:* For class 'C' stations, the Home signal is both the first stop signal and the last stop signal, as starter signals are usually not provided.

## Warner Signals

A warner signal is used only in two-aspect signalling (2LQ, MLQ, 2CL). Its purpose is to warn of an approach to a stop signal further ahead, or to advise a driver of the condition of the block section being entered. As such, it is a permissive signal and may be passed when it is in its most restrictive (on) indication, although when it is on the train must reduce speed.

A warner is always set to the on position for a train which is scheduled to stop ahead at the station. A warner may also be provided in 2-aspect territory on the approach to a gate stop signal. Normally warners are pulled off only when the stop signal they refer to is pulled for the main line (highest permissible speed), and not if a stop signal for a divergence is pulled off. There are some other considerations, see below.

**Combination Warner**

The warner is often paired with a stop signal (for example, an outer-warner combination is very common), in which case the warner's indication is never less restrictive than that of the stop signal, and if the stop signal is*on*, the combination cannot be passed. When the stop signal and the warner are both clear (in the case of outer home signals this is known as 'home double' or 'double home'), the signal may be passed at the maximum speed for that section.

In a combination warner, the stop signal may show Proceed and the warner may be *on*, to indicate that the next stop signal ahead (usually the home signal, in the case of an outer+warner combination) is *on* (at Stop).

In some cases, the warner may not be pulled off (see distance considerations below) at all. Allowed combinations are outer+warner, starter+warner (if no advanced starter), or last stop signal + warner (i.e., advanced starter + warner). The mechanical interconnection between the stop signal and the warner in semaphore signalling, which prevents the warner from being less restrictive than the stop signal is known as*slotting*.

**Lone Warner**

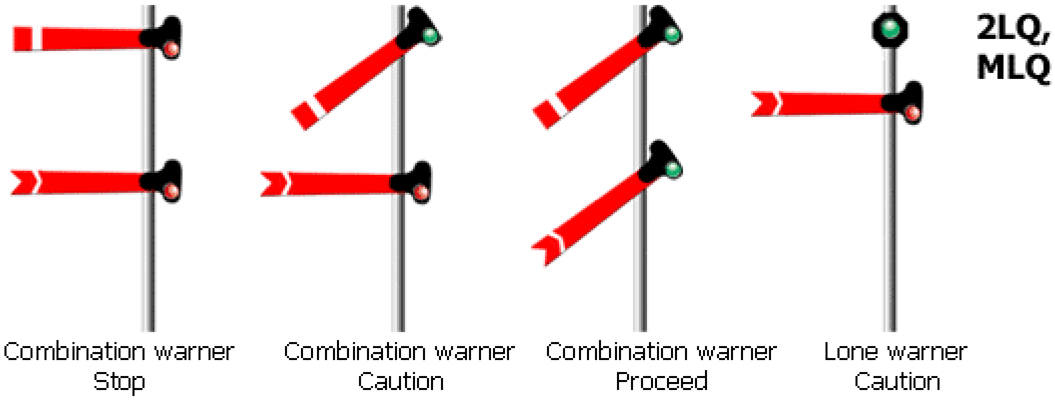
If the warner is by itself, a fixed green lamp is usually placed above it on the same mast (so that technically it is equivalent to a warner below a stop signal which is always clear).

**Unworked warners**

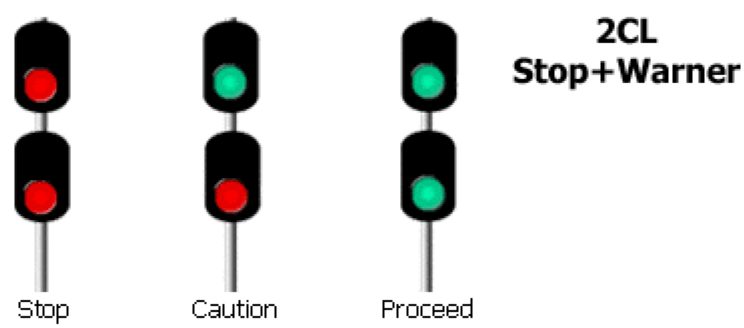
A warner signal may be set up to be permanently in the on position (caution indication). In this case the warner merely advises the driver of a train of the approach to a stop signal ahead or possibly a permanent restriction or problem with the track ahead.

Illustrations covering aspects in both semaphore and color-light systems are shown below.

*Semaphore*: The semaphore arm of a warner signal has a vee-notch at the end; it is red in front with a white stripe (V-shaped) at the end, and white at the back with a black stripe (V-shaped) at the end. Aspects are as shown below.




*Colour-light*: The warner consists of a two-lamp signal (green above red) fixed below the (2-aspect) stop signal on the same post. A warner without a stop signal has a single green lamp (always lit) above it on the same post, and a small circular plate marked 'P' (black on white) below it.




Warner signal indication summary:

- **2LQ, MLQ, 2CL (Lone Warner)**: Caution, Proceed
- **2LQ, MLQ, 2CL (Warner in combination with stop signal)**: Stop, Caution, Proceed
- **MAUQ, 3CL, MACL**: Warners not used.

## Distant Signals

A distant signal (also known as a **pre-warner**) indicates approach to a more restrictive signal further ahead. In IR terminology, the distant is said to 'pre-warn' the driver of the indication of the next signal ahead. Examples: The distant signal shows Caution, and the next stop signal ahead is at Stop. Or, the distant signal shows Attention, and the next stop signal is at Caution.

A distant signal may be at Attention if the following signals guard a divergence and the points there are set for a route other than the main line. A distant signal to the rear of signals at a divergence will be at Proceed if the points are set for the main line at the divergence. In that case, the stop signal for the main line may be at Caution. Of course, both the distant and the next stop signal may be at Proceed.

A distant signal is a permissive signal and may always be passed even in its most restrictive indication. A distant signal is analogous to a distant signal that occurs by itself in UK practice. A distant signal is typically at a distance of 1km or so from the stop signal it protects, but this may vary depending on the particular track requirements.

**Outer and Inner distants**

In some sections two distant signals may be provided to the rear of a stop signal. In that case, the one further to the rear of the stop signal is known as the **outer distant** or the **second distant**, or simply as just the distant signal and the one just before the stop signal is known as the **inner distant** signal. In such a case, the outer distant can only show two indications, *Attention* and *Proceed*, while the inner distant can show *Caution* as well. Two distants are standard on routes with speeds above 100km/h and where goods trains run which require braking distances over 1km.

A distant signal is usually placed far enough (2km or so) to the rear of the stop signal it protects that when it is at Caution a train at the maximum speed for the section can brake safely to a halt before the stop signal. Otherwise, the Caution indication may be replicated further back by using more than one distant until the rearmost distant at Caution is at sufficient distance from the stop signal.

**Gate distant**

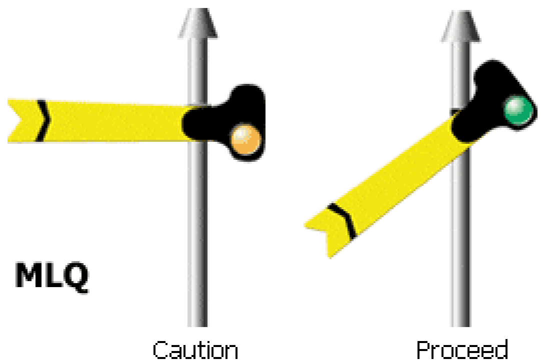
Distant signals may also be provided to the rear of gate signals, in which case they are known as **gate distant**signals and have the 'G' marker just like gate stop signals. However, a distant signal may act as a distant signal for both a normal stop signal as well as a gate signal.

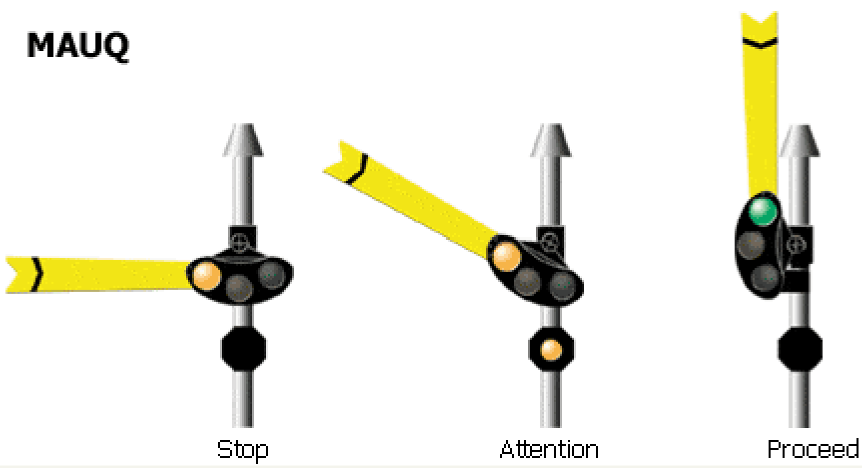
n rare cases distant signals may be mounted on the same mast as the last stop signal of a station or a gate stop signal. In such cases the distant signal operates with the additional restriction that its indication can never be less restrictive than that of the stop signal.

A distant signal showing the Proceed indication (clear) is also known as a 'distant green' from its colour-light indication.

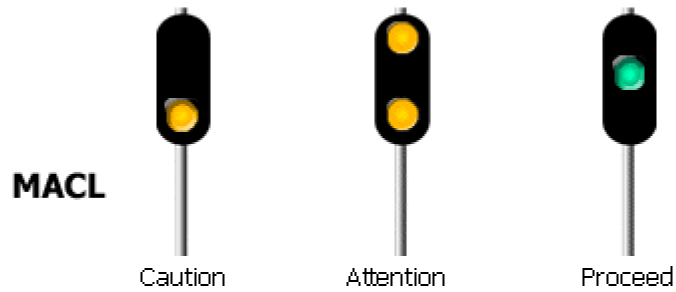
Illustrations covering aspects in both semaphore and color-light systems are shown below.

*Semaphore*: A distant signal has a vee-notch at the end; it is yellow in front with a black stripe (V-shaped) at the end, and white at the back with a black stripe (V-shaped) at the end. At Caution and Attention the semaphore spectacle displays a yellow lamp at night; for the Proceed indication a green lamp is displayed. In upper quadrant territory, an additional yellow light is placed below the signal, on the same post, and is lit when the distant is in the Attention indication, so that at night two yellow lamps are seen.




*Colour-light*: Distant signals have a small circular plate marked 'P' (black on white) mounted on the same post, below the signal (this marker is omitted if the distant signal is mounted on the same post as the last stop signal for a station). The signal itself has 3 lamps, of which the top and bottom are yellow. Aspects: For Caution only the bottom lamp is lit; for Attention both yellow lamps are lit, and for Proceed just the green lamp is lit. The aspects are shown below.




Distant signal indication summary:

- **2LQ, 2CL, 3CL**: Distants not used.
- **MLQ**: Caution, Proceed
- **MAUQ, MACL (sole distant or inner distant)**: Caution, Attention, Proceed
- **MAUQ, MACL (outer distant)**: Attention, Proceed

**Difference between Warner signals and Distant signals**

Although distant signals and warner signals appear to serve similar purposes, there are some important differences between them. Distant signals are generally placed the full braking distance before the first stop signal of a station, whereas a warner can be placed on the stop signal itself (as at a 'B' class station). The distant signal indicates the aspect of the stop signal ahead. With a warner, however, the indication is definite only when it is off ('proceed'); when it is indicating the caution aspect, it could mean that the home signal is at danger, or that the train may be received on a loop line, or that there is a speed restriction ahead, etc. This means that the driver of the train cannot control the speed of the train as carefully as he can with multiple-aspect signals.

# Provision and Placement of Signals

## Distance requirements

**Adequate Distance** is a term that is used in the context of placement of signals. It generally refers to the safe distance to allow in the placement of a signal to allow for errors and overshooting signals or mechanical failures. For some signals, the adequate distance is the **braking distance**, also known as the **warning distance** - the distance a train running at the maximum permissible speed would need to be able to brake to a complete stop. For other signal contexts, the adequate distance is the distance required for the driver to safely brake to the lower speed required ahead.

**Overlap** is a term used for the adequate distance beyond a stop signal, which is required to be clear of obstructions, before a train can be received at that signal when it is at danger.

The provision of overlap reduces the likelihood of collisions if a train overshoots the signal at danger.

**Block overlap** is the overlap associated with a reception stop signal of a station (home or outer), and is the distance to be provided from that signal to the first facing points of the station (for a home signal without an outer signal), or from the outer signal to the shunting limits of the station or to the advanced starter in the opposite direction. It is usually also the distance to be provided between the home signal and the starter signal, regardless of whether an outer signal is present. If an interlocked level-crossing gate is present, then the outer signal is usually placed at least this distance to the rear of the gate; if separate gate signals are provided, they must be at least the block overlap distance from the gate. Block overlap is usually prescribed to be 400m for lower quadrant or 2-aspect colour-light signalling (originally 1/4 mile in British operation), and 180m for MAUQ and MACL signalling. This can in some instances be lower by special permission from the CRS.

Note that in the case of outer and home signals, the distance between them is often higher than the standard block overlap, by 180m - this allows additional shunting activities to happen up to 180m to the rear of the home signal.

**Signal overlap** refers to the overlap to be provided beyond any other stop signal other than the outermost stop signal for the station; the term is especially used for the overlap provided in advance of the starter signal. The signal overlap is normally 180m for lower quadrant or 2-color colour-light signalling, and 120m for MAUQ or MACL signalling. The signal overlap is smaller than the block overlap as it is presumed that a train is generally better under control within the station territory - and there is also a lower likelihood of errors because both signals that the train is moving under (the signal that it just passed that allowed it to proceed, and the signal it is approaching) are controlled by the same authority. (As opposed to the block overlap where the train enters the block section and approaches the outermost stop signal of the station, having received a proceed signal from the previous station.) For the same reason, the requirement that the signal overlap distance be clear of obstructions is relaxed when the train has first come to a dead stop at the signal to the rear.

Thus, the home signal can be taken off only if the signal overlap distance beyond the starter signal is free of obstructions. On a single line, the distance is actually measured from the trailing points, whereas it is measured from the starter signal in the case of double lines. Note that this applies only to trains in motion that are approaching the home signal; for trains at a stand-still at the home signal, the home may be taken off if the line is clear to the starter (double line) or to the trailing points (single line).

**Advanced Starters** are usually placed 180m beyond trailing points.

**Warner Signals** The Warning Distance is the distance required to brake a train to a complete stop and is usually the distance provided between a warner signal and the stop signal ahead that it is associated with; this is important in LQ signalling because the driver has to be prepared to bring the train to a halt after seeing the warner at caution.

If a warner is to the rear of a gate stop signal, it is usually never pulled off unless the first stop signal of the next station is at least 1200m ahead of the gate stop signal, regardless of the indication of the gate stop signal. If a warner is provided in a station whose last stop signal is less than 1200m to the rear of the first stop signal of the next station, the warner is pulled off only when the first stop signal of the next station is pulled off.

**Distant signals** As above for warners, but the distance in question is 1km instead of 1200m.

## Visibility requirements

*Two-aspect signalling*: Outer signals have to be visible for 1200m if train speeds exceed 100km/h; 800m otherwise. If a warner signal is provided to the rear of the outer signal, the visibility can be 400m. Lone warners, home signals, and main starter signals must have a visibility of 400m. All other running signals have to be visible for at least 200m. When this cannot be complied with, repeating signals are provided.

*3- or 4-aspect signalling*: All running signals must be visible for at least 200m. If this is not possible speed restrictions are imposed to the rear of the signal for which visibility is impaired, and repeating signals may also be provided.

## Q. What signals are provided at different kinds of stations?

Generally, fixed signals have to be provided at all block stations (i.e., classes A, B, and C), except those operating trains under the One Train Only system. The minimal signal provisions for block stations with manual absolute block working are described here. Additional signals may be always be provided based on local requirements. Note that the requirements below are for *each* direction of approach to the station.

- **Class 'A'**: In 2-aspect territory, a Warner, a Home, and a Starter signal are provided. In other systems a Distant, a Home, and a Starter are provided. On double-line sections an Advanced Starter is also provided. As the Home signal is the outermost stop signal, the line has to be clear for the appropriate adequate distance (block overlap - 400m for LQ, 180m for MAUQ/MACL/MLQ) beyond the home signal before a train is given permission to approach (i.e., before Line Clear can be granted). The Starter is at an adequate distance beyond the Home. The Warner or Distant follow standard placement guidelines (see below). The Home signal may be bracketed.
  This arrangement is suitable in cases where traffic passes through rapidly, and advance

knowledge of the condition of the block section is required for the driver. With higher running speeds, it is important that the line be clear for a larger distance (including the section of the line within station limits) before Line Clear is given. The first stop signal is necessarily closer to the station (no Outer signal) and this can create constraints - e.g., if there is an approach gradient near the station, making it inconvenient or unsafe for trains to stop at the Home signal. The disadvantage of the arrangement stems principally from the fact that the line within the station between the home and the starter has to be cleared before Line Clear can be given, which limits working flexibility, shunting, and overall traffic flow.

- **Class 'B'**: In 2-aspect territory, an Outer and a Home signal for single-line sections, and an Outer, a Home, and a Starter for double-line sections. Warners are provided if train speeds exceed 50km/h. In other systems, a Distant, a Home, and a Starter signal are provided. The main line Home signal usually has a Warner on the same post in modified lower-quadrant working. A shunting limit board is provided in some cases, or an Advanced Starter instead of it. As the Outer signal is the outermost stop signal, the line has to be clear for an adequate distance beyond it (400m for 2LQ, 180m for MLQ, MACL, MAUQ) for Line Clear to be given. A warner is provided in case the run-through speed for the station is over 50km/h.

  At single line stations, this arrangement does not provide flexibility for shunting compared to an 'A' station, primarily because the shunting activities are still restricted to the portion of the line in advance of the home signal if Line Clear has been given. Therefore, to allow flexibility in shunting activities, the Outer signal is usually placed an additional 180m (beyond the block overlap distance) to the rear of the Home signal, and a Shunting Limit Board appears at the adequate distance in advance of the Outer signal (unless the advanced starter for the other direction appears there, which can be used as the shunting limit marker).

  The arrangement of a 'B' class station allows two trains to be received simultaneously from either direction without block overlap or signal overlap infringement by either. The two trains must be received on the two loop lines. If one train must be received on the main line, then it is accepted directly and the other train is held at the outer signal by keeping it at danger. 'B' stations therefore have higher capacity than 'A' stations, as trains can be on on the main and loop lines simultaneously, while other trains can be waiting at either end on the block sections. 'B' stations are generally used for most single lines, and also for some double lines (except for suburban stations which for the most part use other arrangements with automatic signalling to increase capacity).

  In MLQ signalling, a Distant signal is provided at an adequate distance from the Home signal; the Home is actualy a combination Home and Warner signal or a bracketed home signal with a combination Home and Warner signal for the main line and additional home

signals for the loop line(s). When all signals on the bracketed home are on, then the train must come to a halt and not proceed. For loop reception, the main home signal and warner are both on, and the loop home is taken off; the train is expected to proceed at 15km/h on to the loop and stop on the loop. If the main home signal is taken off while the warner is on (with the loop home being on, obviously), the train is expected to proceed at 15km/h on to the main line and stop there. If both the main home signal and its warner are taken off, the train is to run through on the main line.
Under the MAUQ / MACL systems, trains are received as follows on double lines. For reception on the loop line: Distant at attention, Home at Caution for the loop. For reception on the main line, Distant is taken off, Home is at Caution for the main line. For run-through, the Distant and Home for the main line are both taken off.

- **Class 'C'**: In 2-aspect territory, a Warner and a Home signal are provided. In other systems, a Distant and a Home are provided. The Warner or Distant must be at the braking distance from the Home signal, and should be controlled through block instruments. There is no starter signal, so a train can be received only after the previous train has passed an adequate distance measured from the home signal.
  'C' stations usually exist only on double lines, as they provide no crossing facilities.
- **Class 'D'**: No fixed signals need be provided, and the train is stopped for discharging or picking up passengers under any ad hoc arrangement that is suitable.
- **Unmanned Intermediate Block Posts**: The signals for an unmanned intermediate block post are controlled by the station to its rear. Track circuiting is used to ensure that the last train has passed an adequate distance beyond the Home signal of the unmanned IBP before the next train is received.

In automatic block working, manually operated Home and Starter signals are provided at a block station. Minimally, an automatic stop signal is also provided to the rear of the Home signal. Additional automatic stop signals may be provided between any two block stations.

# Train working systems – I

Contents

- Block system train working

- Non-block train working

# General information on signalling and train working

## Q. What kinds of signalling and train working systems are in use in India?

[4/00] The absolute block system is the most widespread method of train working on IR. The block sections may be handled manually or automatically, or by some combination of those. Some sections still use different forms of physical token systems such as the Neale's Ball Token instruments.

Other than the block system some other special-purpose methods of train working are used in some circumstances. There are many old and new kinds of signalling systems used by IR. Many regions use lower-quadrant or upper-quadrant semaphore signalling (now with electric lamps for night operation, but formerly using oil lamps). Many routes have been fitted with (automatic or manual, 2-, 3- or 4-aspect) colour-light signal systems that are electrically operated.

Apart from these FAQ pages, some extracts of the IR General Rules on train working are also available.

AWS (Automatic Warning System) is an in-cab signal warning system, is used in suburban EMU systems, primarily Mumbai. It was proposed for main lines including New Delhi - Agra, Howrah - Mughalsarai, etc. However, early trials on the Howrah - Mughalsarai stretch did not succeed as the track-side magnets and other equipment were subject to theft and vandalism. A few areas have seen the introduction of forms of centralized traffic control (CTC) in conjunction with automatic colour-light signalling. (CTC was first introduced on the NER's busy MG section between Gorakhpur and Chupra, and later on the Bongaigaon-Changsari section of NFR.) The suburban section of Madras Egmore - Tambaram also has CTC.

Busy urban areas have electronic interconnections among the signal systems of the stations within the areas. Suburban systems generally have colour-light signalling and automatic block systems, sometimes with AWS or some form of automatic train stop systems (ATP, automatic train protection) as well. Automatic train stop systems were tried on some main lines in the 1960's but were given up following excessive vandalism and pilferage of equipment and maintenance problems.

A Train Management System (TMS), from Bombardier, is used on the Mumbai suburban system (Churchgate - Virar) which provides centralized online monitoring of train positions.

The Delhi Metro system uses Continuous ATC (CATC) including ATS and ATP on all its sections. Its metro (underground) section uses a flavour of ATO. Drivers are still on board each train on the underground section, but under normal conditions they don't do much beyond handling the door opening and closing. All normal operations of running the trains -- accelerating them, braking them, etc., are handled by the ATO system, with speeds up to 80km/h. The ATO system was supplied by Alstom (France)..

Around Chennai, several suburban stations have their signals automatically controllable from Basin Bridge using a fault-tolerant system that interconnects the signalling of up to 32 stations using a dual fibre-optic ring. This system also provides for 6 voice channels for communication among these stations. This system was developed indigenously by SR, the Dept. of Electronics, and IIT Madras.

Points and interlockings may be worked mechanically (rod or pipe linkages are common, but earlier, double-wire systems were also used) or electrically (motor driven). Many points exist which have to be manually operated at the location of the points after using a key to unlock the points.

Following British practice, IR's signalling is essentially route signalling where the signals generally indicate which route has been set for a train, letting the driver choose the speed as appropriate for the divergences, curves, etc. (as opposed to speed signalling which is the basic philosophy underlying American practice). Of course no modern system of signalling is purely route-based or speed-based, and there are elements of speed signalling in some of IR's signalling as well.

To give a sense of the variety of systems in use, here is a sample [6/99]:

- Mumbai CSTM - Badlapur : Automatic Multiple Aspect Colour Light Signals
- Badlapur - Pune - Daund : Manually controlled Multiple Aspect Colour Light Signals
- Daund - Manmad : Lower Quadrant Semaphore signals
- Daund - Solapur: Some stretches of Multiple Aspect Colour Light Signals and some sections of Tokenless Upper quadrant semaphore
- Pune - Miraj - Kolhapur : Neale's ball token instrument
- Batala - Qadian, Garhi Harsuru - Farukhnagar : One Train Only system
- Tilwara - Tilwara Mela : Train Staff and Ticket system

## Q. What is 'isolation'?

Isolation refers to methods of protecting one line from the adjacent lines, e.g., in the case of loop lines that branch out from the main line at a station. A train or any rolling stock that is stopped on one of the lines while another train is moving through on the adjacent line should be prevented from moving and running over the points to the main line or fouling the adjacent line. There are several methods adopted to ensure isolation. Haye's Derails (which guide the flanges of wheels over and across to the outer side of the rails to derail a moving vehicle), Scotch Blocks (which prevent points from being set for vehicles on the loop line to be sent to the main line), and similar devices are sometimes used (more so in the past - these are less common now). More commonly now, derailing switches (points that deliberately take the moving vehicle off the line and derail them) or points that lead to sand humps or sidings are used. Derailing switches or points to sand humps, sidings, etc., can also be interlocked (see below) so that they are automatically set to isolate the line when signals are taken off for the adjacent line. In addition, sometimes these switches have sensors so that unintended movement over them automatically bring signals on all adjacent lines back to danger.

## Q. What's the 'clearing point' or 'fouling point' or 'fouling mark'? What is 'overlap'?

The **clearing point** is the point ahead of a stop signal up to which the track must be kept clear of obstructions in order for a train to be accepted from the rear of the signal. In most cases this is with reference to home or outer home signals guarding entrance to station limits from a block section. The distance from the stop signal to the clearing point is the **overlap** (also **overrun**, or **clearing distance**).

The overlap is usually about 400m or so with lower-quadrant or 2-aspect signalling, and 180m with modified lower-quadrant, upper-quadrant, or MACL signalling where warners or distants protect the approach to the stop signal. No trains may be parked to the rear of the clearing point on the track protected by the stop signal. This provides a margin of safety in case a train overshoots a stop signal which is on, because of brake failure, driver inattention, etc.

The **fouling point** or **fouling mark** is a point to the rear of a converging junction, such that a train must be to the rear of that point in order to ensure that any train moving on the other converging line can proceed without being obstructed.

Stop signals guarding convergences are usually placed some distance to the rear of the fouling point for the junction; this distance is also known as the **overlap**, and again, provides a margin of safety against trains overshooting the stop signal. A similar safety distance is maintained ahead of the last stop signal of a station, before pulling off signals for a departing train; this is usually 120m or so.

Fouling points are usually marked by a stone or cement slab with 'FP' written on it by the side of the tracks.

The fouling point may also be marked for a siding to indicate that a rake must be stopped beyond it in order to avoid obstructing other trains passing by on the through tracks or on to other sidings. A number on it indicates the number of standard coaches or wagons that may be safely stabled on that siding.

## Q. What are the last-vehicle indications that IR uses?

The last vehicle of a train is supposed to carry a red lamp at the rear. Earlier, the requirement was for merely an oil lamp, which was often missing or very feeble. In recent years provision of an electric lamp has become more common (it is mandated in the rules).

Last vehicle indications are of different types. A large 'X' is often seen painted on the rear of the coach that is the last one. A set of concentric circles may also be seen, although this seems to be going out of use now. EMU/DMU rakes have a smaller painted 'X' (red on white) at the rear, or sometimes a series of diagonal strokes painted on. (These painted symbols are all in addition to the lamp mentioned above.) In addition, a small board with 'LV' (black on yellow) is often attached to the rear of the vehicle (it stands for Last Vehicle).

If a train passes by a station or signal cabin without the appropriate last vehicle indication (or without confirmation of the number of coaches or wagons as mentioned above), it is assumed that the train has parted and suitable emergency procedures are brought into play.

There are some cases where a Last Vehicle indication is not required -- for instance, when the number of coaches or wagons in a train can be passed on to each block section after verification from the previous block section at the time the Line Clear indication is obtained (and with exchange of private numbers). The information is also provided to the section controllers. In some cases when working entirely within one block section, an 'LV' sign is not needed, if the number of coaches or wagons is communicated telephonically to the next station.

## Q. What's 'interlocking'?

In order to ensure that the signalling system never provides unsafe (conflicting) signals and the points are not set for more than one train that might end up proceeding on to the same section of track and hence suffering a collision, various schemes have been developed to coordinate the settings of the points and the signals within the region controlled by a signalbox or signal cabin.

**Mechanically operated interlocking**

The most prevalent systems today [2003] are still mechanical interlocking schemes that coordinate the positions of the levers controlling the points with the signals governing that section of track and connected branches, loops, or sidings.

For instance, in one common scheme, a key that allows setting the points for a route has to be obtained from the block instrument, and as long as the key is removed the instrument cannot be set to provide Line Clear for a conflicting route. The wires that operate signals, and the rods that control points, are all interconnected in the lever frames at the signal cabins so that they are literally 'interlocked' -- the position of one lever or key physically obstructs the movements of other levers and keys which control points or signals that can be set in conflicting ways.

**Manually operated interlocking**

This is a form of mechanical interlocking as well, but relies on the signalman to move about from one set of points and signals to another carrying with him the keys used to operate them. At small stations and on less busy branch lines various forms of manually operated mechanical interlocking are still [11/03] widespread. At points controlling catch sidings in hilly areas, often the interlocking is manual where the driver has to use a key provided by the stationmaster or signalman of the last station before the siding -- the key is inserted into the interlock box which notifies the signal cabin and the points are then set for the main line and the signal is pulled off, giving the train authority to proceed. (This system is common in many hilly areas, although busier lines with catch sidings are being provided with automatically operating delayed signals where the points are controlled by a timer and are set to the main line only after the train has halted for the prescribed period of time.)

Even as of the late 1980s one had only to go a few kilometers outside any big city along a railway line to spot tiny signal cabins or block huts along quiet lines where all the action was done by the signalman unlocking and locking points and pulling off signals after talking on the magneto-telephone to his counterpart at the next signal ahead.

Key interlocking instruments
(Click for a larger view.)

**Hepper's Key Transmitter** Instruments and similar key dispensing instruments were in wide use for operating points manually. Depending on the state of the block instrument and the interlocking set up for the local layout of lines, these instruments would dispense a key only when the appropriate combination of signals had been set; the key would then be used to unlock points to divert a train on to a loop, for instance -- and while the points were so set, that key would not be released and the signals could not be changed. Hepper's Key Transmittters and other key interlocking systems (Annett's Key, etc.) allowed for operating interlocked ground frames and points outside the range of direct mechanically connected operation.

A common system in use was **Sequential Key Interlocking**, which saved on the installation of point rodding and instead relied on the signalman walking over with a key to lock or unlock points. As an example, consider a station with a main line and a loop line. To receive a train on the main line, a key is inserted into the signal frame in the cabin or platform, which allows the Outer and Home signals of the station to be pulled off.

In order to receive a train on the loop line instead, the key is used as before to pull off the Outer signal, but the Home is kept at danger. Instead, when the train has stopped at the Home signal the key is removed and taken to the facing points for the loop. The same key unlocks the points so they can be set for the loop; it also releases another key which has to be taken back and inserted in the signal frame at the platform to pull off the Home signal to let the train advance on to the loop.

The mechanism was such that only one of these two keys could be released at once; the second key did not allow the operation of the Outer signal, and it had to be taken back to the facing points of the loop in order to release the first key.

**Electrically operated interlocking**

In the more advanced electrical or electronic interlocking schemes, the points and signals are worked from one integrated mechanism in a signal cabin which features a display of the entire track layout with indications of sections that are occupied, free, set for reception or dispatch, etc. The interlocking is accomplished not by mechanical devices but by electrical circuitry -- relays and switches in older electrical or electropneumatic systems, and computerized circuits in the newer electronic systems.

**Panel Interlocking** (PI) is the system used in most medium-sized stations on IR. In this, the points and signals are worked by individual switches that control them. **Route Relay Interlocking** (RRI) is the system used in large and busy stations that have to handle high volumes of train movements. In this, an entire route through the station can be selected and all the associated points and signals along the route can be set at once by a switch for receiving, holding, blocking, or dispatching trains.

As an example, Old Delhi station has an RRI system from Siemens which allows selection from among 1122 possible routes. CR has a large RRI system at Kurla which controls signals from Ghatkopar to Sion on the Main Line, at Lokmanya Tilak Terminus, and from Chembur to GTB Nagar on the Harbour Line. The first route-relay interlocking system was set up on WR at Churchgate station control tower in the 1950s (equipment from Siemens?).

Currently [10/04], the numbers of stations with some form of electronic interlocking systems are: 18 on CR, 195 on ER, 263 on NR, 22 on NER, 43 on NFR, 55 on SR, 101 on SCR, 132 on SER, 44 on WR, 130 on ECR, 99 on ECoR, 154 on NCR, 13 on NWR, 71 on SECR, 34 on SWR, and 76 on WCR.

Regardless of whether the mechanisms are controlled manually or by electronic circuits, and whether they are operated mechanically or electrically, all interlocking schemes usually enforce several or all of the following rules:

- No signal can be pulled off unless corresponding points are set correctly.
- Facing points are locked to the corresponding route when a signal is pulled off.
- Signals for conflicting movements cannot be pulled off simultaneously.
- Points for conflicting routes cannot be set simultaneously.
- Trailing points are locked to the rear when a signal is pulled off.
- Distants, warners, repeaters, etc. cannot be pulled off unless the corresponding stop signals are pulled off.
- Gate stop signals cannot be pulled off unless level-crossing gates are blocked to road traffic.

The description of the possible routes that can be set, and the corresponding dispositions of points and signals are found in the **locking table** and **selection table** for a station. The locking table lists the signals and points controlled; the levers at signal boxes (or control panels at control centres) which operate various signals and points; which signals and points are locked (and in what position) when other signals are pulled off or points set; which track circuits are clear or occupied; etc.

The selection table lists the allowed non-conflicting routes that can be set. The terms *route selection*, *route locking*, *route holding*, and *route release* are used to describe the various steps in the process of picking a route for a train.

In various semi-automated systems of interlocking the electrical or electromechanical mechanisms or the electronic circuitry takes over a large part of the bookkeeping details that determine the sequences in which signals must be pulled off or points set to assign a route to a train. In the more primitive mechanical interlocking systems, such a sequence has to be manually followed; for this purpose the locking and selection tables are used by the signalman, along with *lever leads* which indicate for each signal lever which other levers must be set or cleared.

RRI and PI equipment is from Siemens and some British manufacturers. In recent years interlocking accomplished by modern integrated electronic circuitry instead of electromechanical relay systtems has come into use (**Solid State Interlocking** ('SSI'). [1/01] SSI is in place at 14 stations in India. SSI equipment is manufactured by RDSO. 210 stations have RRI installations, and 1970 have Panel Interlocking. *[Update (3/2003)]* 247 stations now have RRI installations and the number of stations with Panel Interlocking has risen to 2,426.

## Q. What are the different levels or standards of interlocking that IR specifies for stations?

There are three levels of interlocking used by IR.

A **Standard I** interlocked station has mechanical interlocking. It also usually has just one running line and a loop line (and perhaps a couple of sidings). These are usually branch line stations. The points are worked by point levers situated near the points, and the signals are worked from interlocking frames in the signal cabin. Key locking (see above) is used, but the mechanism is such that a key obtained from the points mechanism after setting the points for one route must be used on the signal post locking mechanism to pull off the corresponding signal(s) and also to operate the block instrument, thus interlocking the signals and points. All signals must be operated from the same interlocked frame on the platform, under the station master's control. Through running speed for trains is restricted to 50km/h. (? Some sources say 45km/h.) An Outer signal must be provided, as must a bracketed Home signal to give drivers indication of whether the train is being received on the main line or a loop line so they can regulate its speed appropriately. Starter signals are optional. The main line does not have to be completely isolated from the adjacent loop lines.

A **Standard II** interlocked station may be mechanically or electrically interlocked (usually the latter). These are usually non-trunk main line stations. The main running line at such a station can be completely isolated from the loops and shunting sidings on both sides. In mechanical interlocking, plunger locks or other similar mechanisms must be used to keep the points locked in position when set for a route. Plunger locks may be operated from the cabin, or line-side. In electrically interlocked systems, setting the points activates electrical circuitry that enables or disables the appropriate signal levers and block instruments. A Warner or Distant signal must be provided, along with an Outer and a bracketed Home. Starters are optional, although if there is no starter the Warner must be locked with the block instrument. The signals may be operated from the platform under the station master's control or from a cabin. Through running speed for trains is restricted to 75km/h.

Standard I and II stations sometimes do not have starter signals, only home signals for receiving trains; in such a case trains are dispatched using flag or lamp signals from the station. Standard I and II stations usually have only one signal cabin.

A **Standard III** interlocked station has points and signals that are either interconnected mechanically within the same mechanism, or electrically as with route-relay and panel interlocking. These are usually stations on trunk routes. Usually two signal cabins whose signal and points controls are interconnected are provided. These stations usually have the full complement of signals including warners or distants, outer and bracketed home signals, and also starter signals, for receiving and dispatching trains. (Advanced starters are still optional.) All points must be operated centrally, or in coordination between the two (or more) interconnected cabins. Through running speed for such stations is limited only by the speed limit for the section. The loop lines at such stations have to be completely isolated from the main running line by means such as sand humps, over-run lines, trap points, or derailing switches, etc. In some cases, especially with signals and points too far from the station building for direct mechanical operation, the operation of remote points and signals is dependent on keys provided by the Station Master; without the key the point or signal lever cannot be operated. Interlocking is ensured by having the key dispensed from a key instrument that is connected to the block instrument under the Station Master's control. Common key dispensing mechanisms were the Hepper's Key Instrument, the Electric Slide instrument, and the Interlocked Key Box. In other cases, the block instruments may be located in the cabins, but the signals controlled directly by the Station Master.

**Standard III.I** (or **III/I**) is another designation found for some stations, which indicates that the station is rated as for Standard III, but the loop lines are not physically isolated on one side of the station. Similarly, a**Standard II.I** (or **II/I**) station is rated as in Standard II, but has loop lines or sidings that are not completely isolated on one side of the station.

**Block Working classification of stations** Stations are also classified as 'Class A', 'Class B', etc. See theclassification of stations based on block working methods for more information on this.

## Q. How are non-interlocked (NI) stations operated?

**Non-interlocked** stations are what their name implies: there is no interlocking of any kind. The points have to be set appropriately and locked manually before pulling off a signal. The station master is personally responsible for ensuring that this is done and is supposed to have the keys to unlock the points with him or under his control. Trains are restricted to 15km/h over station limits. Non-interlocked stations are found only on sections with very light traffic. The most basic version of non-interlocked stations have truly no arrangement for controlling the points in relation to the signals and rely entirely on the signalman or station master. Sometimes some simple mechanisms are used that provide some minimal safeguards without providing true interlocking.

**Padlocked points** are common at non-interlocked stations. Here, facing points are equipped with a clamp or through bolt that has a padlock that can be used to lock the points in position. To operate the points, the station master has to hand over the key for the padlock (unless the station is small enough that the station master can walk over and operate the points himself). The key is usually handed over with a badge or token indicating the route to be set, to minimize any misunderstanding in the verbal instructions. Obviously, the procedure takes time and depends on a human element for safety. The locking arrangement on the points is essential; it is not enough to just lock the lever that operates the points.

**Key Locking**: In this system, each set of points has a pair of keys. When the route is set one way, one of the keys is freed and the other must remain inserted at the points; when the points are set for the other route, the first key must be inserted and the other key is freed. The station master keeps the free keys in a glass-fronted box so that he can tell at a glance which routes have been set. Although this system ensures that routes are set and locked for a particular line, it does not ensure that the points have been set properly, and there is no interlocking between the signals and the points. Points may be damaged (e.g., by being trailed through) and the station master has no indication of this if he just relies on the keys in his possession. Badges or tokens are handed out as in the case with padlocked points. Key locking used with facing points (but without any real interlocking or the provision of bracketed home signals) is occasionally termed **Rudimentary Interlocking** in IR's materials.

## Q. What are modified non-interlocked (MNI) stations?

Modified non-interlocked stations are those where setting and locking the points releases a key which has to be used to pull off a signal; however, the block instruments are operated independently. So there is some minimal amount of a safety lock between the points and the signals, but it does not qualify as full-fledged interlocking.

## Q. How are points operated?

When signals are operated by single-wire transmission, points are always operated by rodding. Rodding refers to the long rods or tubes that one can see running parallel to the rails from cabins which have point levers, or from line-side point levers, and connecting with the tongue rails so that the action of the point lever moves the tongue rails to one or another position. When signals are operated by double-wire transmission, points can be operated by rodding or by wire. The principle is the same - the wire can be pulled in either direction and acts to move the tongue rails into one or another position to set the points. Rodding or wire can normally be used to operate points up to 750m, although where signalling uses single-wire transmission the operation of points by rodding is usually restricted to about 320m.

Electrical operation (motor-control) of points is also possible, and widely used at larger stations. The distance requirements above do not apply in this case. Although there is no direct connection, often electrical point operation is provided where colour-light signalling is also in use, mainly because of shared investment in setting up the control wiring, etc. However, there were many examples of stations with electrical point operation but with signalling using semaphores.

## Mechanical Interlocking

**Detector**

A **Detector** is a very basic mechanical interlocking device that ensures that a signal can be pulled off for a route only after the points have been set correctly for it. It also ensures that the tongue rails for the points are positioned correctly (i.e., not warped to one side or another, for instance because of being damanged in trail-throughs). The detector consists of a a set of signal slides that operate perpendicular to the a blade connected to the points which determine the route. The blade connected to the points has a number of notches, matching the number of signals. Each signal slide has just one notch. The notch on the signal slide fits into the notch of the point blade only when the points are correctly set for the route of the corresponding signal. When the signal slide is positioned in this way, it frees the signal to be pulled off. Then when the signal is pulled off, it moves the signal slide such that the points cannot be changed because the notch of the point blade fouls the signal slide.

**Stretchers and Lock Stretcher Bars**

A pair of tongue rails for a switch is often provided with two **stretchers**, which connect the two tongue rails together (perpendicular to the rails). A widely-used kind on IR are known as the **Williams Patent Stretchers**. The front stretcher extends under the stock rail to prevent the phenomenon of 'jumping' or 'dancing' switches. If one or the other tongue rail gets bent out of shape (e.g., by a train trailing through), one or both stretchers will break. A **Lock Stretcher Bar** consists of an additional stretcher connected separately to the tongue rails such that if either the tongue rails bend or the front or rear stretchers break, the notches on the front or rear stretchers will foul the the blade for the detector mechanism and prevent the signal from being taken off for the route.

**Plunger Lock**

Additionally, the lock stretcher has two notches, and a **Plunger Lock**, which is a bar perpendicular to the lock stretcher (and therefore parallel to the rails) fits in one or another of them, when the points are set for the corresponding route. When the lock plunger is set in one or the other notch, it prevents the points from moving. This is an additional locking mechanism beyond that provided by the detector (see above).

Often the locking is accomplished by a separate locking lever after the main lever to set the points is operated. Sometimes the locking is done in the same action as setting the points, but this is less reliable and harder to work.

**Lock Bar**

A **Lock Bar** is a long bar, corresponding to the longest wheel base of vehicles operating on the line (14m - 42' as a minimum for BG, or 13m - 40' for MG), provided parallel to and close by the inside of one of the stock rails, and connected to the mechanism locking the points. It is set up in such a way that when the points are set and locked, the lock bar moves vertically up until it reaches the level of the wheels riding on the rails. As long as the train is moving over the points, one or another wheel presses down on the lock bar, forcing it to be locked in position so that the points cannot be changed.

**Slotting**

**Slotting** is an arrangement for coordinating signals between two different locations (e.g., two cabins for a station), or different signals from the same location. For instance, a signal may be set up so that taking it off from one cabin requires the other cabin to release control; either cabin is able to unilaterally bring the signal back to danger. If there are two non-block cabins at either end of a station, before either one can pull the Home signal off to receive a train, the other cabin has to provide assurance that the line is clear for the adequate distance beyond the starter or trailing points in the area controlled by the cabin, as well as to ensure that points are set correctly. In that case, operating the home signal from the first cabin requires the second cabin to release the signal lever (using a **slot lever** in its frame) after verifying the line is free of obstructions and setting the points correctly. Another example is of a pair of signals that are operated from the same place but which need to be sequenced correctly for taking off. When the slot lever is operated so that the signal lever that it controls can actually control its signal, the term used is 'obtaining the slot'.

A typical method of achieving slotting is to use a **disengager**, which can connect or disconnect the signal lever from the connecting gear mechanism of the signal wire transmission; the slot lever controls whether the disengager allows the first signal lever to engage with the connecting gear and act on the signal semaphore arm or not. **Electrical slotting** uses electrically activated means to achieve the same effect. E.g., in **Cabin Reversers**, the connection between the signal lever and the connecting gear is made through the use of a wedge that is moved electrically to notch with and connect the two, when the slot lever is operated. In **Post Reversers** a similar mechanism is used, except that it is the connection between the semaphore arm and its weight that is engaged by an electrically operated block controlled by the slot lever.

The term 'slotting' is used for electrical interlocking between signals as well.

### Tappet Locking

**Tappet Locking** is a system used to prevent signals being pulled off for conflicting routes. Each signal lever (or point lever, slot lever, etc, in the frame) moves a plunger (also known as driving iron) either directly attached to it or through a connecting mechanism. The plungers move lengthwise. Attached perpendicularly to them are tappet bridles (also known as locking bars). Tappets are small flat bars or wedges that are attached to the bridles with cams, so that they can move slightly sideways (along the bridle). A tappet on the locking bar of one plunger presses against a different plunger. Each plunger has notches that correspond to the wedge shape of the tappets. The notches are placed in such a way that at specified configurations of the signal levers, tappets can fit into the notches. When a signal lever is moved, tappets attached to it can slide in or out of notches on other signal levers' plungers because of their cams. However, a plunger that has a tappet from another signal lever wedged in its notch cannot move - or vice versa. Different arrangements allow for different ways to lock signal levers in pairs or groups. **Normal locking** or **Sympathetic locking** is the case where one lever, when pulled off, locks another lever and keeps it from being pulled off. This is the case, e.g., when pulling off a home signal for the main line must lock the loop homes from being pulled off. If all the participating signals in the group are such that all of them can be at danger simultaneously, and any one may be pulled off while locking the others, it is also known as **Mutual locking**. **Reverse locking** or **Release locking**is when one lever releases another when pulled. This is the case of a home signal that releases a distant signal to be cleared when it is pulled off. **Two-way locking** or **Reciprocal locking** or **Back-locking** is when one lever locks another in either position - considering a home and distant pair, it may be desirable to release the distant only when the home is pulled off, but then also not allow the home to be brought back to danger while the distant for it is pulled off. Finally, **Conditional locking** or **Special locking** is possible, where one lever may lock or release another lever when a third lever is either normal or reversed. More complex 'mechanical computations' are possible but rare. A subtlety in the design of tappet locking signal frames, which has its parallels in locking schemes used in computer systems, has to do with the sequence in which locking and unlocking occurs. If a signal lever is moved partially, the mechanism should ensure that any locking it engages in is activated as soon as possible during the early part of the lever movement (the so-called 'first motion') so that another conflicting signal lever cannot be moved at the same time because the first lever has not engaged its locking tappets yet. Similarly, unlocking should happen as late as possible in the movement of the lever (the so-called 'last motion').

Other forms of mechanical signal interlocking have been used (e.g., tumbler locking) but tappet locking was the most common in India. Some of the concepts above apply even when the actual mechanism of achieving the interlocking is different.

Historical note: Although many manufacturers supplied signal frames to railways in India, the most common frames in British India - lasting long after other manufacturers ceased manufacturing signal frames, were those made by Westinghouse Brake and Signal Co., Ltd., referred to as 'Westinghouse Frames'.

## What are Locking Tables and Pull Sheets?

A **Locking Table** is a table that gives the complete set of interlocking relationships among signal and point levers in a cabin. A **Pull Sheeet** is similar, in that it conveys the same information, but is geared towards the lever operator's convenience in showing which other levers need to be pulled for any lever. A sample locking table is shown below.

| Lever No. | Releases | Requires | Locks normal | Locks both wa |
|---|---|---|---|---|
| 1 | | 2, 3 | | |
| 2 | 1 | 3 or 4 | | |
| 3 | 1,2 | 5,8 | 7,6 | |
| 4 | 2 | 6,5,8 | 7 | |
| 5 | 3,4 | | | 6 |
| 6 | 4 | | 3 | |
| 7 | | 8 | 3,4,13,18,19 | |
| 8 | 3,4,15,18,19<br>16 with 13 reverse | | | |
| 9-12 | Spare | | | |

| | | | | |
|---|---|---|---|---|
| 13 | 15 | | 7,18,19 | |
| 14 | 15 | | | 13 |
| 15 | | 8,13,14 | | |
| 16 | | 14,<br>8 with 13 reverse | 19 | |
| 17 | 20 | | | 7,13 |
| 18 | 20 | 8 | 7,13 | |
| 19 | 20 | 8 | 7,13,16 | |
| 20 | | 17,18,19 | | |

This example (from *Introduction to Railway Operation*, by Francis Da Costa) shows the locking table for a signal frame (in cabin 'A' at a station with two cabins, 'A' and 'B') which has 20 levers: 7 signal levers, 3 slot levers, 3 point levers, 2 point locks, and one 1 gate lock, along with 4 spare levers. The column marked 'Requires' shows which levers have to be pulled first before pulling any given lever. (This column by itself forms the Pull Sheet.) The 'Releases' column indicates which levers are released by pulling a given lever.

Lever 1 operates the Warner - before this is taken off, the main Home and Outer have to be taken off. Hence 1 requires 2 and 3.

Lever 4 is for the Loop Home. To take it off, the route has to be set and locked for the loop (6 and 5) and the gate must be closed (8). Pulling 4 in turn releases lever 2 for the Outer signal. The cross-over lever 7 is locked in normal position to avoid conflicting movements.

Lever 19 is the slot lever for the 'B' cabin main home signal. PUlling it releases the slot (20) for 'B' cabin's warner. Lever 8 for the gate is required because the level crossing must be closed before pulling 19. To avoid conflicting movements, lever 13 for the facing points, and lever 7 for the cross-over points are locked in normal position.

## Cabin Arrangements

There are a few different ways that cabins can be set up for a station. Normally for a Standard III station, there are two cabins, one at either side of the station. Each cabin controls the points and signals on its side. In one common arrangement (more common in the past when relatively less experienced staff - cabinmen or levermen - were posted to the cabins), the block instruments are kept at the Station Master's office, and the Station Master has control over the reception and departure signals (Home and Advanced Starter). The signal levers for taking these signals off and for setting the points appropriately operate only when the Station Master permits, either by direct electrical interlocking from the block instrument to the signal frames, or by keys dispensed by the Station Master. Keys may be dispensed by instruments such as the Hepper's Key Instrument, electric Slide Instrument, or Interlocked Key Box, which are electrically interlocked with the block instruments. A later practice - still commonly seen - was to locate the block instruments in each cabin, while the signals can be controlled from the Station Master's office. However, in cases where double-wire transmission is provided, the tendency is to keep the block instruments at the stations and not at the cabins and have more control over the signals and points from there.

**Inter-cabin control**: Signals and points are slotted as explained above between the cabins to coordinate their operation. For instance, for one cabin to take off the Home signal, the line has to be clear for an adequate distance beyond the Starter or trailing points, which can only be verified by the other cabin. In other cases, setting a route for the main line or loop line by one cabin is not possible without the other cabin verifying that the line is free of obstructions or that an appropriate siding is available.

**Two cabins or one**: Especially with double-wire transmission, all signals and points can in many cases be controlled from one central location. Having one central cabin can save on equipment and staff. However, there are some benefits to having cabins at either side of the station. One advantage is that the cabin staff on either side can check that trains are arriving intact, verifying that trains have cleared the fouling mark (this may be the duty of the guard as well), controlling level crossing gates near them, etc. More eyes watching also means that problems like hot axles or dragging equipment are more likely to be caught. Another consideration is that shunting operations can proceed slowly as all movements have to be coordinated with the single cabin and the guards and drivers of various trains, whereas with two cabins the cabin staff at either end can manage shunting operations at their ends independently. Finally, note that when the signals and points are far, generally speaking keys have to be dispensed by the Station Master for operating them; passing the keys back and forth takes time. (This can be alleviated by electrical interlocking.)

## Electrical Interlocking

Electrical equipment of some kinds may be used even in the mechanical interlocking systems described above (e.g., electrical relays that operate slotting). However, the basic operation there remains mechanical in nature. In electrical interlocking, the fundamental mechanisms use electric control extensively. Electrical interlocking often goes hand in hand with power signalling, although there are or were installations with electrical interlocking provided for semaphore signals.

### Relays

Relays of various sorts are used to turn on or turn off circuits that control signals, points, slots, level crossing gates, etc. **Track relays** are used for track circuits (see below). **Signal relays** control signals.

### Track Circuits

Track circuits are electrical circuits that are formed including the running rails. They are set up in such a way that when a train is on the tracks that are part of the track circuit, the circuit is altered in some way (usually, by current that normally flows in the track circuit being shunted through the conductive body of the train), thereby activating a detector which may then be used, e.g., to set signals at danger for the section.

Track circuits help with interlocked operation as they allow signals to be pulled off only if the section of track they control is safely clear of any vehicles. They also remove the human element of needing to scrutinize the track for the presence of trains that may be out of view of the signalling staff or cabinmen.

Track-circuiting is mandatory in sections where visibility is a problem, shunting operations are routinely carried out on the block section outside station limits on the main running line, or if special situations exist, e.g., if the advanced starter is more than one full train-length ahead of the most advanced trailing points of the station.

**Axle Counters**

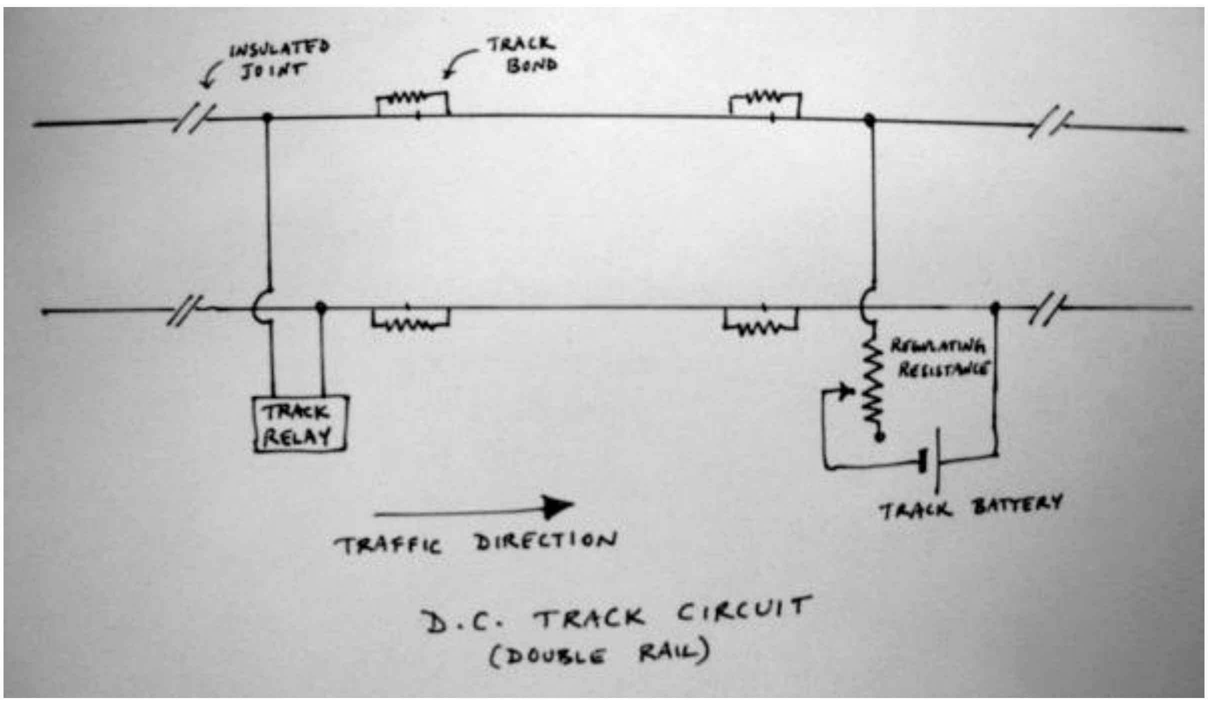
Axle counters are devices that can count the number of axles of vehicles passing by them on the track. Axle counters are installed at either end of the section of track of interest; when the number of axles counted at entrance to the section is the same as the number of axles counted exiting the section, it means the train has passed through the section intact. Axle counters are used in some cases where track circuits are hard or impossible to operate (e.g., where metal sleepers are provided, making track circuit operation impossible without re-installing the track, or where conditions are such that there is too much electrical noise and conductivity problems that make track circuits unworkable).

## Q. What kinds of track circuits are used by IR?

The most common form of track circuit used is the detection of a train by the closing of an electrical circuit between the two rails because of the conducting nature of the rolling stock. This circuit may use DC in the simplest form, or may use AC, at various frequencies or with coded pulses.

**DC Track Circuit (double-rail)**

Double-rail DC track circuits are generally found only in non-electrified sections, and only where there is no concern with stray currents circulating in the earth or in the rails. The track circuit consists of a portion of the track which is insulated from the rest of the track by means of insulated rail joints. Within the section so insulated, bonding wires are provided to maintain good conductivity between adjacent rails. The rails on one side are insulated from those on the other by the use of wooden or other non-metallic sleepers. The **track relay** is connected across the two rails at one end of the track-circuited section, and a DC power source (**track battery**) is connected across the rails at the other end along with a regulating resistance. When there is no train in the section, the circuit is completed through the track relay which is therefore energized. The energization of the relay lights an appropriate indicator lamp in the cabin, but may also pull a signal off for entry to the section. When a train enters the section, it shunts the current through the track relay, which as a consequence is de-energized, leading in turn to an appropriate indication at the cabin, and to signals controlling entry to the section being set to danger and locked from being pulled off. Further, note that if the track battery fails, or the bonding connectors between rails break, the relay is de-energized and these failure conditions also result in signals being set to danger. Where traffic is (mostly) unidirectional on a line, the track relay is placed at the entrance end, so that the relay is de-energized as soon as the train enters the section, and operation of the relay is not compromised by leakage currents and other problems. Leakage currents between the rails always exist, and can reach high levels when it rains and at other times, which has to be taken into consideration when designing the circuit and its operating current values. The ballast makes a difference, with broken stone being the best and cinder being a poor candidate because it holds a lot of moisture. Ballast resistance should usually not be less than 6.5 ohms/km when wet. The resistance of the rails and the bonding wires should be less than 0.5 ohm/km.




DC track circuits of this kind are simple and cheap to install. When there are stray currents found in a region, these track circuits are often very problematic to use. Even if they are used, the presence of stray currents usually severely limits the length of the track which can be part of the track circuit.

**Insulated Rail Joints**

For a DC track circuit to reliably detect the location of a train within its specified section, the section must be electrically isolated from adjacent track (the exception being with jointless track circuiting methods -- see below). Special kinds of rail joints are used, known as **glued**

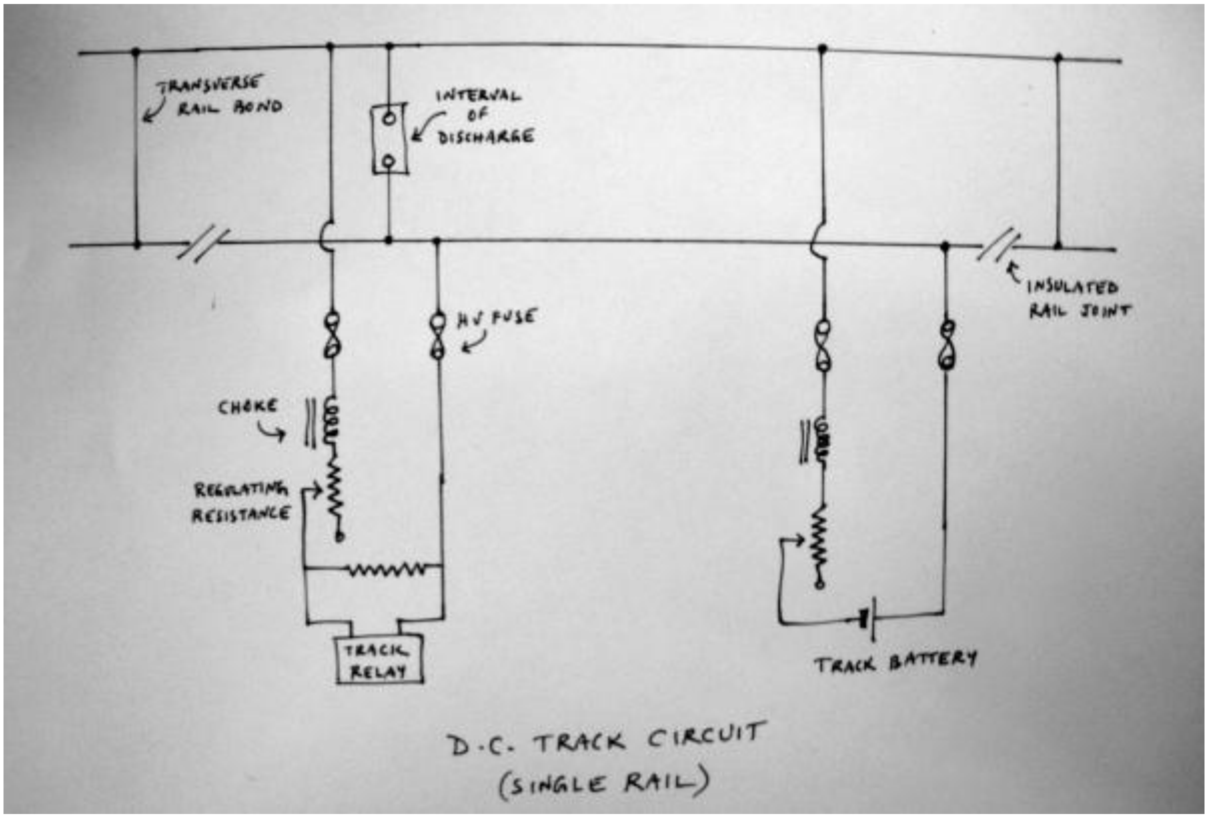
**joints** or insulated rail joints. Usually a special 940mm-long fishplate is used, with 6 holes for fish bolts. Special high tensile strength fish bolts are used and the entire fishplate and bolt assembly is glued on to the joint, including the 'end post' at the joint, using an epoxy impregnated fabric in multiple layers. A typical glued joint is 6.5m long and is welded to the adjoining rails. The glue and fabric ensure that the rail sections on either side of the joint are electrically separated.

**Rail bonds**

At normal joints within a track circuit section, electrical continuity must be ensured. Usually, one or two bonding wires are provided that connect the two rails across a fishplated joint. This is done even though the fishplate normally provides electrical continuity, to allow permanent way operations that involve unbolting the fishplates to continue without interfering with track circuiting. Also, dirt and surface impurities can cause the bolted fishplate joint not to conduct electricity reliably for track circuiting purposes (especially with AFTC or HFTC where the impedance of the joint to the particular frequencies involved is critical).

**Single-rail DC Track Circuit**

In 25kV AC electrified areas, single-rail DC track circuits can be used. Rails on one side of the track are used for the the returning traction current, with adjacent rails being bonded together for conductivity. Rails on the other side are bonded together in the section of the track circuit, but insulated at either end. The track relay and track battery are connected across the rails within the track circuit section as usual, but with high impedance chokes to prevent the traction current from flowing into the relay or battery. High-voltage fuses are also provided to protect the track circuit equipment from accidentally getting 25kV across it from a downed contact wire. The principle of operation is the same as with the plain two-rail DC track circuit described above. As a further safety measure, a high-voltage fuse or 'interval of discharge' (a device like a lightning protector) is provided across the rails so that if the contact wire breaks and falls on the rails, the insulated rail gets connected to the uninsulated one and is therefore earthed. The uninsulated rail on one track is bonded to the uninsulated rail of an adjacent track circuit as well, to provide a path for traction currents if the uninsulated rail breaks. Beyond the track circuit area, tranverse rail bonding connects the rails on either side together - this distributes the traction current better across both rails outside the track circuit.




This system is simple and cheap to install, but has some disadvantages. If one insulated rail joint fails, the track circuit is effectively expanded and will interfere with the operation of adjacent track circuits. Return traction currents or stray currents cause a longitudinal voltage drop across the uninsulated rail, which limits the length of the track circuited section. Finally, in contrast to AC track circuits that use impedance bonds and double insulated rails, a single broken rail cannot be easily detected by the imbalance of return currents.

**Coded Track Circuit**

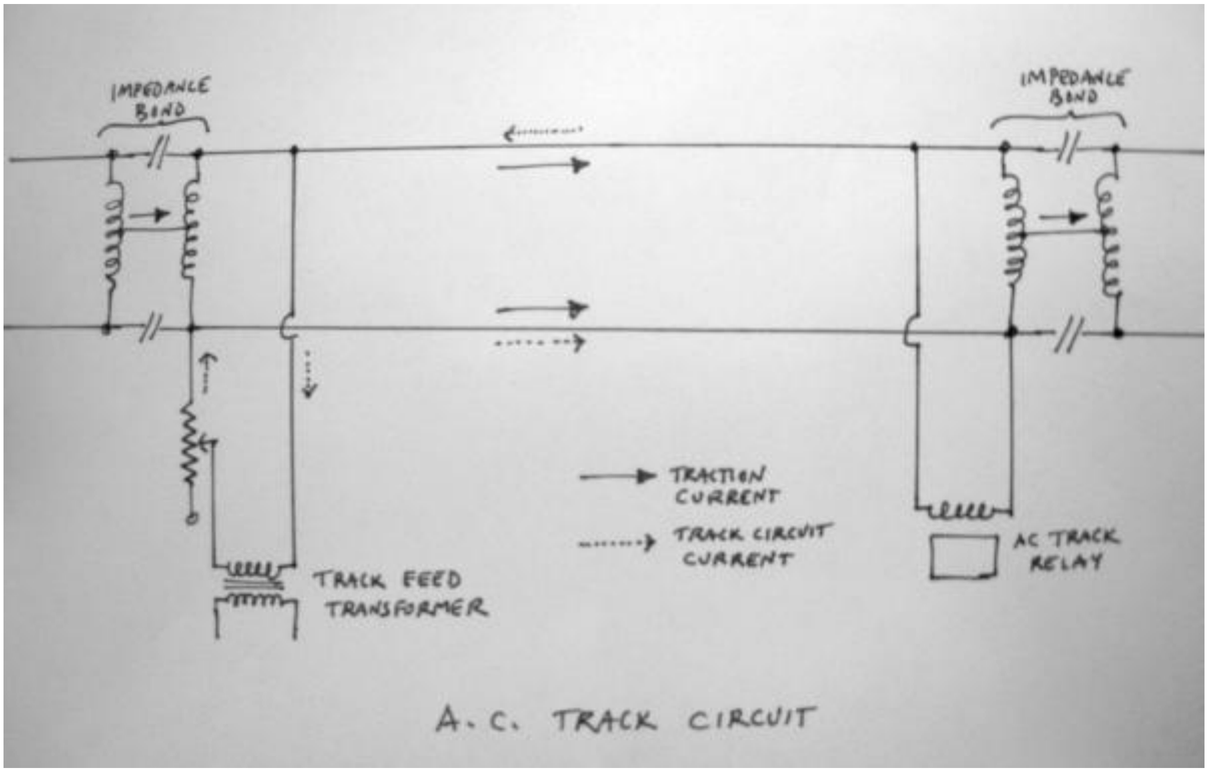
A coded track circuit is a variation on the simple DC track circuit, where instead of a steady DC signal, a pulse-coded current is used for the track circuit. The pulse train is generated by a **code transmitter**. The **track relay**is energized and de-energized by the pulse train, and controls the current in a **decoding transformer**correspondingly by switching its taps. In turn, a **track detector relay** follows the changing current in the decoding transformer and is configured such that it is energized as long as the specific pulse pattern is being transmitted. When the train enters the zone of the track circuit and shunts the circuit, this relay is de-energized, and signals are brought to danger. Coded track circuits have a big advantage over the basic DC track circuits in that they are much less vulnerable to stray currents.

A further advantage of coded track circuits is that different codes can be used at different times to control the signal aspects. For instance, the signal governing entry to a section of track can be set to clear or caution depending on the pulse pattern used. With any of the pulse patterns being used, however, the presence of a train will still shunt the circuit and cause the signal to revert to danger. Track circuits can also be 'overlaid' or have some portions of track in common. In addition, the same coded pulse trains can also be picked up by locomotive equipment by induction to provide in-cab display of signal aspects.

**AC Track Circuit**

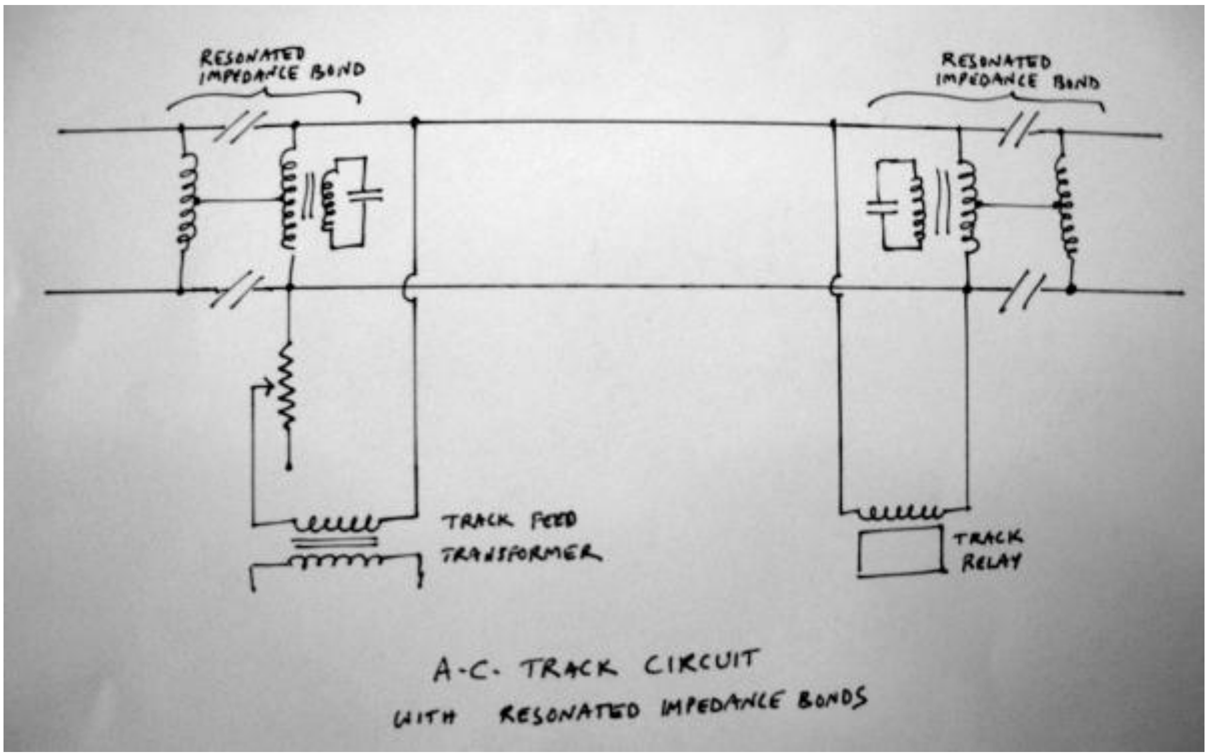
AC track circuits use an AC signal instead of a DC in the track circuit. The frequency used for the track circuit signal is usually 83.5Hz, to avoid interference from the 50Hz traction current. Their principal advantage is that they are immune to interference from stray currents, so that they can be quite long, up to 5km or so. AC track circuits may be used on unelectrified or electrified tracks. **Impedance bonds** see below are provided for the rails at the ends of the track circuit. The purpose of the impedance bonds is to provide a path of low impedance for traction currents to flow in both rails, and to provide high impedance and therefore block the AC signalling current. A band-pass filter and rectifier are used to extract a DC signal from the AC track circuit current, for the operation of the track relay. Apart from the fact that an AC signal is used, the general principle of operation is the same as with DC track circuits.

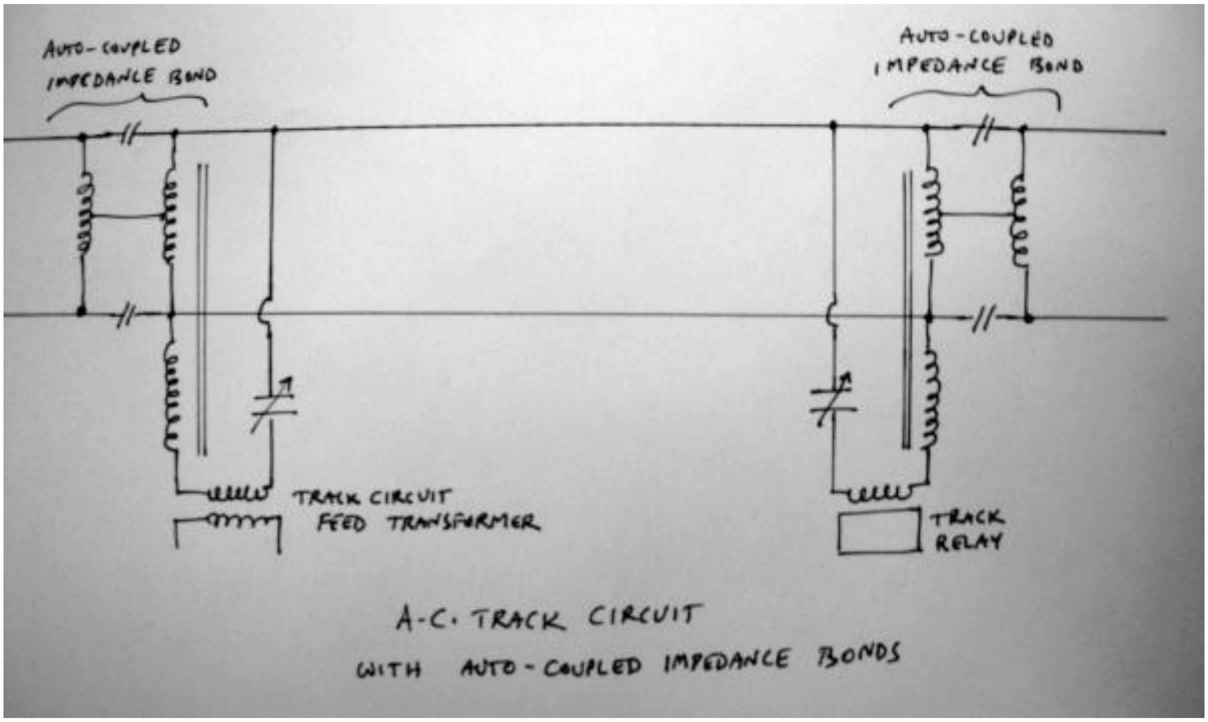
AC track circuits tend to be immune to stray currents and hence can be more reliable, and can be quite long - a few km in length. However, the provision of a separate 83.5Hz supply makes the installation costly.




**Impedance Bonds**

**Impedance bonds** used for AC track circuits consist of two low-resistance windings wound in opposite directions on a laminated iron core. Each winding is connected across the rails on either side of the track, and centre taps from each winding are connected together. With DC traction, under normal circumstances equal currents flow in each half of each winding and if the traction currents are evenly distributed across the two rails, there is no resultant flux in the iron core. In this state, when the core is not magnetized, it presents a path of high impedance to the track circuit current. In the case of an imbalance, the core would be magnetized to saturation and the track circuit current would no longer be faced with a high-impedance path; therefore, an air gap is introduced in the magnetic circuit to prevent saturation, and the impedance bond presents high impedance to the track circuit current in all cases up to about 20% traction current imbalance. With AC traction, when the traction currents are unbalanced, the half coil that carries more current induces an e.m.f. in the opposite half coil that tends to equalize the current. So air gaps are not generally necessary for AC traction. The impedance of the bond to the signalling current can be further increased by adding a secondary coil and a capacitor across it, in what is known as a **resonated impedance bond**. The secondary coil steps up the voltage and allows the use of a smaller capacitor than would otherwise be required. **Auto-coupled impedance bonds**are a modification of the resonated impedance bond idea. Here the winding across the rails in the track circuit zone forms one part of the winding of an auto-transformer, the other part having the capacitor in series. On one side of the track circuit, the other part of the auto-transformer is connected to the supply (100V) thereby being stepped down for the track circuit current, and the auto-transformer winding on the other side of the track circuit is connected to the track relay such that the track circuit current is stepped up to operate the relay. Thus, the current flowing in the bonds is usefully employed in operating the relay.

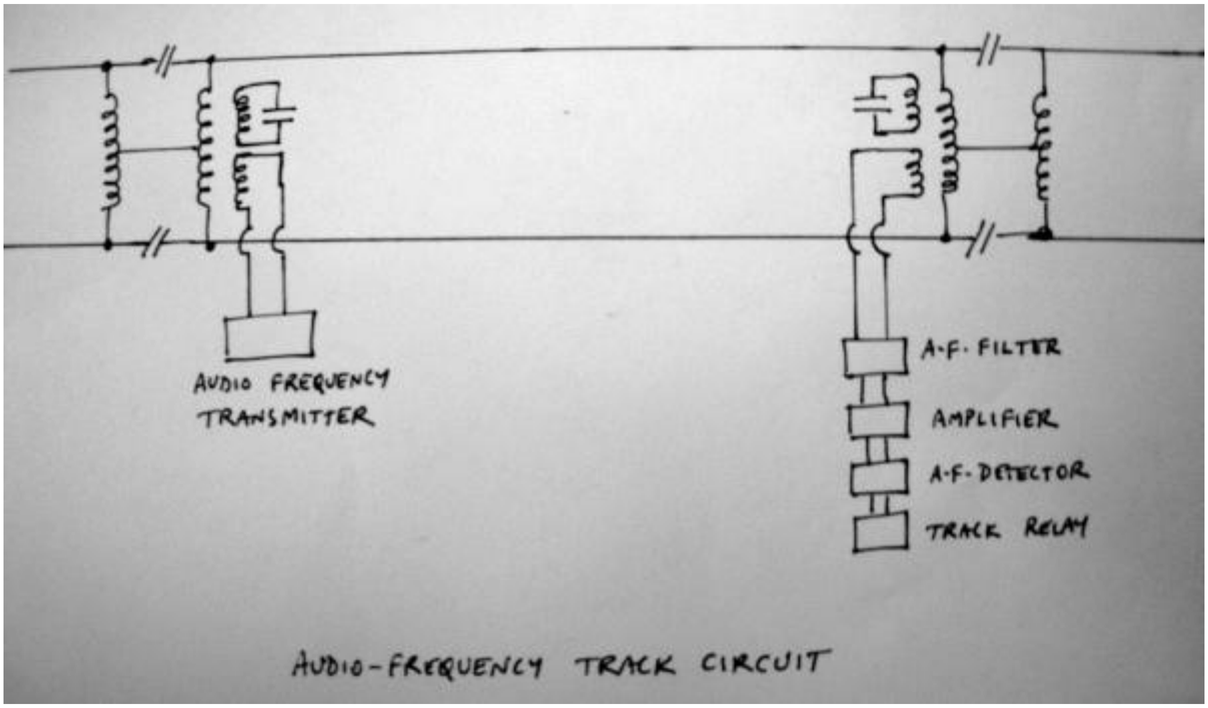





**Audio Frequency Track Circuit**

Most zones now have many sections that use AFTC, or Audio-Frequency Track Circuits, that are like the AC track circuits described above, but using a signalling frequency that is higher. Many frequencies are used. In early systems, 175Hz, 225Hz, 270Hz, 320Hz, and 831.33Hz were common. Multiples of 50Hz were avoided so that there is no interference from harmonics of the common line frequency for other electrical equipment or the AC traction supply. Today, there are many different systems. ABB equipment uses 1549Hz, 1699Hz, 1848Hz, 1996Hz, 2146Hz, 2296Hz, 2445Hz, and 2593Hz. Siemens equipment uses 4.75kHz, 5.25kHz, 5.75kHz, 6.25kHz, 9.5kHz, 10.5kHz, 11.5kHz, 12.5kHz, 13.5kHz, 14.5kHz, 15.5kHz, and 16.5kHz. Siemens equipment uses 1700Hz, 2000Hz, 2300Hz, and 2600Hz. A variant known as DC-coded AFTC from Alstom uses frequencies like 2100Hz, 2500Hz, 2900Hz, 3300Hz, 3700Hz, and 4100Hz.

AFTC is more reliable, especially where both DC and AC traction are in use, and allows the track circuit length to be increased a lot. The pioneers in adopting AFTC over simple DC or low-frequency AC track-circuiting were WR, SR, and CR (Dombivli, Pune-Lonavala, Chennai-Tambaram, Anand-Vatva, etc.). As with the low-frequency AC track circuits, a band-pass filter and a rectifier are used to extract the signal; however, in many cases an amplifier is needed to strengthen the signal.



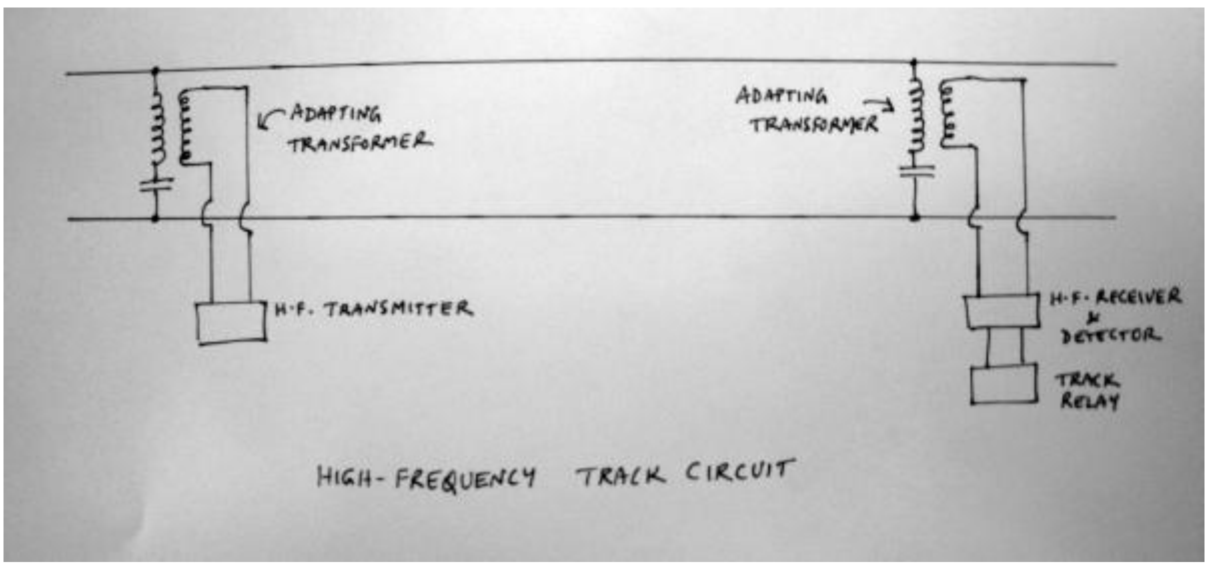

**High Frequency Track Circuit**

As the name implies, High Frequency Track Circuits (HFTC) use substantially higher frequencies, e.g., 40kHz, for the track circuit current. This kind of track circuit operates a little differently from the other AC track circuit types. Impedance bonds are not used. Instead, at either end of the track circuit, rail-to-rail shorts are provided. A signal transmitter that generates the high frequency signal is connected to the rails at one end using an **adapting transformer**, which has one winding across the rails with a capacitor in series, while the transmitter is connected across the other winding. Similarly, a receiver is connected across the rails at the other end using another adapting transformer. The transmitter and receiver connections are a little distance (5m or so) inside from the rail-to-rail shorts. The receiver usually includes a tuned filter, rectifier, and amplifier for the signal frequency. Electrically, the track circuit zone inside the rail-to-rail shorts looks like two tuned LC circuits in parallel, with the inductance of the enclosed section of track in between them in series. The capacitors are adjusted so that the enclosed section of track is tuned to the track circuit frequency. When no train is on the track, the signal from the transmitter is received and detected at the receiver, and is used (via generation of a DC control voltage) to keep the track relay energized. When a train approaches the track circuit, it shunts the track circuit and - depending on the positions of the wheels - either de-tunes the circuit or shorts the transmitter or receiver (or both). Any of these cause the track relay to be de-energized.

In a variation on the above, the transmitter may generate pulse trains of specified duration and patterns with the high frequency signal. These are detected and converted to square waves which activate a peak detector, which in turn controls the generation of the DC control voltage to energize the track relay. In this scheme, different coded pulse trains can be used to control different signalling aspects.

The rail-to-rail shorts define the limits of the track circuit and therefore the circuit is immune to interference from adjacent track circuits. Also, the LC circuit on the receiver side can be tuned very specifically to the track circuit frequency, so that other signalling applications that use other frequencies can be used on the same section of track without compromising the track circuit's operation.

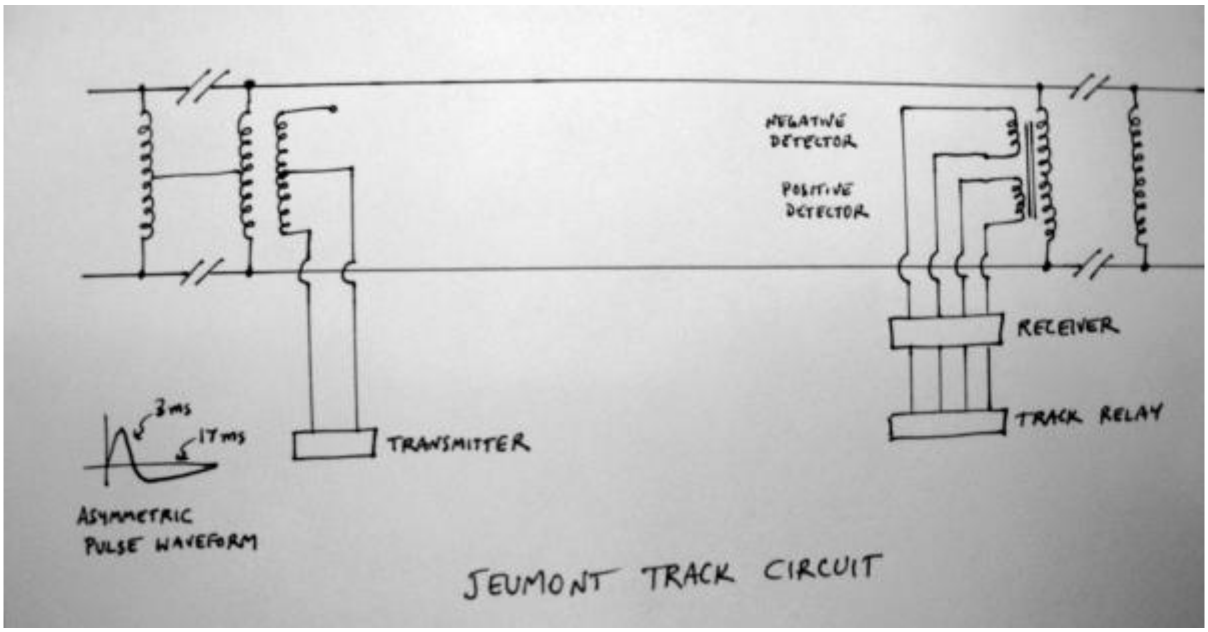
CR was the first zone on IR to experiment with HFTC.




**Jeumont Track Circuit**

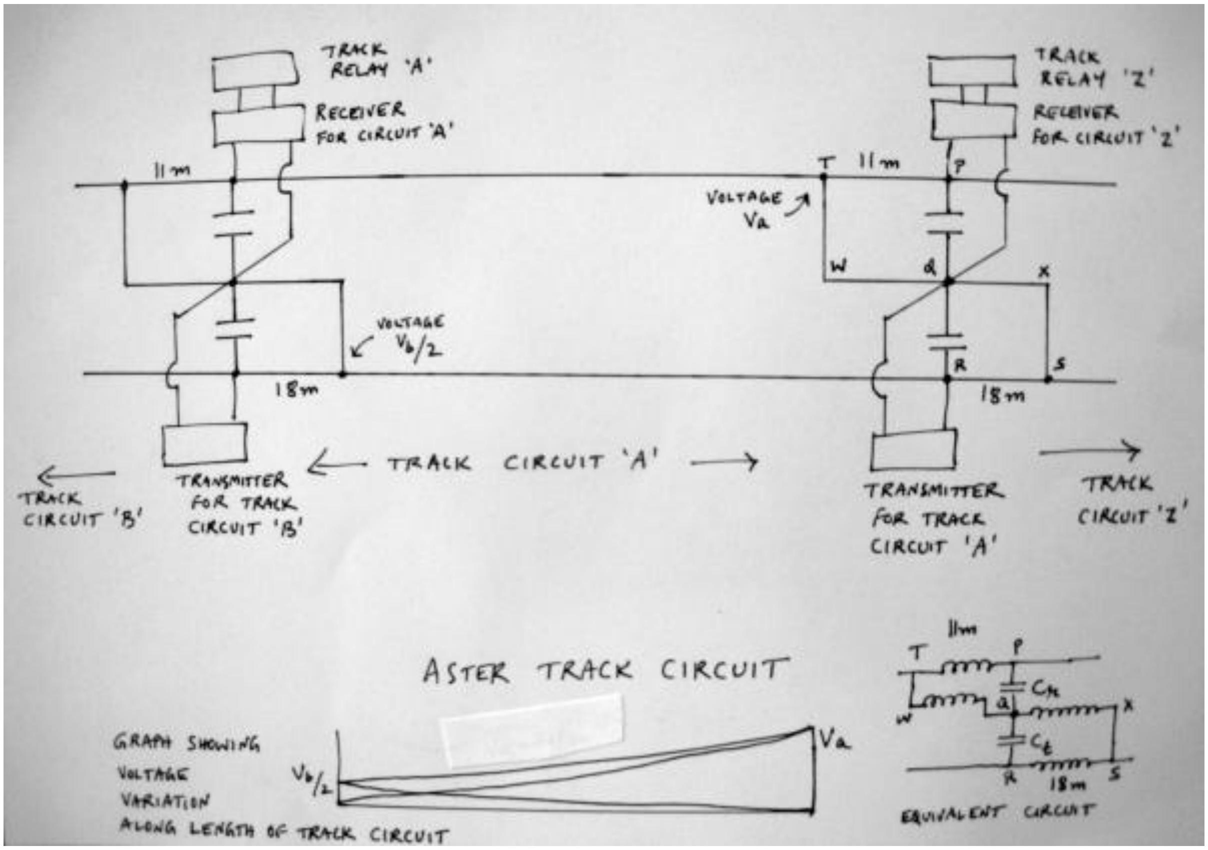
The **Jeumont Track Circuit** (or Jeumont-Schneider track circuit) is a design that has been tried in areas where environmental conditions make it hard to get good contact between rails and wheels, reducing the shunting effect of a train on the track. Often, in such conditions, a higher track circuit voltage helps as the track circuit current can break down and go through thin films of oxides, salts, coal dust, scale, etc., on the surfaces of the rails. However, constant or steady AC high voltages lead to higher leakage currents and therefore waste power. In the Jeumont design asymmetric high voltage pulses with a small duty cycle are used - with a high peak on the positive side (3ms), and a low amplitude negative cycle (17ms). The pulses are emitted at about 3Hz frequency. The low duty cycle keeps power consumption low. A specialized detector rejects symmetric signals (as from the traction currents) and detects the asymmetric pulses. These track circuits were in use at the

Tambaram yards of SR, and in some areas around Kolkata. They are especially suitable in areas with DC traction (but can be used where both DC and AC traction are used) because of the corrosion problems in DC traction areas. They are also suitable for use in tunnels and other areas where oxidation of rails is more intense. As with DC track circuits, slight variants are possible for single-rail or double-rail returns in electrified or unelectrified sections. Some other variations of the basic principle exist - IR literature also refers to some designs as **Pulsed High Voltage Track Circuits**.




**Jointless Track Circuits**

The **Aster Track Circuit** (also referred to as **Jointless Audio Frequency Track Circuit**) is a design suitable for use in areas with long welded rail where impedance bonds or insulated joints cannot be provided. It uses signalling frequencies around 2.2kHz or so. An 'electric boundary joint' is created by connecting two capacitors in series across the rails at either end of the track circuit zone. A 'rejector' cable is connected from one rail about 11m outside the track circuit to the point between the two capacitors, and then to the other rail about 18m inside the track circuit. The capacitors in conjunction with the inductances of the rails and the rejector cable form tuned circuits. In addition, the transmitter for the track circuit frequency is connected across one of the capacitors. This leads to the impressed voltage being available in full inside the track circuit zone, but reduced (usually by half) outside the track circuit. The receiver for the track circuit is connected across the capacitor at the other end of the track circuit, on the side connected to the other rail. Adjacent track circuits use the same principle (the next track circuit has its receiver across the other capacitor at the end where the transmitter of the first circuit is connected.)




In the diagram showing the Aster track circuit, note that the lengths of rail across which the cross-connection T-W-Q-X-S are made are 11m (T-P) and 18m (R-S) respectively. This cross-connection forms the 'rejector circuit' or 'electric boundary joint'. The equivalent circuit is shown at bottom right in the diagram. Note that the track circuit signal is injected across Q-R, and faces a circuit with $C_t$ in parallel with inductances QX and RS. This circuit can therefore be set up so it offers high impedance to the signal frequency, preventing it from propagating it to the track circuit section on the right. Meanwhile, the circuit Q-W-T-P can be set up allow the signal frequency to propagate to the left. Adjacent track circuits can use different frequencies and reduce interference by means of these rejector circuit arrangements. In addition, note that the voltage $V_a$ impressed across QR is available across TU to the left, but gets dropped (to $V_a/2$) across the tracks on the right. The same applies to the voltage $V_b$ applied by the track circuit transmitter for 'B' to the left. See the graph plotting the net voltage as we move from one end of the track circuit ('A', the region in the middle) to another - the voltage from track circuit 'B' (to the left) is reduced in half, $V_b/2$, on the left end of track circuit 'A', and falls essentially to zero at the right end of 'A'. The voltage from track circuit 'A' starts at about zero on the left end, and rises to its full value $V_a$ on the right. The net voltage therefore rises as we go from the left to the right from $V_b/2$ to $V_a$.

Other kinds of jointless track circuits exist, where the detection of the section occupancy by a train is done by measuring the attenuation of the signal which is at a frequency (about 10kHz, usually) which undergoes significant attenuation in rails over the distances of interest and whose propagation characteristics are known. This also means that the entrance of a train into the track circuit section is not determined precisely based on its position -- instead, safety factors are incorporated in the calculations to yield zones within which train occupancy can be determined in a guaranteed fashion. The system can be made even more reliable by coding the signal in a pulse train allowing the receiver to distinguish between signals of different track circuit sections (see below).

In a variation of the jointless track-circuiting scheme, trackside units can be used to set up a resonant circuit and constrain the signal (usually between 1.5kHz and 3kHz) to a particular section of track. The advantage of jointless AFTC is clear in that insulated joints are not required, reducing maintenance, allowing the use of long welded rail sections, and eliminating the problems of insulated joint failures. Jointless AFTC sections can be 1-1.5km in length.

**Coded Jointless AFTC**

This system uses a mechanism such as the Aster design (see above) where insulated rail joints or impedance bonds are not needed. In addition, rather than using single frequencies for the track circuit current, coded pulse trains are used, which further reduces interference between adjacent track circuits. Jointless AFTC is in use on the Delhi Metro, and a few other places on the IR network. It was first introduced on the Tambaram - Madras Beach section of SR. AFTC equipment used by IR is from Adtranz, Siemens, US&S, and Alsthom. Jointless AFTC units are manufactured in India by Medha Ltd.

## Q. What kinds of axle counters does IR use?

[5/99] Axle counters are widely used by IR to ensure that all wagons or coaches of a train have indeed passed a given point — out of a block section, out of the station limits, out of yard limits, other point zones, etc. ('last vehicle proving', 'block proving', or 'block verification', serving the same purpose as the visual 'Last Vehicle Check' or LVC that is done otherwise). Axle counters may be of the single or multiple entry type. Axle counters today are mostly of the electronic variety. They use piezoelectric sensors on the tracks, which are triggered by the weight of a pair of wheels moving over them. Older models with electromechanical treadles actuated by the wheels of a passing train are also seen, as are some variants which use photoelectric detectors or magnetic detectors (using the Hall effect to sense the perturbation of magnetic flux) to count axles. The 'counting' is today usually done by digital circuits ('SSDAC' = solid-state digital axle counter, also generically termed an 'electronic axle counter'), but in the past the counting up and down was accomplished using electromechanical relay circuits. Digital circuits are more compact and far more reliable than the older electromechanical counters.

Usually two sensors are installed, at either end of the track section to be monitored - one that counts up as axles enter the section, and the other which counts down as axles leave the section. The section is deemed to be clear only when the resultant count is zero. More complex installations with additional sensors are sometimes used, where the counts of axles registered by each sensor are compared with logic taking into account the direction of motion, etc., to yield a final result of whether the section is clear or occupied. Signals and points are interlocked with the occupancy indication from the axle counter so as to prevent trains from being routed to occupied sections.

As with much other trackside equipment, the sensors are usually powered by a 24V DC supply; there may be battery back-ups for reliability. In the case of solid-state equipment, there are even redundant computation paths provided so that the final decision of track occupancy is done with a '2 out of 2' or 'best of 3' choice from multiple logic units.

A typical axle counter is usually able to handle track sections up to a few kilometers in length, and all typical train speeds seen today in India. Maximum counts registered by sensors may be quite high, as much as 16,000 (not for long trains (!), but to keep track of total traffic in a given period).

Even with all this the axle counts are not 100% accurate and there are sometimes glitches in the counts. One sometimes sees small rooms marked 'Axle Counter Room' near the station master's office where the equipment for reading the axle counts is housed. One of the supplies of digital axle counters in India is Applied Electro-Magnetics India, Ltd. The use of axle counters was pioneered by WR and CR. Over 65,000 are now used across India [2003].

## Q. Does IR use any other method of Last Vehicle Proving

Apart from axle counters or track circuits that indicate that a train has passed out of a section of track, in some places magnetic detectors are used for last vehicle proving. A permanent magnet suspended a few inches above the track from the last vehicle of a train passes right over a sensor which is positioned in the center of the track. The sensor works on the principle of the Hall effect, detecting and amplifying the Hall e.m.f. induced by the passage of the magnet. In other sensors, the passage of the magnet may also change the reactance of a saturable reactor, thereby triggering a relay or tripping a circuit.

## Q. Does IR use automatic track-side hot-spot detectors, trailing equipment detectors, etc.?

IR does not appear to have begun using any hotspot detectors or trailing equipment detectors or other methods for automatic detection of mechanical problems in rolling stock, apart from some isolated experiments. Axle counters or track circuits are the primary means of ensuring that a section of track is clear - problems from broken or detached equipment are detected by human vigilance.

## Train Working with Power Signalling

Power signalling (i.e., signalling with electricity - usually this means colour-light signalling, but may also include electrically operated semaphore signalling) is usually associated with some specific systems of train working. These may be refinements of the basic Absolute Block System, or arrangements to support the Automatic Block System.

See the section on block working for more details on this, including **Lock and Block**, **Open Block working**, and**Controlled Manual Block working**.

## Q. Are there any in-cab signalling methods, ATP, etc. used by IR?

[5/99] Some WAP / WAM models have in-cab AWS / ATS (auxiliary warning system, automatic train stop). AWS provides prior in-cab notification of distant or home signals that are displaying danger or 'on'. ATS provides for a locomotive to be brought to a halt in case it overshoots an 'on' signal that it should not have.

This has been tried out on the Mughalsarai-Howrah section (ER) but is not in wide use although it was installed in the 1980s. (Pilferage of the track equipment is said to have been one reason for slow adoption by the railways.) Some Mumbai-area suburban EMU routes of WR and CR have ATS and AWS systems (WR had AWS from the 1980s, while CR got it more recently, in 2000).

If a signal at Caution is passed at above 25km/h, a buzzer sounds in the cabin and the motorman has to respond within 15 seconds to avoid application of the emergency brakes. The system also halts the EMU rake if a signal at danger is passed. The lineside transmitter for this is placed in between the rails a short distance before the signal, and the receiver for this is placed on the leading truck of the loco. CR EMUs do not have this system [7/00] and run without its benefit on WR tracks.

AWS systems usually work by means of electromagnets placed on the track that are activated by the signal aspects and whose magnetic fields are sensed by the AWS sensor mounted on the loco. A variation of AWS is being tried out [6/02] on the Delhi-Mathura section where instead of using magnetic sensors a radio signal is used to activate the buzzer or other alerting device for the driver.

[11/99] A system of loco identification and automatic proximity alerts has been proposed for the Konkan Railway. In this scheme, each loco would carry a beacon that transmitted its identification, including the train number, direction, etc. Ground-based receivers would pick up the beacon signals and relay the information to traffic control centres. Also, if there were other locos within a short distance (2km?) with the same beacon system, an alert would sound in the loco cab. This same system (or a similar one?) is also to be introduced on NFR [7/00].

Anti-collision devices (ACD) that will bring a train to a halt if it is within a certain distance to another train on the same tracks have also been proposed [7/01]. These were developed by Konkan Railway. These depend on computing the 'crossing number', a measure that takes into account the converging and diverging routes encountered by a train in order to figure out whether two trains that appear dangerously close (detected by means of radio beacons) are in fact safe because they are on different adjacent tracks, or not. ACD deployment began on Konkan Railway and now [12/04] there are plans to use them on nearly 3,500 route-km of NR, NFR, SR, SCR, and SWR.

Some WCAM-1 locos have a transceiver that is supposed to alert the driver of a derailment or other problem ahead. Very few locos seem to be equipped with this. [1/00] A version of ATP using Siemens ZUB equipment has been deployed in portions of the Calcutta and Bombay suburban systems. (How extensive is this?)

[4/00] IR is looking into procuring ETCS level 2 equipment to be installed on the trunk lines betweeen the four major metropolises, and later on other main lines. ETCS level 2 equipment allows for communication of target speeds, safe braking distances, etc. from lineside equipment to the on-board computers of the loco. It includes a measure of ATP (Automatic train protection) in that it can slow down or stop a train if required when the driver exceeds the safe speeds for given signal aspects; but it does not include full ATC (automatic train control).

[4/00] A pilot ETCS installation for an 84km stretch of the Delhi-Mathura line is planned with 40 locomotives to be fitted with the equipment.

[2/01] A system of ATC is being tried out for the Calcutta Metro. When deployed (expected some time in 2001) this will allow for automated routine operations, and reduced headway of 8 or even 5 minutes between the trains (currently headway is 10 minutes on the metro).

[6/03] The Delhi Metro uses in-cab signalling and is planning the use of ATC / ATO operation of the subway trains.

Mobile Trunk Radio Communications (MTRC) is used on some sections (Bhusawal - Itarsi, Itarsi - Nagpur, Nagpur - Durg). This is an older analog system dating to the 1980s, which allows the Traction Loco Controller to talk by radio to train crew that are carrying a receiver with them in the locomotive cab. Digital versions of MTRC have been considered and are slated for trials soon [2/05].

[12/04] IR is also considering the use of GSM-R technology on parts of its network. Siemens AG is supplying GSM-R equipment for 700 route-km of the NFR in West Bengal, Assam, and Bihar as an initial project for IR to experiment with the technology. [5/05] The North Central and East Central zones are also setting up some GSM-R services. GSM-R is a set of standards for railway-specific communications, integrating voice, data, and control communications, which is based on the popular GSM standard for mobile telephone communications.

[5/05] A Train Protection and Warning System (TPWS), based on ETCS Level 1 has been proposed for the Chennai Beach - Gummidipoondi section. EMUs will be monitored using track balises and lineside transmission devices (LEU or Lineside Electronic Unit). Signal aspects will be available in the EMU cab, and EMUs will be automatically braked if its speed is in excess of the safe speed appropriate for the signal aspect.

**Anti-collision Device** (ACD) Konkan Railway has developed a system involving radio receivers and transmitters fitted on locomotives, which aims to prevent or minimize the chances of collisions. The transmitter sends out a coded signal that identifies the train and its direction, route, etc.

Proximity and directional sensors and circuitry to handle the train identification information from other transmitters in the vicinity allows the ACD to sound an alarm and/or apply the brakes if it discovers that two trains have been routed on to the same track. Some versions of the ACD are also said to include the use of GPS to provide accurate information on the location of each train.

The ACD equipment has been put to use in several sections. It has been claimd [6/03] that equipment-related accidents have gone down substantially in the Jalandhar-Amritsar section because of ACDs.

Some zones of IR have recently [12/04] been experimenting with using GPS to report train positions and expected arrival times, etc.

## Q. What other methods of communication with train crew are used on IR?

Handheld radios (walkie talkie sets) are widely used now (since the late 1990s) by train crew, yard crew, etc.). Some stations have transmitters allowing them to broadcast to all walkie talkies in the vicinity. Often, because of their higher power they are able to transmit to walkie talkie sets carried by crew that are farther away than the distance the walkie talkies can normally operate within, so that they cannot receive any messages in the reverse direction in such cases!

The Rajdhani Expresses still use a primitive though reliable form of communication. A pair of wires are connected to a telephone socket on the end of the first Rajdhani coach, usually a generator van. This telephone line then goes through the entire rake to the last coach where the guard has a telephone instrument. The driver also has a portable instrument which he plugs into this wire and communication between the guard and driver becomes possible even if the walkie talkies cannot function for some reason.

### Q. What systems does IR use for control and reporting of signals and related equipment?

Panel Interlocking or Route Relay Interlocking are common in most busy stations. Usually, with these the aspects of all signals and positions of trains in various track sections is shown on a control panel. The control circuits usually use underground cables along the track, and sometimes overhead cables. Trackside cables are not used much because of the possibility of pilferage and sabotage.

Many areas have data logging equipment for each piece of signal equipment, which records information on the functioning of the signal and sends it to a computer at a central point (usually the division headquarters) where reports can be generated and alarms raised for various kinds of malfunctions (power failure, signal passed at danger, train entering without line clear, signal lamp failure, loose packing of points, etc.). A typical data logger used in such a system monitors all signal equipment and track circuits 5-50 times a second and signal power supplies every second.

## History of interlocking in India

Historically, before the advent of block instruments, access to sections of railway tracks was done by the issuance of 'Line Clear' certificates (analogous to the use of track warrants in the USA) by the station-masters of the stations to which the sections belonged. The GIPR and EIR were in the forefront of mechanizing this process by installing block instruments, semaphore signals, and interlocking. Paper Line Clear tickets are still used in special circumstances and when communications have been disrupted.

### Early days

The List system of interlocking (named for G H List) for signalling was introduced in 1892 at six single-line crossing stations of the North Western Railway. These employed a detector and locking system for protecting facing points. The system was enhanced by A Morse and came to be known as List & Morse interlocking.

The earliest full cabin interlocking arrangements were installed by the GIPR on its Bombay-Delhi route in 1893 with equipment from Saxby and Farmer of the UK. (Equipment devised by John Saxby.) Ajmer station was another of the early ones to get interlocking, as were the stations on the Lonavala-Pune route. The List & Morse system (devised by G H List and A Morse) was employed at 29 (or 28?) single-line crossing stations between Lahore and Ghaziabad in 1894.

Other improvements included the Hepper's Electric Key Transmitter. Invented by Major Lawless Hepper, a signal engineer of the North Western Railway this system replaced manual key interlocking. (Major Hepper (later Sir Lawless) later became the General

Manager of the GIPR. His earlier invention, the Hepper's Key Instrument, which dispensed keys for the manual operation of points too far from the cabin for lever frames, was used extensively as well.)

### Improvements and new systems

The adoption of cabin interlocking progressed rapidly and by 1912 almost the entire Bombay-Delhi route was equipped with it by the GIPR. Syke's Lock and Block systems were introduced on the BB&CI Rly. and others starting in 1910 or so. Around this time track circuits and power signalling (electric and electro-pneumatic) were also introduced for points and signals

These were used at major stations such as Bombay, Madras, and Calcutta. By 1931 more than 700 stations across India had interlocking. Lever frames from Tyer & Co., Westinghouse (60- or 70-lever frames were not uncommon) and others, and all-electric frames from Siemens (e.g., at Madras Egmore and Madras Beach in 1935) were in use, as were many locally built lever frames based on various British designs.

Various forms of single-line signalling were developed early, influenced by British designs but heavily modified locally. Double-wire signalling, devised by E W Baker of the Assam Bengal Railway came into use for operation of points and signals and was also used on the South Indian Railway. This allowed the use of steel wires instead of rodding arrangements. The South Indian Railway and the Assam Bengal Railway were the first to adopt this.

In other places, double-line signalling instruments were similar to those of the London and North Western Railway, as the same engineer had worked at the LNWR. (*His name is not known -- clues?*) Individual hand levers for points were heavily used, operated by various systems of key interlocking.

Power signalling started to be used much more in the 1930s. Many of these arrangements were of an American style, and operated 3-position upper quadrant signals – an American feature – even though general practice at the time was to use two-position lower quadrant signals.

The use of electropneumatic and electromechanical systems spread widely in the 1930s. Around 1945 Bandra station boasted an all-electric interlocking frame.

# Train working systems – II
# Block & Non-block working

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# Block System

## Q. What is the Absolute Block System of train working?

'Absolute Block' refers to a system where the the track is considered to consist of a series of sections, such that when one train is occupying a section of track (the **block section**), no other train is allowed to enter that section. In addition, no train can enter an empty block section without first securing the permission of the station in advance. This is the most widely used system for ordinary train routes.

A station or signalbox controls a block section in one direction (from its rear), and no train may enter that block in that direction without permission from that signalbox (the station or signalbox is said to accept or receive the train). When a train has been accepted, no other trains can be accepted on that block section until it has left that block section.

Obviously the two signalboxes at either end of the block section have to tightly coordinate their actions, especially in the case of block sections that allow bidirectional movement on a single line. The permission to enter the block may be in the form of a physical token carried by the train crew while the train is in the block, or may be implicit in the aspects of signals governing access to the block.

The block section is usually taken to be the section of track from the most advanced signal controlled by the station in the rear (usually the starter or advanced starter signal) , and the rearmost signal controlled by the station ahead (usually the home or outer home signal).

Sometimes a long stretch between two stations may be formed into two or more block sections (intermediate block) to increase track utilization. The same principle applies in receiving a train from one intermediate block section into the next one. The signal controlling entry to an intermediate block section may be operated by staff at one of the stations, or may have a small signalbox (block hut) where the signal is located.

In automatic block territory, however, there may be several block sections between stations; the signals protecting entry to these sections are controlled entirely by the movements of trains on the sections, as detected by track circuits.

The portions of track that lie between the rearmost outer signal controlled by a signalbox of a station to the most advanced starter signal controlled by a signalbox of the same station are said to be within **station limits**, or to form the **station section**. Thus, as one goes along the track, one passes from the station limits of one station, through one or more block sections, and then enters the station limits of the next station. The act of admitting a train into station limits is termed **reception**, and the act of sending it out of the station is termed**despatch**.

The restriction on more than one train or rake occupying a block section is stringent and can be lifted only in very special circumstances, some shunting operations, for repair and maintenance work, or emergency operations. For instance, a material train may be sent into a block section that already has other departmental vehicles on it. A traffic train may be sent into a section that has an inspection trolley on the tracks. In all such cases, appropriate caution orders are issued to the drivers of the trains involved, and the driver of any vehicle that is proceeding into the block section in contravention of standard block working rules must carry the appropriate authority to proceed.

Within station limits, however, trains may be moved around by the signalman or station master without reference to other stations or signalboxes, and in fact, depending on the rules for **station working** in effect for the station, shunting operations, calling-on signals, etc. may allow more than one train to occupy a section of track within station limits. There are many stations where two full trains are routinely moved to the same track, to use the same platform (see the trivia section).

Station working rules are determined for each station in consideration of its peculiar track layouts and facilities. Movements within station limits are generally restricted to a lower speed (15km/h) except for through trains on the main running line(s). Analogous to station limits, **yard limits** are the regions associated with marshalling yards, sheds, etc. where the requirements of shunting or other activity make it desirable to relax the requirements on the number of trains or vehicles occupying a section of track.

Block working, or the method used to implement the block system, can be of several kinds, noted below.

**Block instruments** (see below for details) control the coordinated movement of trains on the block section; the block instruments of the two stations or signalboxes at either end of the block section are electrically interconnected for this purpose. (Normally a simple audio-frequency modulated code transmitted over trackside or underground wires is used for this purpose; earlier block instruments were connected directly (by DC voltages).) In physical token block areas, the block instrument is also the device that dispenses the tokens, and hence is also known as the **token instrument**.

Block instruments are quite old. However, in some areas with light traffic, block instruments were not used. Instead, magneto-driven telephone communication was provided between adjacent stations to allow coordination of signals (also known as **telephone block**.

In areas with **track circuits** (previous page) block working may be accomplished without block instruments by using the information from the track circuit to coordinate the aspects of signals using electric or electronic circuitry.

In automatic signalling areas, block working is handled by the track circuits connected to the signalling system such that the movement of the trains controls the signals.

Block working can be done with **axle counters** too. Here, the task of deciding whether a train has entered a section without parting can be automated by counting the axles as they pass the last signal from the dispatching station and comparing with the count of the axles at the home signal of the receiving station. If they match ('last vehicle proving') the previous block can be opened for the next train. More often, though, axle counters are used in conjunction with track circuits simply to detect the presence of a train on a section for block working.

Communication between the two signalboxes these days is often by telephone, but in the past telegraph instruments that sounded bell signals were universal, and these are still used a lot today. The bell code used by IR is described below.

IR's classifies stations according to their role in the block system and their rules for issuing Line Clear indications. See the section on stations for details.

Also see the extracts of IR General Rules on train working.

## Q. What's a token system or a tokenless system?

A token block system uses a physical item (the token) of some sort, such as a ball as in the Neale's Ball token system (see below), which is physically carried or manipulated in some way to indicate permission for a train to enter a block of track. A tokenless system, such as may be obtained by a combination of interlocking and semaphore signals, does not require the train crew to carry or manipulate anything tangible to enter or leave a block of track; they follow the signals and interlocking handles the rest.

(There are also token systems where the 'token' is an electronic radio signal with a code on it that is transmitted to the loco; such systems are not in use in India. E.g., Radio Electronic Token Block working in the UK.)

## Q. What kinds of block instruments are or were used in India?

Neale's Ball Token Instrument
(Click for a larger view.)

In India, the most prevalent form of physical token system to be found in recent decades is the Neale's Ball Token System and variants such as Neale's Voucher Block, Neale's Tablet Token, etc. Other systems such as Theobald Key Token, Webb and Thompson electric token staff, Tyer & Co.'s key token instrument (one-wire three-position instrument and others), etc., were also widely used.

Robert's Key Staff instruments were used to control single lines on the Mysore State Rly. and the Madras and Southern Mahratta Rly. Neale's Ball Token came into wide use in the interbellum years just before Independence. Mr Neale, by the way, was an engineer on the GIPR. Most early block instruments followed British designs and practices.

Neale's token system was innovative when it was introduced, as it combined, for the first time, the token handling system with the block instrument operation into a single system.

Tokenless block instruments aim to do away with the time-consuming process of manually exchanging tokens. Tokenless operation on single lines is more recent, having started in the 1970s. Among tokenless systems used today by IR, common types of block instruments include push-button tokenless single-line block instruments made by the Signal & Telecom Workshops of SR at Podanur, Diado single-line tokenless instruments, Kyosan single-line tokenless instruments, etc.

Tokenless working of double line sections is much older, because of the inherent safety factor of not having to worry about opposing train movements on the same line. For double-line sections, tokenless instruments made by a collaboration between Siemens (Germany) and General Electric Co. (UK) were in wide use; these are still known as 'SGE' instruments although they are now manufactured at the Podanur workshops.

There are also the so-called Double Line Lock and Block instruments (see below for Lock and Block working) which rely on a mechanical route-blocking arrangement activated by the presence of a train, (the wheels depressing a treadle that activates the interlocking to ensure only one train is on a block section at a time — or indeed, even achieving interlocking between signals under the same cabin). Early on different kinds of Lock & Block instruments were in use on heavy-traffic lines in India; instruments were from Sykes & Co. and other manufacturers.

## Q. How do the block or token instruments work?

In manual block working of double lines, the block instruments that connect the two signalboxes (and which dispense the tokens in the case of token systems) have to be coordinated by the signal operators at the two signalboxes.

The signalbox that accepts a train into its block section must first set the *Line Clear* indication on the block instrument which is reflected in an indication in the block instrument of the signalbox in the rear. The signalbox in the rear cannot pull off signals allowing any trains to proceed into the next block section until such a *Line Clear* indication is received. When a train enters the block section, the signalbox in front sets the block instrument to *Train on line*. When the train passes the signalbox in front, the block instrument indication is set to *Line Closed* (also known as *Line Normal* or *Line Blocked*). When there are no trains expected to be approaching or occupying the block section, the normal state of affairs is for the indications on both block instruments to be *Line Closed*.

In single-line token block working, where a train may be accepted in either direction on the same track, instead of *Train on Line* there are two indications *Train Coming From* and *Train Going To*, which are set by the receiving and sending stations appropriately. In sections with track circuits, the cooperation of the receiving station is not required to set *Train Going To*, whereas in manual sections the receiving station must set *Train Coming From* first before *Train Going To* can be set by the sending station.

**Tokenless Block Instruments** With tokenless block instruments, the starting signal is the sole authority to the driver for the train to enter the block section. Therefore, before the last stop signal of the station can be pulled off, the previous train (in either direction for a single line) must be verified to have cleared the section and the signals must have been set back to danger.

Single-line working has the obvious complication over double-line working, in that the direction of working needs to be established for each train. In particular, no permission should have been granted for a train in the opposite direction. A common mechanism used is to electrically interlock the block instruments on either side, so that the block instruments from where *Line Clear* is given is automatically changed to *Train Coming From*. Only then, and with the cooperation of both station masters, can the other block instrument be changed to Train Going To. This may also be interlocked with a Hepper's Key Instrument or an Interlocked Key Box to release a key for the last stop signal of the station from where the train is departing. Both of these can be ensured (as with Lock and Block working, see below) by providing continuous track circuiting, or by providing entry and exit detection using detectors. Alternatively, signals can be interlocked such that the last stop signal can be pulled off for one train at a time by block acceptance or direction lever control.

Push-button type tokenless block instruments operate in Open Block mode (see below) where either station master can obtain *Line Clear* after the previous train has arrived intact. With handle-type and other block instruments, both station masters' cooperation is needed before *Line Clear* can be obtained.

In tokenless single-line sections, the *Train on Line* indication is retained in addition to the other two. The block instruments may be automated in sections with track circuiting, so that *Train on Line* is set automatically when a train enters the block section.

The block instrument usually also dispenses one or more shunting keys which allow interlocked operation of shunting signals between the first and last stop signals of the station, and may similarly also dispense other keys or tokens that allow operation of particular points, connections, and signals so as to ensure that a line that has to be isolated really is free of potential obstruction from other lines.

More recently, these different kinds of token instruments have been coupled with electronic devices known as the **Universal Fail-safe Block Interface (UFSBI)** which accepts input from these block instruments and reproduces the status of the instrument at the other end over a separate channel entirely (usually on the voice channel or a spare channel of a quad cable, OFC, or radio link), to provide additional safety interlocking and fail-safe capability of the token instrument operation. UFSBI devices can work with Neale's token instruments, handle type token instruments, tokenless single-line Diado instruments, and tokenless double-line SGE instruments.

## Q. How is the Neale's ball token system or other physical token system worked?

This system is primarily used for single line routes (although it is seen on others too, e.g. MS-KMU-TPJ). The ball token system relies on the crew's physical acquisition and carriage of a small metal ball to mark a train's permission to enter a section of track. The ball is dispensed by a Token Instrument at either end of the block. The two instruments are interconnected so that at any given time, one and only one ball can be handed out from either of them, ensuring that only one train from either direction can enter the section of track ('block') controlled by them.

The token is dispensed by the token instrument only when the block indication is set to Train Going To (see above) after Line Clear has been granted and Train Coming From has been set by the receiving station. While the ball token is carried by a particular train's crew, no other train may enter that section of the track. The token instruments at either end of the block will not give out any tokens until the token carried on the train currently in the block is returned to one of the token instruments. The block indication at the sending station cannot be changed from Train Going To until then. This is usually supplemented by mechanical interlock systems for the points on successive blocks of the tracks; changing the points at one block causes a notification at the signal box for the next block.

The ball token may be engraved with the station codes for the stations at either end, and usually also has a serial number. IR rules require the loco driver or assistant driver to enter the serial number in a register carried in the locomotive cab. In some variants of the ball token, such as tablet token systems, the token is so designed with different patterns of grooves on it that it cannot be inserted into the token instrument of the next one or two block sections beyond the section for which it was intended (in case it is carried beyond the receiving station in error.

A bell or other telegraph mechanism between signal boxes provides for communication of a few basic messages, such as whether the train is on a block, whether it has left the block, whether permission is granted to enter the block, whether a train has had to stop for an emergency in a block, whether it has had to reverse direction, etc. See the bell code below for the full details.

When a train stops at a station, the driver or assistant driver relinquishes any token they might have carried for the previous section, and picks up the token for the next section.

In case the train is 'passing through', i.e., not stopping at the station, the assistant driver puts on a thick arm protector and leans out of the loco. One of the station staff carries a reed and leather hoop about two feet in diameter with a pouch which holds the token. The assistant driver in one rapid move drops the older token and picks up the fresh token from this man standing on the ground. Then the assistant driver shows the green flag to the station master as well as honks the horn to indicate a good 'pick up'. Then he shouts the token number along with the section name to the driver who enters it in his log. The token is picked up in the night in the same way, except the man from the station also carries a flaming kerosene soaked rag or lights a naphtha flare, to indicate his position in the darkness. A short (3' - 4') upright piece or rail or post, usually all white, sometimes with a stripe or two, and located close to the tracks, marks the position where the person handing out the token has to stand for the token exchange.

Picking up a token by hand is generally done only at low speeds. At higher speeds the hoop holding the token is actually mounted on a pick-up stand; the person on the ground stands next to it with a green flag. A pick-up rod on the side of the loco is positioned in just the right manner to snag the hoop and lift it off while the train is in motion. Impromptu "shock absorbers" made of used hose-pipe lengths were used on the side of the loco to prevent the token from being bumped around excessively thereby possibly breaking the hoop or pouch.

## Q. What happens if lots of trains go in one direction in a section that uses physical tokens, and one station then runs out of tokens?

As may be deduced from the description of token block systems above, there is a problem if the traffic is not symmetric in both directions between the two stations at the ends of a block section. Eventually, one of the stations will run out of tokens to dispense to trains. This condition is known, not surprisingly, as a *token exhausted* condition, and results in all traffic in that direction being suspended until tokens (recovered from the other station) can be refilled in the empty block instrument.

In order to avoid this situation, every so often (depending on the traffic), tokens are taken from the station that is receiving an excess of them and returned to the other one (which is dispensing more than it receives); this is known as *token balancing*.

## Q. What is the bell code used to communicate between signal cabins for block working?

IR's bell code has some points of correspondence with systems used in the UK in the early part of the 20th century. The system of bell codes to convey messages from one signalbox to another is given below. An 'X' indicates a short strike on the bell, and a dash indicates a pause.

**Bell Codes**

| Message | Code |
|---|---|
| Attention | X |
| Line Clear Inquiry | XX |
| Train entering Block Section | XXX |
| Train leaving Block Section, Obstruction removed | XXXX |
| Cancel previous, Cancel last (given in error) | XXXXX |
| Danger or Obstruction | XXXXXX |
| Stop and Examine Train | XXXXXX-X |
| Train passed without tail lamp or missing tail board | XXXXXX-XX |
| Train Divided | XXXXXX-XXX |
| Runaway Vehicle (single line, or double line wrong direction) | XXXXXX-XXXX |
| Runaway Vehicle (double line, right direction) | XXXXXX-XXXXX |
| Instrument test | XXXXXXXXXXXXXXXX<br>(16 beats) |

The acknowledgement for each of these messages is given by repeating the same message immediately.

## Q. What are single line block, twin single line block, etc.?

A **single line** block system has just one track, which may be used for traffic in both directions. Signals are provided for both directions, and the token exchange or other system of interlocking works for traffic going either way. The basic principle is to restrict access to a block of track to a single train at a time, whether going in the up or down direction. [10/02] E.g., Palghat - Podanur section which is one of these increasingly rare single-line sections with bidirectional traffic.

In a **double line** section, each line is dedicated for a given direction, so that the up and down tracks are separate. However, to improve traffic throughput, sometimes the **twin single line** system is adopted, where either of the two lines in a doubled section can be used for bidirectional traffic. Again, as with a single-line bidirectional system, signals are provided for both directions on both tracks. Just before or after a station, track branches to switch from one line to the other are provided, so that traffic on either line is not held up if one of the lines is occupied at the station. The Coimbatore - Palghat (perhaps just the Podanur - Palghat part?) section is an example of twin single-line, as are Morappur - Salem, Dansihpet - Lokur, Yeshwantpur - Bangalore City, etc. These sections tend to have a poorer safety record.

A few sections with heavy traffic have **multiple line** systems. In a **triple line** system as is found in some ghat sections where it is necessary to have multiple lines to segregate slower and faster traffic but there is no room to build four tracks, three tracks are used, and the middle track then acts as a bidirectional single line. In a **quadruple line** there is a pair of up tracks and a pair of down tracks. Sometimes these may allow for segregation of fast vs. slow traffic or suburban vs. long-distance traffic, but not always.

## Q. What is an Intermediate Block Section?

Intermediate Block Sections are provided to increase track usage in areas with absolute block operations where the distances between successive stations are large, causing each block to be very long. The heart of the absolute block system is the idea of only permitting one train ever to be on a block at any time; however, if the block is very long, this restriction reduces the possible traffic on the route.

An intermediate block section is an additional block section which does not necessarily correspond to any station, and which is provided solely to decrease the block lengths. Such intermediate block sections are generally used if block lengths would otherwise be more than about 10-15 km. IR prefers block lengths to be on the order of 4 to 8 km, under normal circumstances.

Normally an intermediate block section is guarded by a single stop signal (and perhaps a distant) which is similar to the Home signal for a station. Once a train has crossed the intermediate signal another train may be allowed into the preceding block, just as with the block sections for stations. An intermediate block is usually controlled by the signal box at the preceding station. E.g., between Dahanu and Gholvad on WR is an intermediate block section, which is controlled by Dahanu in the Down direction and by Ghovad in the Up direction.

Many intermediate sections have automatic signals using track circuitry to detect the presence of a train; however, manual operations are not uncommon. An 'intermediate block post' is a station (a class 'C' station) at the boundary of an intermediate block section. Normally only a stop signal and a permissive signal are used for entry to the intermediate block.

An intermediate block signal is usually provided with a callbox for the driver of a train to talk to the station master or signalman of the controlling station in case the signal stays *on* for long, as the location of the signal may be well out of visible or audible range of the station, making it hard for the presence of the train to be noticed by the station.

If the signal is defective, the driver informs the station master of the station in the rear (controlling the intermediate block), who then obtains a Line Clear notification from the station master of the next station (with exchange of private numbers) and then authorizes the driver to proceed past the defective intermediate block signal (again with exchange of private numbers). If the phone itself is defective, the driver informs the guard and can then pass the intermediate block signal after stopping at it for 5 minutes, and proceeding at 15km/h (at 8km/h in low visibility) to the next station. Once the next station is informed of the defective signal, the station in the rear is also informed of the situation and thereafter the entire stretch between the two stations is treated as a single block section. At that point following trains from the station in the rear will be allowed into the block section with written authorization to pass the defective signal.

Intermediate block sections have no significance for crossing or precedence of trains (express/passenger, freight/passenger) — they are purely provided to decrease the headway or spacing between successive trains. Usually there is no interlocking of any sort provided (i.e., there are no points to route a train differently as the intermediate block signals change, there are no sidings or loops at the signals).

## Q. What do the terms 'block station', and 'halt station' mean?

A *block station* is a station (along with its signalbox) associated with one end of a block section. Each block section has a block station at either end; the block stations control access to the block in either direction. A*halt station* is a station that is not associated with the end of a block section and has no associated signalboxes and no role in controlling the entry of trains into a block section. These usually serve for picking up or dropping off passengers, etc. at intermediate points in the middle of a long block section. The train proceeds on the flag or lamp signal given by the guard of the train; the duration of the halt is prescribed in the working timetables.

## Q. What is a 'block hut' or 'block post'?

A *block hut* or *block post* is a minor station (usually Class C; see section on stations) on a section with light traffic, which does not have the full complement of home and starter signals to control the reception and departure of trains. It often has just a single stop signal, and a permissive signal (a distant) to its rear. Line Clear is not granted to a train until the whole of the last preceding train is known to have passed (complete -- without parting) at least 400m beyond the home signal and is known to be continuing its journey. An*intermediate block post* is a Class C station similar to a block hut on a double line, however in this the signal corresponding to the block post is actually controlled by the signal cabin at the station to the rear, and the intermediate block post is not manned at all. See intermediate block section. The terminology 'Block Hut' in contrast to a block post is often taken to imply that the station or halt is manned.

E.g., on the Howrah - New Delhi line, the Dhanbad - Mughalsarai section (especially around Gurpa - Gujhandi) has many block huts, in some cases with practically every other station or halt being a block hut.

## Q. What is Lock and Block?


Sykes Lock and Block instrument
(Click for a larger view.)

Lock and Block is a refinement of the Absolute Block system which is often used in areas with power signalling. (Although there is no direct connection with power signalling, the availability of electricity makes it possible.) It is especially relevant on double lines where entry of the train to the block section is controlled by taking off the last stop signal of the station in rear. With Lock and Block, the last stop signal cannot be taken off unless line clear has been received from the station in advance, and furthermore, once taken off the signal cannot be cleared a second time with the same line clear authority. In addition, the entry of the train into the block section replaces the last stop signal to danger. Lastly, line clear cannot be given for a second train until the first train has moved an adequate distance ahead of the last stop signal (and the signals have been put back to danger). This does not ensure that the entire train has passed, nor does it guard against train parting just beyond the signal, but does provide some additional safeguards over the basic token-based block operation. Track circuits or axle counters can be used to detect when the train has passed an adequate distance beyond the last stop signal. In early days - starting from the late 19th century, **Sykes Lock and Block** devices were commonly used to implement lock-and-block operation.

## Q. What is Open Block?

The basic token-based Absolute Block system described above has three states: Line Clear, Train on Line, and Line Closed. (Of course, on single-line systems there may be Train Coming From and Train Going To instead of Train on Line). This is also known as Three-Position Block, or Closed Block, because the fundamental assumption is that the block section is closed as the default state, and after a train has been received intact after a Line Clear, the line must go to Line Closed, and a second Line Clear is needed for any further operation. In the Open Block system, the block section reverts to Line Clear after Train on Line, after the train has been received intact. In other words, the default state of the line is open, and either station may send a train on the line without the prior permission of the other station. This, obviously, contradicts a basic principle of Absolute Block working that the station in advance must give permission for a train to enter the block section. The advantage is that some time is saved in not having to ask for and obtain Line Clear - but safety is reduced and this requires careful and vigilant working. Sometimes this is combined with Controlled Manual Block (see below). Push-button type token instruments often work in Open Block mode - either station master can obtain Line Clear directly, after the previous train has been acknowledged to have arrived intact and the instrument has been normalized.

## Q. What is Controlled Manual Block?

Controlled Manual Block is a system where a manually operated block instrument is used for obtaining the Line Clear permission from the station in advance; however, the clearance of the section must first be verified through track circuiting. The block instrument is connected to the track circuits, and it is not possible for Line Clear to be granted unless the track circuits verify the entire block section to be clear of obstruction. Axle counters can be used instead of track circuits as well.

## Q. What's a Moving Block system?

Moving block is a more advanced system usually associated with ATC (Automatic Train Control). As of [1/00], it is not in use anywhere on IR. In moving block systems, a train's position and speed are communicated to control equipment which then computes the appropriate headway to be maintained between and other trains on the same track, and accordingly manipulates the signal aspects and speed controls for the trains on the track. The fine control over the speeds and positions of the trains allows for tight headways and correspondingly high utilization of the track.

## Q. What is Automatic Block Signalling? (What is the Automatic Block system?)

In Automatic Block Signalling (ABS) the signals are automated and operate in conjunction with track circuiting or other means of detecting the presence of a train in a block section. [2/05] As of March 2003, IR had 3,606 kms of track under the ABS system.

When a train enters a block section, the stop signal protecting that block changes automatically to on or the Stop aspect. As the train moves ahead out of that block and into the next block, the signal aspect changes automatically to Caution. In multiple-aspect signalling, when the train is 2 blocks ahead the aspect then changes to Attention, and then to Proceed when the train has passed 3 blocks ahead. In 3-aspect signalling, the aspect changes to Proceed when the train is 2 block sections ahead. In automatic block territory 2-aspect signalling is not used. Each change of a signal to a less restrictive indication requires the train to have moved an adequate distance in advance of the signal.

The gray, white, or silver boxes marked 'LOC CAB' found by the side of the tracks contain the circuitry to accomplish the automatic signal transitions. Any number of automatic block stop signals may be provided in between two block stations; thus with this system, the two stations do not define the ends of a single block section as is usually the case with manual absolute block working (excepting, of course, the case of intermediate block sections). Minimally one automatic stop signal is provided to the rear of a block station's first stop signal.

The Home and Starter signals of a block station must be manual or semi-automatic (see below) even in automatic block territory, and cannot be fully automatic (however, they may still be operated remotely from a central location if the station does not have its own control cabin, as with the Mumbai area sttaions that come under the TMS (Train Management System) centralized traffic control system).

Note: Automatic Block Signalling is an American term and is the same as 'Track Circuit Block' in British terminology; the American influence starting from the 1930s and through the war years on signalling and interlocking developments in India probably led to this usage in India.

**Automatic signals** are normally always in the *clear* position (Proceed aspect), except when the next signal ahead is manually operated, in which case the normal aspect shown is either Caution or Attention. Automatic block signals are provided with a small circular plate marked 'A' (black on white) on the post of the signal or next to it. In contrast to these, **manual signals** are worked by the signal operator and are normally always in the *on* position and have to be explicitly pulled off by the operator.

There are also **semi-automatic** signals which can work either as automatic signals or in manual mode. When working in manual mode, a semi-automatic signal assumes the *on* position automatically when a train occupies a block section ahead of it just like an automatic signal, and can be manually pulled off only after block sections ahead are clear. These are provided with a small circular plate marked 'A' (black on white) which is lit by a white lamp when the signal is working as an automatic block signal and not lit when the signal is being worked manually. The reason for providing such dual-mode signals is that sometimes the signals control diverging lines that are used only occasionally or only at certain times of day (e.g., goods shed lines, industrial sidings). In such cases, it is preferable to keep the signal in automatic mode for the bulk of the heavy traffic passing straight through on the main line, but to change it to manual mode when traffic needs to be diverted off the main line. In addition, semi-automatic signals are also provided at stations with loops where the signals can be set in automatic mode for trains running in quick succession straight through on the main line, and only changed to manual mode for trains that need to be received on the loops.

Gate stop signals in automatic block territory are provided with both a 'G' marker as noted above for gate signals, and also an 'A' marker (white on black). Calling-on signals in automatic territory have the 'C' marker as usual in addition to the 'A' marker, and these are found only at entrances to stations which have their own control cabins to decide the calling-on aspects.

When approaching a fully automatic block stop signal which is *on* in automatic block territory, the train must come to a standstill to the rear of the signal, but then in some cases, after waiting for some time (normally 2 minutes, sometimes varies from day to night -- 1 minute in daytime and 2 minutes at night), if the signal does not change aspect the train may pass the signal at danger at a low speed (typically restricted to 15km/h), with the driver alert for other vehicles or obstructions on the track. This is also allowed on the Mumbai suburban networks when an automatic block signal has failed. Incidentally, fully automatic signals often do not appear on the control panel at the control towers.

**Delayed Signals**: Automatic signals as described above are to be distinguished from *delayed signals* or *time-delay signals* which are also sometimes confusingly called *automatic signals*. These are automatically pulled off after a train has halted to the rear for some predetermined amount of time (using a timer controlled by a track circuit). They are mostly found at brake halts on steep ghat sections. These signals also usually have an 'A' board attached, but they have nothing to do with automatic block working as described above.

Other than track circuiting axle counters are used in some sections to detect the presence of a train in a section and its departure from the section. Intermediate block sections often use axle counters instead of track circuits to detect the presence of a train on the block. Currently [1/01] about 2000 axle counters are used for detection of a train's presence in a section in conjunction with track circuiting, and about 150 axle counters are used for block working by means of automated last vehicle proving.

## Q. What is Permissive Block (or Absolute Permissive Block) Signalling?

Normally, in Absolute Block Signalling, the single-line section between points where sidings or loops are provided must be treated as a single block in order to prevent two trains from entering it at the same time. However, this also reduces track utilization in the case of trains following one another in the same direction.

In these cases, a variant of absolute block signalling is used, called Absolute Permissive Block, where for opposing movements (trains in opposite directions), the single-line section is treated as a single block, whereas for following movements (same direction), the single-line section is treated as a sequence of smaller blocks, allowing many trains to be on the single line at the same time.

This is done by having lineside signals at several points along the single-line, which function as normal block signals for following movements; but for opposing movements, all signals for an opposing train turn 'on' ('stop') for the section of track in front of a train that is already in the single-line section. Permissive block signalling is more often used for freight movements than for passenger trains. Sections with absolute permissive block include Gorakhpur-Chupra (NER) and Bongaigaon-Changsari (NFR).

## Q. What is the 'authority to proceed'?

Authority to proceed is the formal name for the permission or authorization that allows a driver to take a train into a section of track, in either block or non-block systems of working. It is also known as *train working authority*. In places where token block instruments are in use, block tokens constitute the authority to proceed. Normally in tokenless block working the authority is implicit in the aspects of signals, although it may be a paper form if signals are defective or missing, etc., or if signalling has been disrupted by equipment failure, floods, etc. In non-block working or under special circumstances, authority to proceed is physically given to the driver on a paper form, or conveyed to him by telephone or walkie-talkie.

Any form of authority to proceed which is in physical form (token, paper form, etc.) is also known in IR rulebooks as *tangible authority to proceed*, and strict rules govern how it is handled and passed on from one staff person to another.

The following are the most common types of tangible train working authorities in the block system. These are almost always issued on paper forms (except, of course, the block tokens). When these are issued in unusual circumstances (e.g., communications or signalling failure, floods, etc.) in sections where tokenless working is the norm, private numbers must be issued by the station masters concerned along with the paper authority. If communications between stations are disrupted the section controllers can issue paper authority with exchange of private numbers.

- Block token (Neale's ball token, tablet token, electric staff token, or key token)
- Paper Line Clear ticket
- Starting Permit: Allows a driver to take his train on to a block section to begin its journey. Usually references a token number or paper line clear ticket.
- Authority to pass defective signal
- Authority to pass reception signal at On (to enter station limits)
- Authority to pass departure signal at On (to leave station limits)
- Authority to pass signal at On (gate, automatic, semi-automatic, or manual signal)
- Authority for train reception on unsignalled line
- Authority for train departure from unsignalled line
- Authority to proceed in Automatic Block section during prolonged failure of signals
- Authority to proceed without Line Clear
- Authority to proceed without Line Clear in Automatic Block territory
- Conditional Line Clear certificate (granting Line Clear following the reception of a train known to be en route)
- Caution Order (may enforce restrictions, or may cancel previous notices. A Reminder Caution Order reiterates a previous one.)
- Nil Caution Order (notice of absence of special restrictions until the next notice station)
- Guard's authority to work a part load from a section (in case of a train that has parted)
- Guard's permission to Driver to proceed with complete or partial train from mid-section to the next station
- Guard's permission to Driver to return to section from next station, when train has parted
- Authority to enter block section for shunting
- Shunting order when blocking forward
- Shunting order when blocking back
- Line Clear certificate for trolley / motor trolley / motor lorry
- Line Clear certificate (double line) for trolley / motor trolley / motor lorry
- Authority for trolley / motor trolley / motor lorry to enter block section without Line Clear certificate.

In non-block systems of train working, the following kinds of authority to proceed are used:

- Authority to Proceed, Following Trains system
- Pilot-guard Ticket
- Train-staff
- Train-staff Ticket
- Metal Token for One Train Only system

## Q. What is a Private Number?

A Private Number is a number, obtained over the telephone or telegraph from the station master of the station granting Line Clear or requesting points to be set or signals to be pulled off. This number is noted on the paper forms such as the Line Clear Ticket or Conditional Line Clear Certificate and can be verified later at the receiving station (the one granting Line Clear) or requesting the signal or points change. This is an additional safety device.

Private numbers are printed or typed up in advance on booklets which are supposed to remain in the custody of the station master or his immediate staff. In theory, it is not possible for anyone outside the station master's office to predict the next private number that will be issued since they are pseudo-random in nature and do not follow any sequence or pattern. Hence, the verification of the private number provides a good confirmation that the action it refers to was performed correctly and not in an unauthorized manner. Under rare circumstances, two consecutive private numbers may turn out to be the same or nearly so; in this case the second one is cancelled and a new one issued by the station master.

In addition to blocking or clearing trains, private numbers can be used to confirm control messages for rerouting trains, permitting unusual movements such trains on the wrong line, issuing new speed limits directly through the control office, or exchanging any other messages between section controllers and station masters. For instance, notifications of temporary speed restrictions, temporary line blocks or power blocks, etc. Another case is that of closing the gates for road traffic at non-interlocked level crossings (in this last case, private numbers are generally used only when the level crossing is on a block section and not within station limits).

Security buffs will note that while the possession of a valid private number shows that the action performed by someone was authorized, it is not an entirely fool-proof system. In particular, the system does not guard against impersonation (the person to whom the private number is revealed may not be who he says he is, or the person providing the private number may not be the one authorized), nor does it provide non-repudiation (the person who is given the private number can disown having obtained it) or spoofing (there is no way for the person who receives a number to verify that the number provided is a legitimate private number before acting upon it). Hence, mechanical or other interlocking systems are still used in conjunction with private numbers.

# Non-block train working

## Q. What other forms of train working are used on IR other than the block system?

IR on occasion uses the following systems of train working:

**Following trains system**

In this system, trains are worked between two stations by dispatching them one after the other (all in the same direction) at specific intervals (generally at least 15 minutes). The trains are run at specific speeds (less than 25km/h). This ensures that there should only be one train in every 5km stretch in the section between the stations. The maximum number of trains simultaneously present in the section is restricted to 4.

Trains are dispatched only after the station masters of both stations have been in communication and have agreed upon the number and timing of the trains. The driver of a train being dispatched in this system must carry written authorization (*Authority to Proceed, Following Trains System*) specifying the destination, speed, and details of preceding and following trains on the section.

This system was introduced in many areas as an emergency measure in 1941 in order to cater to the urgent wartime needs of the railways in India. It is still used in some areas when there is a requirement for large unidirectional movements of many freight trains (also known as the *Corridor System*).

**Pilot guard system**

Here, a *pilot guard*, a specially authorized railway official, accompanies the train (he is said to pilot the train). As above, a train is not dispatched until at least 15 minutes (usually) have elapsed since the preceding train, and speeds are limited to 25km/h.

The pilot carries written authorization (*Pilot Guard Ticket*) with the destination, departure time, and speed of the train, which has to be handed over to the station master at the destination station. Only one pilot guard is allowed to be on duty for a section at any given time, of course. Rarely, the driver or guard of the train may carry the ticket and the pilot may not actually accompany the train. (Usually the case if two or more trains are to leave together from one station under this system, in which case the pilot guard travels on the last one.)

The pilot guard system is used when it has been agreed upon earlier that trains will be dispatched in a specific direction using the system, but the precise times are not known in advance and communication cannot be established with the destination station immediately prior to sending the train out.

**Train-staff and ticket system**

This system is used when it is necessary to send trains in both directions between two stations on a single line. A single *train staff* is used, and trains may only be dispatched from the station which has physical possession of the train staff.

If several trains in one direction are to be dispatched, they are spaced in a manner similar to the Following Trains system, and each driver except that of the last train is handed a *train staff ticket* authorizing him to proceed. (Technically, the driver is also supposed to be shown the train staff before proceeding). The driver of the last train physically carries the train staff along with him in the locomotive. (This is similar to the pilot guard system except that the train-staff replaces the pilot guard's physical presence on board the locomotive). No other train can then be dispatched from that station.

The driver then hands the train staff over at the destination station. From that point onwards that station can start dispatching trains in the other direction in the same manner. Hence the train staff acts as a guarantee that trains are not simultaneously dispatched in opposite directions. E.g., Tilwara - Tilwara Mela (NR).

**One train only system**

In this system, as the name implies, there is only one locomotive being worked at a time in the (single-line) section between two stations, or a single station and a spur section of track with no station at the other end. One of the two stations at either end (or the sole station if there is only one) is designated the *base station* for the section. The loco may be dispatched light or with a vehicle load in either direction at any time.

The driver carries a metal token given to him by the station master of the base station. The token may also be in the form of a wooden baton. The token identifies the section for which it is valid. Of course, only one such token should ever be in use at any time on the section. (Rarely, written authorization is provided instead of the token.) This system is usually employed only for short single-line spurs, and not on through lines. E.g., Batala - Qadian, Nawan Shahr - Rahon, Ratangarh West - Sardar Shahar, Garhi Harsuru - Farukhnagar.

A variant allowing one locomotive at all to be present (no other locomotives are even allowed to be brought into the station limits) called One Engine Only system was in effect between Rajka Ka Sahaspur and Sambhal Hatim Sarai. (All these are on NR.) This system is also used sometimes on new tracks where pointwork or signalling construction is not yet finished.

In Jan. 2004, the second phase of the Chennai MRTS began operation with the One Train Only system between Thiruvanmiyur and Thirumayilai because points for turnouts / sidings were not yet ready across a stretch of 9 stations.

**Section Clear**

In this system, permission to approach a station is given to a train only when the line is known (manually verified) to be clear up to the first stop signal of the station. The driver is given written authorization as the authority to proceed.

Also see the extracts of IR General Rules on train working covering these non-block systems.

# Railway Operations - II

Contents



## Caution Orders, Restrictions, and Blocks

### Q. Why do trains sometimes slow down on some sections instead of continuing at the same speed throughout?

There are many reasons for a reduction in speed. There may be **permanent speed restrictions** on the section of track: because of sharp curves or curves with inadequate cant; approaches to crossovers, diamonds, etc.; structures too close to the track; ghat sections; lineside tenements or pedestrian traffic; level crossings; old bridges or culverts; inferior track or lighter rails than normally required; unstable trackbed; frequent threat of flooding, etc. The working timetable usually has a detailed list of these restrictions for all sections within a division.

There may also be **temporary speed restrictions** (also simply temporary restrictions) such as **engineering speed restrictions** because of construction work or track maintenance, or because of flooding or other track damage, etc., all of which necessitate following the appropriate **caution orders** or caution notices in force for the section. See below for more on this. Sometimes newly-laid track may not yet have been certified for higher speeds while lower speed traffic is allowed.

### Q. What is a caution order?

A Caution Order (or caution notice) is a written notice issued by a station master (or other official) to the driver and guard of a train, formally advising them of special conditions and restrictions in effect on the section of track that the train is about to enter. The Caution Order may have instructions on speed restrictions and other special procedures to be followed on account of damage to the tracks, flooding, work on the permanent way or on the electrical equipment, accidents (or reminders of spots where accidents recently occurred), work on or damage to OHE equipment, or unusual situations.

A caution order can also be issued to advise the driver and guard of the presence of manually operated or motor trolleys, tower cars, MOW wagons, or other such maintenance or emergency vehicles that have entered the block section ahead. The caution order usually specifies the location of the affected section of track, the temporary speed limits in effect, the locations of caution indicators and termination indicators, etc.

Some representative examples of caution orders are the following:

- Track doubling in progress - whistle to alert men at work
- Track destressing - 20km/h
- New colour-light signal location
- Level crossing gate - no acknowledgement given; be prepared to stop if gateman does not display hand signal
- Accident spot - 75km/h
- Up distant signal number ... of station ... inoperative due to a cable break; keep a good look-out, whistle while approaching and Proceed

A caution order is generally issued by the station master of of a station adjacent to the block section which is affected. In addition, divisional caution orders are also issued by station masters of certain specified stations on the route, known as **notice stations**.

A caution order is specifically addressed to the driver and guard of a particular train identified on it. Separate caution orders are issued for each train passing through on to the affected section. At many of the larger stations nowadays the caution orders are printed out but at smaller stations, handwritten notes still prevail.

A **nil caution order** is issued by a notice station to inform the driver and guard of a train that there are no special caution instructions or temporary speed restrictions in effect between that station and the next notice station. A **reminder caution order** may be issued by a notice station to reiterate caution orders already issued by other stations or authorities.

,409(in lieu of proper caution order)

| मध्य रेल | सतर्कता आदेश , आमला..इटारसी | Central Railway |
|---|---|---|
| नागपुर मंडल | CAUTION ORDER-* AMLA–ITARSI | Nagpur Division |
| गाड़ी क्र/Train No.* | [illegible] | DATE - दिनांक |
| | 2 [illegible] 250 [illegible] | 25-04-2007 |

To The Driver of Train No. * you are hereby instructed to exercise following cautions between आमला..इटारसी AMLA–ITARSI section as under

Note :- Driver to be cautious while working OT rakes, Avoid jerks, sudden braking on turnout, curvature & Ghat Section

Note : DRIVER TO REMAIN VIGILANT IN THE GHAT SECTION FOR ANY LAND SLIDES, BOULDER FALLING ON TRACK ETC & BE PREPARED TO STOP SHORT OF SUCH OBSTRUCTION IF ANY HE WILL ALSO CONTACT S.M. ON DUTY AT NEXT STATION AND REPORT SUCH INCIDENT FOR NECESSARY ACTION.

| S. No. | Section From | Section To | Kilometer From | Kilometer To | Speed KMPH | Cause | Date of Imposition | Date of Cancellation |
|---|---|---|---|---|---|---|---|---|
| 1 | आमला AMLA | यार्ड YARD | 874/03 | 874/01 | 75 | Consolidation. | 22-04-07 wef 0800 | TFA |
| 2 | बरसाली BARSALI | यार्ड YARD | 865/23 | 865/21 | 70 | Dekayed wooden sleeper in T/Out | 20-04-07 wef 0800 | TFA |
| 3 | मरामझिरी MARAMJHIRI | धाराखोह DHARAKHOH | 841/47 | 841/35 | 45 WF OEHS SIR | Cutting Removal | 13-04-07. wef 0800 | TFA |
| 4 | मरामझिरी MARAMJHIRI | धाराखोह DHARAKHOH | 839/15 | 838/13 | 30 WF OEHS SIR | Distressing Work. | 25-04-07. wef 0800 | TFA |
| 5 | मरामझिरी MARAMJHIRI | धाराखोह DHARAKHOH | 837/37 | 836/45 | 30 WF OEHS SIR | Distressing Work. | 23-04-07. wef 0800 | upto 0800 of 25-04-07 |
| 6 | धाराखोह DHARAKHOH | घोड़ाडोंगरी GHODADONGARI | 829/15 | 829/13 | 30 WF OEHS SIR | Repair of Bridge Work. | 25-04-07. wef 0800 | TFA |
| 7 | बरबतपुर BARBATPUR | यार्ड YARD | 803/09 | 803/07 | 20 WF OEHS SIR | R/Ment of T/Out of P/No. 105-B | 23-04-07 wef 0900 | TFA |
| 8 | ताकू TAKU | यार्ड YARD | 766/23 | 766/21 | 75 | Consolidation. | 05-04-07 wef 0800 | TFA |
| 9 | किरतगढ़ KIRATGARH | यार्ड YARD | 755/13 | 755/11 | 50 WF OEHS SIR | Fish Plate Joints Broken | 24-04-07 W I E | TFA |
| 10 | इटारसी ITARSI | यार्ड YARD | 744/22 | 744/24 | 20 WF OEHS SIR | Derailment on P/No. 235 & 236 | 14-04-07 W I E | TFA |

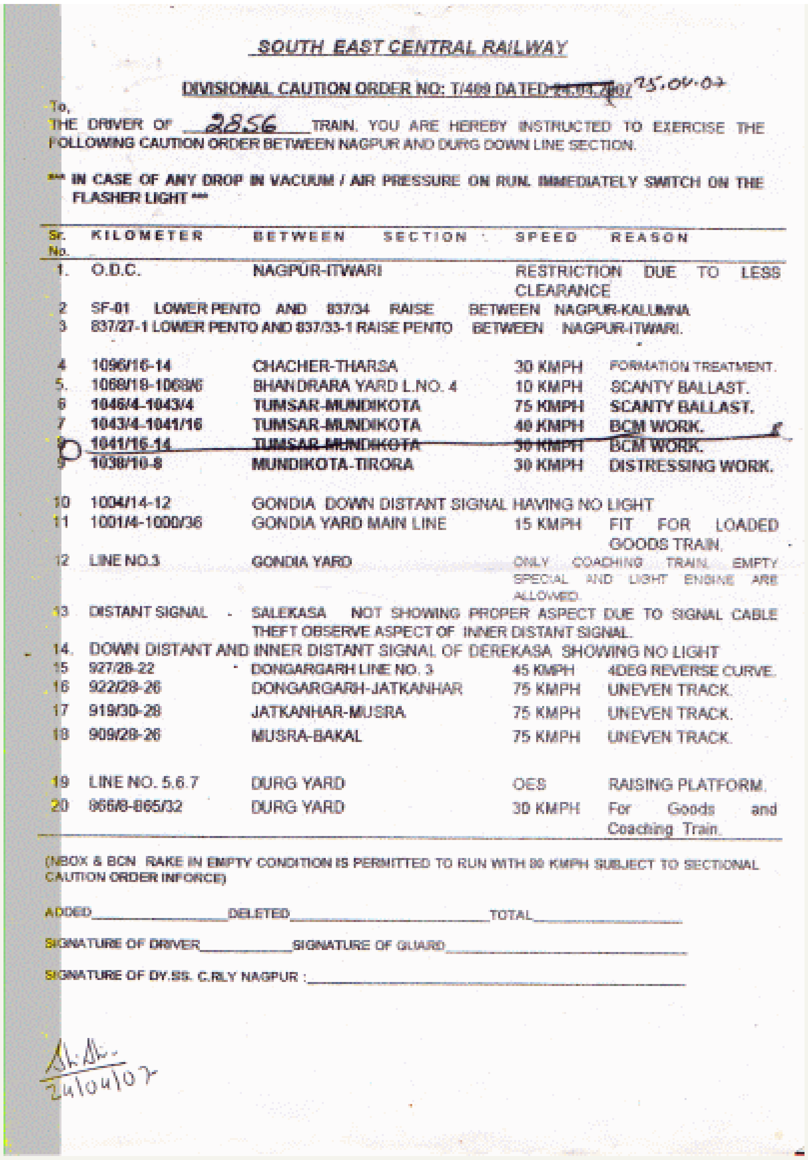
दिनांक Date- जोड़ा Added घटाया Deleted- कुल.. Total-

चालक के हस्ताक्षर Signature of Driver

गार्ड के हस्ताक्षर Signature of Guard

उपअधीक्षक के हस्ताक्षर Signature of Dy.-SM & Station Stamp

*Caution Order, Amla-Itarsi, April 2007. Click for a larger view.*



**SOUTH EAST CENTRAL RAILWAY**

**DIVISIONAL CAUTION ORDER NO: T/409 DATED ~~24.04.2007~~ 25.04.07**

To,
THE DRIVER OF 2856 TRAIN. YOU ARE HEREBY INSTRUCTED TO EXERCISE THE FOLLOWING CAUTION ORDER BETWEEN NAGPUR AND DURG DOWN LINE SECTION.

*** IN CASE OF ANY DROP IN VACUUM / AIR PRESSURE ON RUN. IMMEDIATELY SWITCH ON THE FLASHER LIGHT ***

| Sr. No. | KILOMETER | BETWEEN SECTION | SPEED | REASON |
|---|---|---|---|---|
| 1. | O.D.C. | NAGPUR-ITWARI | | RESTRICTION DUE TO LESS CLEARANCE |
| 2 | SF-01 LOWER PENTO AND 837/34 RAISE BETWEEN NAGPUR-KALUMNA | | | |
| 3 | 837/27-1 LOWER PENTO AND 837/33-1 RAISE PENTO BETWEEN NAGPUR-ITWARI. | | | |
| 4 | 1096/16-14 | CHACHER-THARSA | 30 KMPH | FORMATION TREATMENT. |
| 5. | 1068/18-1068/6 | BHANDRARA YARD L.NO. 4 | 10 KMPH | SCANTY BALLAST. |
| 6 | 1046/4-1043/4 | TUMSAR-MUNDIKOTA | 75 KMPH | SCANTY BALLAST. |
| 7 | 1043/4-1041/16 | TUMSAR-MUNDIKOTA | 40 KMPH | BCM WORK. |
| 8 | ~~1041/16-14~~ | ~~TUMSAR-MUNDIKOTA~~ | ~~30 KMPH~~ | ~~BCM WORK.~~ |
| 9 | 1038/10-8 | MUNDIKOTA-TIRORA | 30 KMPH | DISTRESSING WORK. |
| 10 | 1004/14-12 | GONDIA DOWN DISTANT SIGNAL HAVING NO LIGHT | | |
| 11 | 1001/4-1000/36 | GONDIA YARD MAIN LINE | 15 KMPH | FIT FOR LOADED GOODS TRAIN. |
| 12 | LINE NO.3 | GONDIA YARD | | ONLY COACHING TRAIN, EMPTY SPECIAL AND LIGHT ENGINE ARE ALLOWED. |
| 13 | DISTANT SIGNAL - | SALEKASA NOT SHOWING PROPER ASPECT DUE TO SIGNAL CABLE THEFT OBSERVE ASPECT OF INNER DISTANT SIGNAL. | | |
| 14. | DOWN DISTANT AND INNER DISTANT SIGNAL OF DEREKASA SHOWING NO LIGHT | | | |
| 15 | 927/28-22 | DONGARGARH LINE NO. 3 | 45 KMPH | 4DEG REVERSE CURVE. |
| 16 | 922/28-26 | DONGARGARH-JATKANHAR | 75 KMPH | UNEVEN TRACK. |
| 17 | 919/30-28 | JATKANHAR-MUSRA | 75 KMPH | UNEVEN TRACK. |
| 18 | 909/28-26 | MUSRA-BAKAL | 75 KMPH | UNEVEN TRACK. |
| 19 | LINE NO. 5,6,7 | DURG YARD | OES | RAISING PLATFORM. |
| 20 | 866/8-865/32 | DURG YARD | 30 KMPH | For Goods and Coaching Train. |

(NBOX & BCN RAKE IN EMPTY CONDITION IS PERMITTED TO RUN WITH 80 KMPH SUBJECT TO SECTIONAL CAUTION ORDER INFORCE)

ADDED________ DELETED________ TOTAL________

SIGNATURE OF DRIVER________ SIGNATURE OF GUARD________

SIGNATURE OF DY.SS. C.RLY NAGPUR :________

24/04/07

*Caution Order, Nagpur-Durg, April 2007. Click for a larger view.*

## Q. What are speed restrictions and engineering restrictions?

These are various kinds of speed limits below the normal sanctioned speed limit for the route section in question, imposed in stretches of track where unsafe conditions exist because of track damage, ongoing repair work to track or OHE, accidents, or unusual circumstances in the construction of the permanent way (see above).

A **temporary engineering restriction** is specifically one that is imposed for a fixed duration on account of ongoing work on the permanent way or OHE equipment; a **permanent engineering restriction** is one that is in effect indefinitely because of characteristics of the permanent way. Other temporary speed restrictions may be imposed because of flooding, track damage, accidents, etc. A **stop dead** restriction is one which requires a train to come to a complete halt before obtaining permission to proceed.

For short-duration (1 day or less) temporary speed restrictions, hand signals are used at appropriate points (30m to the rear, and 800m (more in some cases) to the rear) to advise drivers of the location of the restriction. For a short-duration stop-dead restrictions, a red banner flag is placed across the tracks just before the obstruction, and another banner flag is placed beside the tracks 600m (BG; 400m for MG/NG) before the location of the affected portion of track. Three detonators are also placed 10m apart, about 1200m (BG; 800m for MG/NG) before the banner. Hand signals are used 30m to the rear of the obstruction and 45m to the rear of the detonators.

For longer temporary speed restrictions (lasting more than a day) a speed indicator is placed 30m to the rear of the affected portion, and a caution indicator 800m (or more in some cases) to the rear. For longer stop-dead restrictions, the speed indicator is replaced by a stop indicator, whereas the caution indicator is placed 1200m to the rear (BG; 800m for MG/NG).

Normally the driver and guard of a train are issued caution orders that provide details of the temporary restrictions. Caution orders are not issued for permanent restrictions of any kind.

The caution or stop indicators, banner flags, hand signals, and speed indicators are all dispensed with if the affected portion of track is within station limits and if it can be appropriately isolated by the settings of points and leaving signals protecting it 'on' (at danger). The caution indicator is also dispensed with if the affected portion of track is protected by an automatic signal less than 1200m (BG; 800m MG/NG) from the obstruction. In this case the detonators and banner flags are placed at 180m and 90m to the rear of the obstruction for a stop-dead restriction.

## Q. What are blocks? Line blocks, power blocks, etc.?

A block is a bar on through traffic entering a particular section of track. It may affect only certain kinds of traffic, or may close the tracks to all trains; it may affect one track of a double line or multiple line, or may affect all tracks up and down. A block is used when work of a more involved nature is undertaken and speed restrictions are not suitable because through running on the affected line is not possible.

The simplest is a **line block**, or **traffic block**, which blocks a particular track (or tracks) when repair or construction work has to be carried out on the permanent way, points, crossings, interlockings, OHE, signalling equipment, etc. Such blocks are sometimes also called **possession blocks** (since the permanent-way staff 'take possession' of the tracks).

A line block is requested by the engineering official in charge, and granted by the Divisional Railway Manager. The station master of a station adjacent to the affected block section receives a copy of the line block order from the DRM, and he decides when to implement the line block. In busier sections the Section Controller is also involved in deciding when to impose the line block. In some cases, if the traffic disruption is extensive and the block is required for longer than usual, necessitating much rerouting and rescheduling of trains, the block is termed a **megablock** (or 'mega block').

The guard of the last train that is to run through on the section before the line block comes into effect is given the notice from the station master that the line block will come into effect as soon as that train leaves the block section. A caution order is also issued to the driver of this last train, advising him to look out for a stop indicator or signal from the engineering crew. When stopped by the engineering crew, a copy of the line block certificate is handed to them. Once the last train clears the block section, the block instruments are set to line blocked status and remain so until the block is removed.

A **power block** is a bar on all traffic using electric traction, on account of work on the OHE equipment. In addition to the station masters and Section Controllers, the Traction Power Controller has to coordinate when the electricity supply to the catenary in the affected section is to be shut down. A **power and traffic block**bars all traffic, not just electric traffic, on the section when work is being done on the OHE. A **programmed power block** is a power block imposed on a regular schedule as part of the routine maintenance regime for the OHE.

An **emergency power block** is imposed when accidents or other occurrences cause damage to the OHE or defects are noticed. An emergency power block may also be requested by the driver of an electric loco when it is urgently necessary to perform repairs or inspection of the pantographs and other electrical equipment (especially on the roof of the cab) while the loco is in a block section.

A **local block** is a block for a siding or loop or other line which is not a main running line. (Similarly, **local power block**.)

## Unusual situations and block protection

(Also see the extracts of IR General Rules on accidents and other extracts from the IR General Rules on train working.)

### Q. How are communications or signals failures handled?

In case of signalling equipment or block equipment failure (e.g., power failure, floods), if communications can be established between adjacent stations (by telephone on the public network or control telephones of the railway network, or in the past, by telegraph or bell code), paper line clear tickets may be issued to trains to proceed. Such paper authority is given along with issue of private numbers by station masters to establish proper authorization, authentication, non-repudiation of the action. Paper or verbal authority to proceed (with issue of private numbers) can also be given by section controllers if communications have broken down between adjacent stations.

If there is a total breakdown of communications, the station master of a station can still issue a paper authority to proceed to the first scheduled train departing a station, subject to a restriction to run at or under 15km/h and a requirement to sound the horn or whistle freely to alert any possible oncoming train.

## Q. How are trains run when tracks are flooded?

Flooding is very dangerous to the permanent way. The earthworks become unstable, ballast can be washed away, and the forces of the water by its movement, buoyancy, and scouring action can seriously weaken and move the track so that it is no longer stable and secure enough to support the weight of a train reliably.

Hence, great care is taken when flood waters rise and affect a railway track. If the trackbed is known to have been laid in a stable manner (or specially built to withstand floods in a flood-prone area), certain rules of thumb are adopted. If the water level does not cover the ballast and the track can be seen to be undamaged, trains may in general move (with caution) over the affected sections. When the water level rises to cover part or all of the ballast, special operating rules go into effect, which differ based on local conditions.

In some divisions, the rules are that if the water does not cover the rails, it may be piloted across with gangmen walking ahead of it and observing the track as it comes under load; while if the water is above the rails, gangmen may have to inspect the entire length of flooded track first and issue a written certificate providing the driver of the train with authority to proceed.

In flood-prone areas like Mumbai, the tracks are built to withstand a certain amount of flooding. In such cases, the rule is generally that trains can proceed (with caution) on flooded track even if the water is a few inches above the rails, as long as the rails can be seen. E.g., on WR, for water less than 3" above rail level diesel locos are operated at 5km/h, and electric locos at 15km/h. Electric locos can be operated at 8km/h up till 4" of water, while diesel locos (WDM-2) must not be operated if the water level rises above 3".

For each class of locomotive, there is a certain height of water beyond which it absolutely cannot proceed on flooded track as its equipment may be damaged otherwise. For instance, diesel locomotives of the WDM-2 class are not to be used if the water level above the rails is more than 3".

## Q. How are trains run in the fog?

Due to restricted visibility in thick fog which pervades northern India in particular during the winter months, trains are known to get delayed and schedules get thrown haywire. Obviously, these delays have their genesis in the fact that the drivers can't see the signals at sufficient distance and have to reduce speeds when approaching signals, so as to be able to take action considering the aspect of the signal as and when it becomes visible.

Earlier, drivers used to check their speeds based on their own judgment and feel. This led to some drivers being exceedingly slow out of caution, while others occasionally overshot signals out of an anxiety to not be seen as 'dragging their feet'. Northern Railway decided to lay down instructions as to how the drivers should move in fog. These instructions are given below.

**Northern Railway : Train Operation during fog**

Automatic Block System: In automatic signal territory, the maximum speed of a train is restricted to 30km/h during dense fog. Depending on the severity of fog, the driver is expected to control the speed of a train and restrict it further if necessary.

Absolute Block System: The maximum speed of a train is restricted to 60km/h in absolute block system territory in dense fog, and depending on the severity of fog, the driver is expected to control the speed of the train and restrict it further if necessary. Further, special rules are in effect as follows:

- No train awaiting line clear should be advanced beyond the starter signal.
- No shunting is to be carried out on non-isolated lines in a yard after giving line clear to a train.
- All IBH in semaphore signal territories are shut down and converted to single block sections for the duration of the fog.
- Fog signalmen are provided to place detonators 270m in the rear of the first stop signals so as to give the drivers an audible warning of the proximity of the stop signal. *(See below.)*
- Lime markings are made across the tracks at the signal sighting boards.

Although the final decision on the speed rests with the driver, the upper bounds of 30km/h or 60km/h help them in deciding the appropriate speed, and also allow the operating department staff make better projections in publishing the revised schedules of trains in foggy weather.

**Detonators in foggy weather**

Detonators are used in foggy weather or otherwise when visibility is severely impaired, to provide an audible indication to the locomotive crew that the train is approaching a signal. These detonators are flat, disc-shaped metal containers, usually coloured red, which contain an explosive mixture that detonates with the application of pressure (and therefore when the wheels of the locomotive pass over). A detonator is attached to the top of the rail using a metal clasp at the bottom of the detonator. These detonators normally have a shelf life of 7 years, although this can be extended to 10 years with annual inspections.

It is the station master's responsibility to assess whether visibility is impaired badly enough to warrant the use of detonators. At each station, there is a nominated **Visibility Test**

**Object** (VTO) that is used to gauge visibility. A VTO, which must be at least 180m away, may be a post specially erected for this purpose, with a lamp for the night; or the arm (during the day) and backlight (at night) of a semaphore signal; or the light of a fixed colour light signal (day and night). If the VTO is not visible, then it is necessary to use detonators on all running lines of the station.

Detonators are placed in pairs - 10m apart - at a distance of 270m in the rear of the signal to be protected, which is usually the outermost signal on the approach to a station (in double distant territory, the detonators are placed 270m to the rear of the inner distant signal). Usually, fog signal posts are erected to mark the locations. Recently [11/04] IR has begun erecting shelters by the side of the track as well, for the benefit of the staff who have to stay there to replace the detonators as each train passes by.

The detonators have a safety radius of about 45m; staff must remain outside this distance from the detonators when they explode, to avoid injury; and locomotive crew also take care not to lean out of the cab on approach to stations when there is a possibility that detonators may be in use.

Deploying the detonators is considered a critical safety-related activity, hence the station master is authorized to call on all available staff for this, even off-duty staff if necessary. During prolonged foggy periods or if there are not enough station staff, the permanent way gangs can also be pressed into service for this.

## Q. When can trains be run without brake vans or without guards?

Normally, all trains are required to have a brake van or guard's van and a guard on board. However, in a few cases the brake van and the services of the guard can be dispensed with, especially in sections where block sections are completely track-circuited, which reduces the possibility of undetected train parting. Brake vans can also be dispensed with on specially designated short sections (typically, less than 30km, as with Northern Railway) even without track circuiting; however in this case a guard must usually accompany the train. The pre-conditions for this are as follows:

- The last vehicle must have a tail lamp or tail board.
- When the train is granted Line Clear, the number of the last vehicle must be recorded and conveyed to the section control and also to the adjoining station.
- The train must stop at every station along the way and the number of the last vehicle must be recorded and conveyed to section control.
- The guard must travel in the leading locomotive, or in the banker if one is provided. Note that a banker is required for operation without a brake van if the grade is steeper than 1 in 200.
- The weather must not be foggy or stormy.
- There should not be any break of communications along the line.

- Single-line working should not be in force if the section is a double line section.

## Q. What are the train working procedures in case of accidents, derailments, etc.?

(Naturally, there are well-defined rules on obtaining medical help and emergency services, etc. in the case of accidents, and assisting injured people and preventing further injury or death takes the highest priority. But here we focus only on train working guidelines which come into play for accidents.)

The general principle is to protect the train that has been involved in the accident: this is done by ensuring the block section remains closed to further traffic, and by providing additional temporary signals in the form of flares, detonators, banners or hand signals (lamp/flag), etc. to prevent any train from colliding with the train involved in the accident in case signals have been pulled off at the station at either end, or in case there is a signal failure due to the track circuit not being tripped.

Detonators are placed as follows: one 600m from the train, and three about 1200m from it, 10m apart (on the other gauges the distances are 400m and 800m). If the section is a double line section, the other line is also protected similarly if there is any chance that it might be fouled by the accident or derailment. Passing trains on the other line must be stopped and given information about the accident. The guard is technically responsible for the protection of the train and the adjacent line(s).

The engine crew also help in this, and also ensure that parking brakes are set and the locomotive parked in a safe condition if possible. (If the locomotive is in working condition and can be detached from the train, it may be used to travel ahead to the point where the detonators need to be placed on the track.) The driver also switches on the flasher light of the locomotive (if provided), and sounds the horn in a danger signal. If the loco does not have a flasher light or if the flasher fails, if it is necessary to warn an oncoming train the headlight is flashed on and off.

The flasher on the brake van or guard van (if provided) is also activated to warn trains from the rear. The guard and the engine crew also then attempt to contact the nearest station by telephone or other means, if no passing train could carry the information.

Once information about the accident is received, the signalman or station master of the adjacent station sets the signals to On and the block instruments to 'Train on Line', and locks the equipment in that position in order to prevent any other train from being granted permission to enter the section. This is done for both (all) lines on a double (multiple) line section irrespective of the line on which the accident occurred, until it is established that the other line(s) is (are) not fouled.

Normally, even without notification of an accident, if a train is unusually delayed (within 10 minutes of its normal running time), the station master is expected to inform the stations ahead and to the rear and arrange for signals to be left at On and the block section protected. Passing trains on other lines are stopped and informed about the possibility of an accident. If the accident causes the catenary or one or more lines to be damaged, a power block may be applied. Where provided, the emergency siren at the station may be sounded, or other means of notification used to set accident-relief plans in motion.

*Assisting locomotives* or accident relief trains are given authority to proceed without Line Clear into the block section where the disabled train is, as well as authority to pass a signal at danger (the last stop signal of the station) (unless on double or multiple line sections where the assisting train is moving in the wrong direction on the other track).

A caution order is also issued which advises the driver of the assisting train of the location of the disabled train, and the station to which it should be taken if it is to be moved. If the disabled train is moved, the assisting train is governed by the stop signals of the station to which it is being taken, or, if on the wrong line of a double/multiple line section, it draws up almost to the last stop signal (facing the other way) and waits for the signal to be pulled off or written authority to proceed past the signal at danger to be granted by the station master of the next station.

## Q. How are runaway vehicles and out-of-control trains dealt with?

In case of trains passing signals at danger or running through a station out of control, or moving on block sections without authority to proceed, the station master must inform the next station ahead of this occurrence (and on controlled sections must inform traffic control). The station master of that station then sets its departure and reception signals to On, and sets the points to a clear line (likely the main running line if it is clear).

In sections under traffic control, the section controller may set the departure and reception signals, for several stations along the way, to On as a precaution. Signals for adjacent lines on double or multiple sections are also set to On as there is a danger that the runaway vehicles may derail on the block section and foul adjacent lines.

Detonators are provided on the line to alert the driver if the runaway has a locomotive with a driver in it. If it is suspected the train is completely out of control and the driver perhaps disabled, points may be set for sand traps or catch sidings in order to stop the train, but usually not if there are passengers in the train except in extreme circumstances. If the runaway consists of just one or two vehicles, it is usually derailed promptly by using diverting it to a sand trap or catch siding, or even a dead-end siding or loop line, or using derailing blocks. If necessary, a sleeper or other obstruction is placed on the track.

In areas where the exchange of flag signals between the guard or driver and the station crew or signal staff when a train passes through a station is mandatory, the failure by the guard to display the all-right signal causes the train to be considered a potential runaway and subject to being faced with On signals ahead of it.

## Q. How is train parting dealt with?

If a train parts en route with a coupler failure, the guard uses his brakes to attempt to slow down his portion of the train to a safe halt. (If the train is being banked, the banker brings the train to a halt on seeing the guard's signal, and also sounds a danger signal to attract the attention of the driver in front.) If the front portion of the train has not yet departed from view, the guard can also use a flag or lamp signal (green, waved strongly up and down) to attempt to indicate to the engine crew that the train has parted.

Often the driver will notice the train has parted from the break in the continuous brakes (leading to a loss of brake pressure and also auto-regression of the master controller) and also the reduced load on the locomotive. Or, if lucky, the crew may happen to look out and spot the guard's signal. (Under normal circumstances, the driver or his assistant always look back from the cab periodically to visually check that the rake is whole and has no obvious problems, especially on curves when all the coaches or wagons are visible.) In any case if the driver notices the train has parted, he brings his portion of the train to a halt. If the two portions of the train are close by, and it is possible to couple them together, the train may then proceed normally as a whole train. If it is not possible to couple the portions together, normally the guard can give the driver written authority to proceed with the front part of the train.

The guard also decides whether the same locomotive should return to assist and move the remaining portion of the train, and gives the driver written instructions to this effect. The driver hands over any tangible authority to proceed that he had been carrying (token, staff, or written authority to proceed) to the guard. The driver takes the partial train to the next station, while the guard stays with the rest of the train after protecting it at the rear with flares, detonators (placed as described above) and possibly using hand signals (flag/lamp) to alert oncoming or passing trains. In bad weather or with poor visibility the front of the train is also protected. Parking brakes are applied where provided, on all the vehicles of the train portion.

In rare instances, an engine failure or loss of power, or a train stalled on a gradient, may require that a train be deliberately parted by uncoupling the locomotive or a portion of the train. In this case too, the driver hands over his tangible authority to proceed to the guard, gets written permission to proceed from the guard, and then proceeds (with or without a portion of the rake) to the next station.

If the driver notices too late that the train has parted, and reaches the next station and stops there, he does*not* relinquish any tangible authority to proceed (token, staff, or written authority to proceed) until the rest of the train that is left on the block section is safely brought in by an assisting locomotive and the block section cleared of all the portions of his train.

In the above cases where the driver knows that the train has parted, he must stop at the first station he arrives at and inform the station master that the block section is still obstructed; if a signal cabin is passed the signalman can also be so informed. This allows the block section to be kept free of traffic by leaving block instruments at 'Train on Line' and keeping the signals at On.

In the above cases, if the guard has instructed the driver to return with assistance to the remaining portion of the train, the station master grants authority to proceed either on the same line or on an adjacent line for the locomotive to reach the disabled train portion. Block sections remain appropriately closed to traffic when this happens.

If a train passes through a station and is seen (by the station master or other staff exchanging signals with the train) to have parted (i.e., does not have the Last Vehicle sign or lamp on the last coach or wagon), the block instruments for the section to the rear are kept at 'Train on Line' and the station to the rear is informed of the parting of the train; signals remain on so that the block section cannot be entered by any other train. In addition, the station ahead is informed of the train parting so that the signals there can be set to On to stop the train. A cabinman or the driver of a train going in the other direction may also notice a train has parted -- the procedure is similar in such cases, with the nearest stations being informed and the block section closed off to other traffic.

## Q. What happens when the Alarm Chain (Emergency Chain) is pulled in a coach? (ACP, Alarm Chain Pulling)

The alarm chain in a passenger coach is designed to create a break in the continuity of the brake pipes (whether vacuum or air brakes), immediately resulting in a loss of brake pressure (or vacuum) and thereby cause the train brakes to be applied. With vacuum brakes, a clappet valve is provided that is released by the pulling of the alarm chain, and with air brakes, there is a similar passenger emergency valve that can vent the brake pipe to the atmosphere. See the page on IR brake systems.

At the locomotive, in addition to a warning lamp or buzzer being sounded, in most locos the master controller undergoes auto-regression, with the notches falling to zero rapidly as the locomotive's motive power is switched off. The guard may also notice the loss of brake pressure (although he may not know it is due to the pulling of the alarm chain) and is expected to apply his brakes as well immediately. It is possible for a driver to override the alarm chain pull in a few circumstances, and this is in fact done in a few cases where it is known that miscreants resort to pulling the emergency chain solely to get the train to stop at a point convenient for themselves (but note that such an act by the driver or guard of deliberately ignoring an indication of alarm chain pulling is a serious offence).

In recent years, locos have been fitted with emergency flashers on the roof of the cab, and these flashers are also activated when the brake pipe pressure is lost for any reason other than the driver's application of the brake valve (A9). This alerts drivers of oncoming trains of the possibility of a derailed or parted rake which may foul other tracks, since the brake pressure may have been lost for those reasons as well, and at the locomotive it is not possible to tell whether the loss of brake pressure is due to the pulling of the alarm chain.

ACP also causes a small lever to be released near the emergency brake valve (usually mounted near one end of the coach) which does not retract to its normal position even when the chain is released. This allows the driver or guard to find out in which coach the ACP actually occurred. When the coach is isolated, the lever needs to be manually reset. Until this is done, the lamp and buzzer in the locomotive cab are continuously activated. A circuit breaker controls the lamp and alarm bell in the locomotive cab; in cases where defective equipment causes the lamp and bell to go off, the driver can disable them by placing the MCB in the 'off' position; despite the obvious safety hazards, sometimes this is resorted to by drivers when driving trains through sections where spurious ACP incidents ae very common.

## Q. What are catch and slip sidings? How are runaway trains managed?

Catch sidings are sidings provided to divert runaway trains off the main line on approach to a station, or on steep downward slopes. Points are normally set to route all trains to the siding, which may end in a *sand trap*to slow down and halt any train that is moving too fast and out of control. This prevents runaways from entering station or yard limits, or from hurtling down a slope and derailing.

A train that has to proceed on the main line must come to a halt before the catch siding (usually a signal is provided for this), and wait to get authorization to proceed. In some cases, this happens when the driver sounds the horn or whistle to let the signalman or station crew know the train is waiting for the authorization to proceed. In some cases, especially in remote areas, the loco crew is provided with a key by the signal cabin in advance; this key unlocks the points to allow the train to proceed on the main line.

In a few cases, there are also automatic points that have sensors that set the points after detecting that the train has approached and waited for a prescribed period of time. In less busy sections, station crew or pointsmen may also arrive to manually set the points using a lever at the location, rather than operating them remotely.

**Slip sidings** are similar, but they are located on main lines in the direction away from a station or yard. Again, the points are normally set to divert all trains away from the main line, and a train must halt until the points are set and the signal (if provided) pulled off before proceeding. Slip sidings are often provided when there is a downward slope (greater than 1 in 26 or so) away from the station or yard, as then there is a risk of stabled rakes rolling out of the station or yard limits if the brakes fail.

Slip sidings are also provided on single line sections at cross-over points to protect trains that are waiting for a cross-over, from collisions if a train coming in the opposite direction fails to stop in time and overshoots the cross-over points. Slip sidings are also used when a double line ends to become a single line.

Shunting operations in yards are also normally carried out with the points set normally to lead away from the main line, except for very rare occasions where shunting activity must be carried out on the main line. For any train starting from the station (either with rake having been marshalled there or with coaches or wagons having been attached or detached at that station), where vacuum or air continuity was lost and brake power has to be rebuilt, the points are set for the main line only when the driver signals (using the horn or whistle) that brake power has been regained fully.

## Banking and Ghat Operations

### Q. What are bankers? Why are bankers used?

A banker is a locomotive that assists in hauling a train up a steep gradient. A banker is attached to the rear of the train and pushes the train from the rear while the normal locomotive of the train pulls it as usual from the front.

Bankers are used for two reasons. One is that, of course, the leading loco may need assistance on a steep gradient. However, a more important reason to have a banker at the rear when ascending a grade is to protect the train from a possibility of coupling failure and consequent parting which would cause a portion of the train to hurtle backwards because of the gradient (guard's brakes being generally inadequate for such a situation). When descending a grade, bankers may be attached at the front to provide extra brake power (or sometimes just to allow the locos to be returned to their shed after having banked trains up the grade earlier, without taking up a separate slot on the timetable).

On an incline, when the train is being pulled up, the couplers come under a lot of strain. Normally, on level track, the couplers only have to sustain the forces corresponding to the static and rolling friction of the wagons or coaches. But when being pulled up, a component of the wagons' or coaches' weight also forms a part of the load on the couplers (the proportion of the weight arising from the sine of the angle of the gradient). Hence, there is a much higher probability of coupler failure when going up an incline. Finally, the additional locomotives help contribute extra brake power for the rake on the slope.

Often two, three, or even more banking engines may be provided on particularly steep grades and for heavy freight loads. It is common to see 3 rear bankers for passenger trains with 21+ coaches. On the Igatpuri-Kasara section even descending trains get two or three front bankers. It is common to see [8/03] the Kushinagar Exp. get two WCG-2 bankers and a WCAM-3 up to Kasara.

Other trains on the same section often get three WCG-2 locos banking in front of a WCAM-3 when descending. Sometimes, however, bankers are attached to trains simply because there are available locos that need to be returned to one shed or the other, and using them as bankers is a way to move them rather than sending them light and reducing track utilization. The working timetable for a division specifies the local rules in effect for how many and what kinds of locos to use as bankers for different kinds of trains and loads.

The safety requirements for train operation set forth by the Commissioner of Rail Safety forbid operating passenger trains on steep gradients without bankers. Goods trains are sometimes operated on such sections without bankers if loads are light. EMUs are sometimes moved between Pune and Mumbai for maintenance and no bankers are used in such cases on the ghat sections as they are not carrying passengers.

The specific rules for what inclines necessitate bankers may vary from one zonal railway to another. In addition, bankers must be used for gentler inclines if there are special circumstances such as operation without brake vans.

See the section on couplers for some information on the limitations of the ordinary screw coupler used most commonly on BG passenger stock. The limits on the tensile force the screw coupler can handle necessitate the use of bankers for most Mail or Express trains these days even on fairly gentle gradients of 1 in 60 or so, since the rakes have been getting longer (and therefore heavier) in recent years. Hence the Nagpur-Itarsi ghat section requires bankers for all passenger trains with 18 or more coaches. Many trains with 17 coaches are run through on the ghat section for fear of overstressing the couplers if a stop is made and the train has to start on the incline. With CBC couplers, the allowable tensile loads are far higher. Goods trains with CBC couplers often don't need bankers on slight to moderate inclines for train parting reasons, but may require bankers to assist the leading loco.

Often, brake vans are removed from the rake before a banker is attached at the rear, because the common 4-wheeled brake vans are light and do not share the same mass/inertia characteristics of the freight wagons, causing them to be jolted around excessively and very often jump the rails due to the buffing action between the wagons and the banker locos. A newer, long 8-wheeled brake van has recently [6/04] been developed which may avoid this problem, at the cost of making the rake longer.

In addition to the use of bankers, ghat sections often have special rules of operation. Mandatory brake halts are provided for steeper grades so that a brake power check can be done before the train proceeds on to the grade. Stopping at the top of a grade before descending also ensures the train is under control before proceeding. In steam days it was often common, for the steeper grades, to inspect all the brake cylinders of the rake at the mandatory brake halt, with defective ones being replaced immediately. There are also timed signals provided in some places; the train must stop at the signal for a specified time before it goes off and the points switch away from the catch siding, ensuring that only trains able to come to a halt there can proceed. 'Auto Emergency Brakes' are provided for locos intended for use on several ghat sections. These apply the brakes automatically if the speed exceeds a certain threshold.

## Q. How do the drivers in the leading loco(s) and the banker(s) communicate?

These days, it is more common for crew to be issued walkie-talkies, so communication is a bit less of a problem, but without them, coordinating the banking efforts with the leading loco always called for great skill and ingenuity. The drivers made use of horn signals, brakes, and also closely observed the load on the locomotives (by monitoring the traction motor currents, engine rpm, etc.). With all this, the drivers ensure that the leading loco does not handle too big a load (putting the couplers under strain), nor do the bankers handle too much of the load (working against the leading loco).

In steam days it was even harder, as there was no convenient gauge corresponding to the motor current or other meters in modern locos that allow judging the load. Then, all communication was through the whistles, monitoring the vacuum in the brake pipe, and monitoring the steam intake and 'listening' to the loco!

## Q. Are there any special requirements for locos to work ghat sections?

Many locos can be used as bankers on ghat sections. Usually, goods locos are used for banking duties, although this is not a rigid rule. The leading loco on a ghat section can in general be any loco provided it has suitable braking systems, etc.

There are some **ghat special powers** -- locomotives that are specially modified for duties on steep gradients. These are usually equipped with an 'Auto-Emergency' ('AE' or 'AEB') brake system, which is an electronically controlled system which monitors the speed of the loco and applies the brakes automatically if it exceeds 25km/h (or other speed limit appropriate for the section).

These powers are especially used on steep gradients where catch sidings may not be provided (e.g., Braganza ghat Castle Rock - Kulem; in contrast, CR's Lonavala-Karjat section and SER's Krandol-Kacheli section have catch sidings and systems like AEB are not usually used). The AEB system is normally kept switched off in normal sections, and switched on only in the ghat section; the keys for these are kept with the station masters so that the drivers do not have the ability to override the system. Gooty is the only shed currently [6/03] where locos with AEB are regularly homed. (However, at least one loco in the 14xxx series homed at Krishnarajapuram has been spotted with stencilled indications that it had AEB ith a 30km/h restriction. [9/06]) In the past there were many WDM-2/2A/2B locos with AEB but now they have been phased out, and the locos with AEB now are WDM-3A and WDG-3A units.

A further safety feature in the Castle Rock - Kulem section is the running of trains in the so-called **corridor system**, where multiple goods trains are run in the same direction on the ghat section at times when passenger trains are not run, to maximize goods throughput while not endangering passenger trains in case of runaways.

There are many mandatory **brake halts** provided on steep sections. At these locations, the train must come to a complete halt before proceeding. **Delayed signals** are usually provided, which automatically clear after a track circuit with a timer detects that the train has stopped for the requisite amount of time. Usually, there are automatic points provided at these locations as well; if the train does not stop for the required duration the points will not be set for the main line and the train will be diverted to a catch siding or trap. Sometimes the brake halt is operated manually: a staff person is stationed at the halt and works the points and pulls of the signal only after the train has come to a halt, and the driver has signed in a register maintained for the purpose.

The drivers for trains negotiating steep ghat sections also have special training in driving on those sections.

## Traffic flow (left or right)

### Q. Which side does traffic run on the tracks in India?

Like road traffic, railway traffic is also on the left as a rule. The rule generally applies to all double-line sections, and a train moves on the right side tracks only in exceptional situations. Of course, it does not make any difference for single-line operations, and bidirectional movement is allowed on both tracks in the case of twin single-line sections.

In the case of some ghat sections and others where there are three tracks, the central one is used for traffic in either direction. In a few cases right-hand-side running (also sometimes known as 'American style') is adopted such as on the MG sections between Tambaram and Chengalput and surrounding areas. The reason for that was that the MG locos (YAM-1, etc., YDM-4 (short hood leading), steam locos YP and YG) and the MG EMUs all had right-hand-side seats for the drivers. This made right-side running more convenient since the signals are located by the side of the permanent way and not between the two tracks.

BG electric locos all have the driver's seat on the left. Most BG running is on the left, and almost all BG signals are on the left side of the track. BG steam locos had the driver's seat on the right, as does the WDM-2 (from the American designs) and in all of these the drivers depended on the assistants calling out the signal aspects, especially with the long hood leading.

Perhaps to fix this situation, the WDG-3A ('baldie' and short hood) and WDM-3A ('baldie' only) switched to a left-side seat for the driver. However, curiously, the newer WDM-3A locos have been given a right-hand-side seat for the driver. One curious oddity today [12/03] is the Dhanbad-Sindri section where between Pradhankhanta Jn. to Sindri traffic is on the right.

## Communications

### Q. What are the telecommunications systems that IR uses?

Most of IR's telecommunications needs are handled by telephone / telegraph cables and other control communication cables running alongside the tracks (often underground in electrified areas) or overhead (usually in non-electrified areas). Important circuits of control and communication include **section control** for overall control of train running, **deputy control** and FOIS (Freight Operations Information Systems) for freight movement monitoring, **traction power control**, **remote control**, and SCADA sysems for control and switching of the OHE in electrified sections, **traction loco control** for coordinating locmotive allocations, **engineering control** for coordinating maintenance and permanent-way work, and **S&T control** for signalling and related communications. More recently, computerized ticketing/booking and other status information as well as more monitoring and data processing and management systems have come on line and have resulted in new communication systems carrying their data traffic as well.

Low-traffic and rural areas often have fairly simple communications set-ups. Token instruments in many cases are connected by fairly simple telegraph mechanisms. Station masters and signal cabins usually have telephonic contact with their counterparts up and down the track. IR's telephony is a mixture of Strowger (mechanical relay) exchanges and more modern digital exchanges, with the older electromechanical systems being gradually phased out.

In electrified areas, telephone and other communications are usually carried on shielded underground cables to avoid interference from the OHE. Often 4-wire circuitry is used (2 wires for transmission and 2 for reception) to minimize interference problems. Repeaters are used every 40-50km for loaded/balanced cables; amplifiers / equalizers are used at stations for non-balanced cables. In some areas, old analog twisted pair wires between stations have been utilized in a more efficient manner to carry 6 or so digitized voice channels (ADPCM), for distances up to about 10km. (The system is known as TeNET, and was developed by IIT Madras.)

For longer distances (coordinating across longer stretches, zonal communications, administration) IR uses microwave communications (2GHz and 7GHz (7.125GHz and 7.425GHz) for administration, 8GHz and 18GHz for control communications) with backup wireline telephony. Analog microwave equipment is from Harris and Toshiba. The microwave links besides having more bandwidth than the older telephony cables also avoid the problem of cable theft. Most links have 120 channels, and more recent ones (post-1987) have 960 channels.

The four major metropolises are interconnected by a digital 34+2 Mbps microwave channel [1/00] with equipment from Alcatel and NEC. In 1999, IR had nearly 15,000 route-km of analog microwave links and 3,700 route-km of digital microwave links. The UHF microwave links use 5 to 7 repeaters for each division, spaced every 50-60km. Each repeater station has two transmitters, two receivers, standby battery and generator sets, etc. Some of these handle both analog and digital links (100+ analog channels, 56 digital channels in a common configuration). Data loggers report status back to the divisional headquarters.

In addition, spread-spectrum CDMA communication is in use between a few stations ([1/00] Mumbai-Mathura on WR, Mumbai-Wadi on CR, Wadi-Secunderabad on SCR). Other major routes not covered by these have UHF TDMA links. Satellite 'micro-earth terminals' are used at several remote locations (as of 2000, over 120 such).

Major stations' computer networks are also connected via trackside cables. Control communications and control for electric traction substations is usually done through trackside metal cabling; some stretches have now been upgraded to use optical fibres. Signalling systems of some nearby stations in busy areas are interconnected with fibre-optic rings that also carry phone and data traffic in addition to signalling and control traffic.

Much of the PRS system for ticketing and reservations (see below) is connected together by 64kbps leased lines, although lines of higher bandwidth are beginning to be used as more applications are being made available (train status enquiry systems, station enquiries, etc.).

With the spread of the Internet in India, many of the railway institutions are now connected to the public Internet, and they are also connected among themselves with a wide-area intranet known as 'RAILNET' which covers most of the zonal and divisional headquarters, training institutes, production units, and offices of the Ministry of Railways.

**Optical Fibre Communication**

Since about 2000, a major effort has been underway to provide optical fibre communication links between stations. Part of the push for this came from the Department of Telecommunications' declining interest in maintaining IR's leased-line communication and control circuits since its (DOT's) own infrastructure was increasingly moving to microwave and optic fibre links.

However, the other reason is the promise of raising revenue by commercial marketing of the communication capacity to Internet and telecom companies and others. So far [2/02], fibre-optic links have been provided along the routes among New Delhi, Ahmedabad, Mumbai, Pune, Bangalore, Chennai, Hyderabad, and Kolkata. A 24-fibre cable standard is followed.

Some small sections or separate systems (e.g., the Delhi Metro) use, or are planning to use, fibre-optic communication extensively.

### Q. How do ground staff, train crew, signalmen, and others communicate?

Since about 1999, handled radio sets (walkie-talkies) have been issued to most drivers, guards, and other staff on the move. These handsets usually have a fairly short range (a kilometer or so). VHF radio sets have been installed in the loco cabs for a few important trains such as the Grand Trunk Express, Tamil Nadu Express, and the Rajdhanis and Shatabdis, for communication between the loco and station controllers.

Some systems like the Delhi Metro also use mobile radio systems for train communication; the radio system is integrated into the larger system of communication which includes optical-fibre communication between stations, etc.

Another method of wireless communication with train crew, MTRC, or Mobile Train Radio Communication, has been set up for trials in some places, including on the Nagpur-Itarsi, and planned to be set up on sections like Pune-Bhusawal. The older systems are analog; the newer ones are supposed to be digital and based on CDMA ttechnology. More recently [12/04] there has been talk of moving to GSM-R communications.

See the section on flag and lamp signals, whistle codes, etc. for more information on communication.

### Q. What is the 'stone throw' method of communication?

In the days before walkie-talkies or other means of communication between the cab and the station staff were available, a very simple but effective method was used by a driver or guard to communicate with the station master or his staff at stations where the train did not halt. He would write his message on a piece of paper, wrap it around a stone, and throw the stone with the message on to the platform as the train went through the station. And as the train passed by the Asst. Station Master or Khalasi or other official giving the 'all-right' flag signal on the platform, he would shout out to him that he had dropped his message. Often, a few stones were kept just for this purpose in the loco cab or the guard cabin!

## Ticketing and Reservation

### Q. What are/were Edmondson card tickets like in India? Are they still used?

Until a few years ago, the mainstay of IR's ticketing were the Edmondson tickets* which were issued manually (machine-punched or even hand-written in some cases) for all train journeys, reservations, etc. Indian Edmondson tickets show(ed) a fair bit of variation. Apart from the expected information such as the endpoints of the journey, the date, distance, class, and fare, tickets were often colour-coded to indicate the class of travel or the issuing zonal railway. (Note that the date was usually stamped or indented by a punch machine while the other details were pre-printed on the cards.) The zone is usually indicated by initials (e.g., 'N.R.') on the back of the ticket, and security markings of various sorts may be found on the front and back forming a background for the other printed text.

White card stock was used for the reservation tickets to go along with the journey tickets, before journey-cum-reservation tickets were introduced. Other kinds of tickets issued included platform tickets, supplementary charge tickets (for superfasts, etc.), retiring room tickets, and tickets against warrants for military personnel. For journeys crossing zonal railway boundaries, a red wavy stripe was often printed on the ticket to indicate the 'foreign' nature of the travel, a legacy of the time when such travel indeed meant going through more than one railway company's territory.

In addition, reservation confirmation, cancellations, and other such documents issued on Edmondson card stock often had different colours or special backgrounds. Sleeper card tickets were pink; AC-3T were light blue; and First Class tickets were generally a leafy green colour. (These may not have been standard across zones.) WR's Mumbai suburban card tickets were printed on yellow, blue, and pink stock. Edmondson tickets in India are often not punched or cut to indicate cancellation or use; instead the ticket checker often just puts his initials on the tickets.

There are many interesting aspects of Edmondson tickets that were issued in India. In some places, e.g., on the Mumbai suburban system, station names are not printed in full; only the the codes are shown. Also, the origin and destination shown are the outer limits of the zone for travel in which the ticket is valid, not the actual end-points of travel. Return tickets in two halves, each retained by a ticket collector at either end, are or were issued only in some places; examples are the MG EMU system in Chennai, at Mumbai and other big stations, etc.

Card stock used at some stations, especially the small and less busy ones, can be really old, so that the tickets may be issued even 15 or 20 years after the stock was printed. This can mean that the prices shown are extremely out of date; in some cases even the names of stations may have changed. E.g., a Second Class Ordinary (passenger) train ticket from Jamnagar to Aliyavada could be obtained recently [2004], printed on stock from 1980, with a preprinted price of 55 paise (although the current price is Rs 7), and showing a distance of 15km (it's now 19km following the change in alignment after gauge conversion in 1984).

Also recently [2004], a ticket could be obtained for a journey from Hadmatiya to Khambaliya, printed on card stock from 1976 (!) which has both stations named with 'Jn' after their names, as they used to be junctions 30 years ago. Following the recent creation of new zones, card tickets can often be found [12/04] with the old zonal indications; e.g., a second class ticket from Khurja Jn (NCR, previously NR) to Delhi (NR) has the security diamond markings of NR, yet carries the horizontal wavy stripe indicating a 'foreign' journey across zones.

Read more about Edmondson tickets in India.

*(*) Edmondson tickets: This is the name given to tickets issued on card stock, with a preprinted or machine-punched serial number, invented by Thomas Edmondson of Lancaster, UK, in the 1830s as a means of preventing fraud and making the job of ticket-checking less onerous for the Newcastle and Carlisle Railway in the UK. They became very popular on all UK railways, and spread from there to railways around the world and of course to railways in India. Typically they were printed on card stock about 0.8mm thick, and the standard size was about 57.5mm x 30mm.*

Cardboard Edmondson tickets are still to be found, issued at smaller wayside stations, on remote branch lines, etc., and often only for unreserved travel. Upper class tickets in card form are especially hard to find for mail/express trains now [12/04] because these trains often do not stop at the small wayside stations that still issue card tickets, or if they do, they only have a small quota for lower class accommodations.

Platform tickets are still issued on card stock at many stations, including those of NR, SER, CR, etc., where they are usually on white stock. SER card platform tickets have additional security markings. New Delhi and Delhi Jn. currently [12/04] issue card platform tickets. An interesting aspect of card platform tickets issued at some places like New Delhi and Delhi Jn. is the indication on the tickets of the specific point of issue, e.g., the Main Gate, East Hall (at Delhi Jn.), or even the specific counter of issue (Window 1, Window 2, etc. - Jamnagar, although this appears to have stopped now [12/04]).

The picture gallery has some photographs of tickets.

## Q. What kinds of tickets have been or are used in India other than the old Edmondson card tickets?

The early Rajdhani Express tickets were unusual. The Bombay Rajdhani tickets resembled airline tickets in format (although somewhat thinner), and the Howrah Rajdhani tickets were also wide like airline tickets but shorter, so that they resembled excess baggage tickets issued by the airlines of the time. WR and CR began issuing stiff paper tickets ('RapidPrinter' paper stock) for the Mumbai suburban trains some time in the 1980s or so, although card tickets continued to be issued at some stations for many years. Platform tickets (for access to the platform areas) are issued in square paper form at many stations, especially WR, NWR, etc. At bigger stations around the country, however, platform tickets are now printed on the same stock as regular tickets since the same self-printing ticket machines (SPTM) can be used to obtain them. RapidPrinter paper stock is used [12/04] for platform tickets in some places (e.g., Surat, Ahmedabad, Nagpur).

With the advent of computerization and networked reservation systems, tickets and reservation slips are often now printed by computer on continuous feed paper. (Below you can find brief description of some of the main components of the new systems in place for computerized reservation and ticketing.)

The picture gallery has some photographs of tickets.

## Q. How are computerized reservations done? What are CONCERT, PRS, IMPRESS, POET, and UTS?

Before computerization set in, reservations were generally issued only on the basis of fixed quotas for each station (and, for some important stations, using the 'return journey quota' (RJQ) for the return trips), or after a labour-intensive and time-consuming process of requesting and confirming reservations via telegrams to distant stationmasters. It was often difficult or impossible to reserve journeys from intermediate stations to other intermediate stations, especially at short notice. With the advent of computerized reservations, the situation has improved tremendously.

The IR system is very complex, resulting in a daunting set of requirements for computerization. Not only is the volume over 600,000 seat and berth reservations a day, but there are also: 7 passenger train categories, 72 types of coaches, 7 classes of accommodation that can be reserved, over 40 quotas, and around 80 types of concessional fares. The fares depend not only on the distance (being computed telescopically) with the complication of 'chargeable distances' being different from the actual distances travelled, but also the accommodation type and the transit time.

The **CONCERT** ('Country-wide Network for Computerized Enhanced Reservation and Ticketing') system is a networked system for computerized reservation and ticketing and other online information retrieval applications, and has been operational nationwide since April 1999 (although the first prototype was developed in January 1995 and tested at Secunderabad). It has five major regional centres (Secunderabad, New Delhi, Mumbai, Chennai, and Kolkata).

At each of these centres, an Alpha VMS cluster with a Sybase database [2002] provides the computational resources. These five nodes are connected by 64kbps leased lines owned by the Dept. of Telecoms. (Now being upgraded to higher bandwidth as more data-intensive applications are being deployed.) Lower-bandwidth lines then connect all the 'Universal Terminals' (or PRS terminals) at different stations to these major nodes. Implementation of the system began in the early 1990s.

CRIS (Centre for Railway Information Systems) designed and built the entire system. The system was deployed in stages, beginning in 1994 at Secunderabad, in 1996 at New Delhi, in 1998 at Kolkata, and finishing up with Mumbai and Chennai in 1999.

**PRS** — ('Passenger Reservation System') is the application software for handling passenger reservations that now runs on the CONCERT system. However, the origins of PRS go further back, as it started with a pilot project in 1985 at New Delhi. This was **IMPRESS** ('Integrated Multi-Train Passenger Reservation System'). The first version ran on VAX-11/750 computers running VMS and was written in FORTRAN. The system could then only handle reservations for trains at one station. Access was by VT220 terminals at the remote nodes

It was extended in 1987 to a few more locations (Mumbai - June 1987, Calcutta - July 1987, Chennai - October 1987) and with additional features, and by 1990 had been deployed to handle the bulk of the long-distance reservations at five locations (the above four and Secunderabad (begun July 1989), which had a Cyber computer system instead of the VAX systems the others used). These five PRS nodes operated independently, each with its own local database, and could not exchange information. The CONCERT system and the development of the networked nationwide system addressed this shortcoming, and the five PRS systems were interconnected on 18 April 1999. The hardware was also upgraded from VAX/VMS servers to Alpha/VMS servers. In January 1995, the first prototype of CONCERT was developed, and networked reservations were available through the experimental linking of the Secunderabad and New Delhi nodes. Bangalore had a separate PRS system implemented on custom ECIL hardware with a different software package, which was later switched over to CONCERT.

In addition to the PRS terminals used by ticketing staff to issue reservations and tickets, **IVRS** ('Interactive Voice Response System') can be used by passengers to get status information over the phone, as well as**POET** ('Passenger-Operated Enquiry Terminal') self-service terminals at stations. IVRS was introduced in 1994; the first version was based on an Oracle database containing schedule information, linked to the PRS system, and was built by CMC in conjunction with AT&T. More recently [8/02] the ability to book tickets over the Internet has been made available. This was originally restricted to major cities (New Delhi, Mumbai) and is now [12/02] being extended to many more cities.

**NTES** — ('National Train Enquiry System') is a system to provide real-time information on the status of trains (arrival/departure and platforms), journey planning (the 'SMART' package), station facility enquiry and enquiries about railway travel rules (the 'GLOBAL' enquiry package). The system is the 'brains' behind the display boards and CCTVs at stations, and the IVRS and Internet-based status enquiry applications. The system uses Alpha Unix servers with Sybase databases

**UTS** — ('Unreserved Ticketing System') is the counterpart to PRS, and deals with unreserved ticketing. This is a system of networked self-service terminals that allow passengers to buy unreserved tickets for any journey, up to 30 days in advance, without having to go to the ticket windows at the departure station.

Begun as a pilot project on August 15, 2002, the system now consists of terminals set up at 10 New Delhi area locations (Delhi, Delhi Jn., Hazrat Nizammudin, Delhi-Shahdra, Ghaziabad, Shakurbasti, Delhi Kishanganj, Sarojini Nagar, Shivaji Bridge & Tilak Bridge) and

13 more set up in October 2002 (Delhi Sadar Bazar, Dayabasti, Subzi Mandi, Delhi Azadpur, Okhla, Sewa Nagar, New Azadpur, Badli, Vivek Vihar, Sahibabad, Vivekanandpuri, New Gaziabad and Mangolpuri). As the system is networked, it allows IR to monitor the sales of tickets on various trains and adjust train capacities to the changing demand, besides making it easier for passengers to buy their tickets.

**SPTM** — ('Self-Printing Ticket Machine') self-service terminals at stations, an older concept, allow passengers to buy unreserved tickets for specific trains and routes. These machines are not networked and their sales are not reflected immediately into the PRS and UTS systems for capacity planning. The first such machine was introduced at New Delhi in 1990.