1 Signals - Their Forms and Functions

1.1 Introduction

Before dealing with the construction of model signals, if they are to be present on a layout, it is necessary to look at the types of signal and their functions. Section 2 will then look at how they are positioned and used in typical track layouts.

Running signals control the movements of trains on running lines and their main purpose is to maintain a safe distance between trains running on the same line and in the same direction. They provide protection at converging junctions and directional information at diverging junctions. Coupled with a single line control system, they maintain safe operation of single lines.

Subsidiary signals control lower speed movements and are designed to be easily distinguished from running signals. The usual method is to employ a smaller signal located below its relative stop signal or a ground signal.

Colour light signals are replacing semaphore signals on main lines although semaphore signals are still in operation at many locations. Running colour light signals can be two aspect, replacing older semaphore signals, but more commonly they are three or four aspect to provide improved indication to drivers, particularly on lines carrying heavy traffic. Subsidiary signals in colour light areas usually take the form of position light signals to distinguish them from running signals, although the SR often made use of floodlit disc signals as an alternative.

Terms relating to the location of a signal can sometimes appear confusing. A simple way of visualising this is to imagine standing in the middle of the track facing the direction of travel; everything in front is 'in advance'; everything behind is 'in the rear'. In the Figure 1-1 below signal C is 'in advance of' signal B while signal A is 'in the rear of' signal B. Similarly, signal boxes controlling block sections are said to be 'in advance of' or 'in the rear of' the adjacent box depending on the direction of travel. Before the days of power boxes controlling long stretches of line, alternate boxes were often found on opposite sides of the tracks to their neighbours to permit the signalmen to examine both sides of a train. The Figure 1-2 illustrates this point.

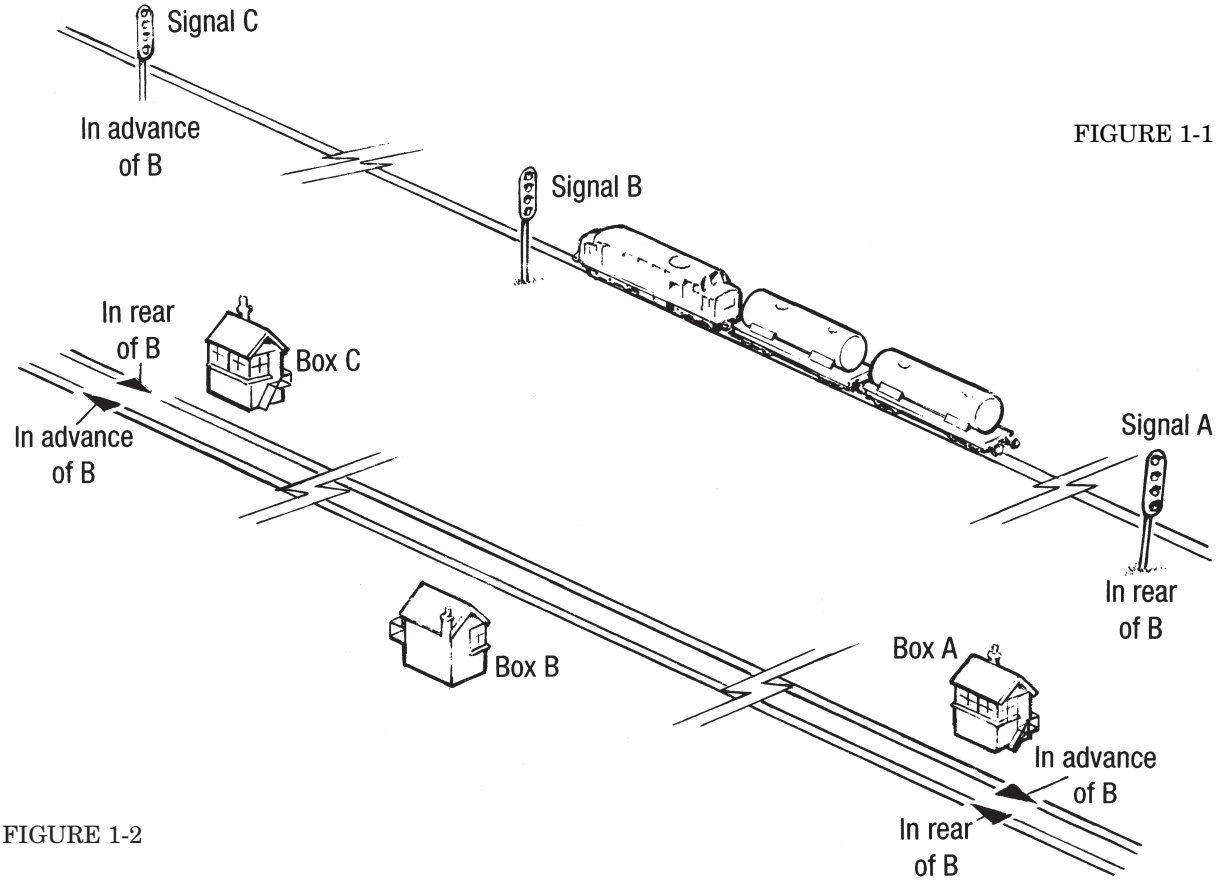

FIGURE 1-1

FIGURE 1-2

Compiled by A. Garraway, J. R. Hadwin, D. Strivens, M. Walshaw.
Drawings by D. Morton, G. Wheeler.

1.2 Semaphore Running Signals

These have arms some four or more feet in length. When BR was formed, much signalling still consisted of the individualistic types of the pre-1923 companies, including the slotted post types of the NER and the somersaults of the GNR while the GWR (and Western Region) stuck to its lower quadrant type. The rest of BR saw the upper quadrant gradually taking over as signals required replacing. The two principal types in current use are the stop and distant signals.

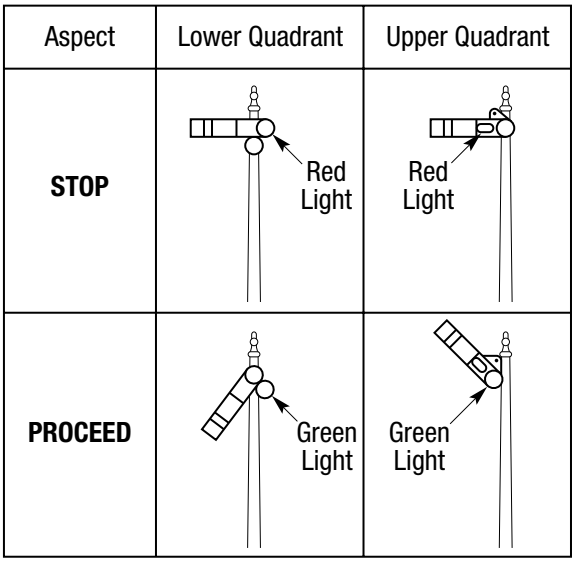

FIGURE 1-3
Stop signal aspects.

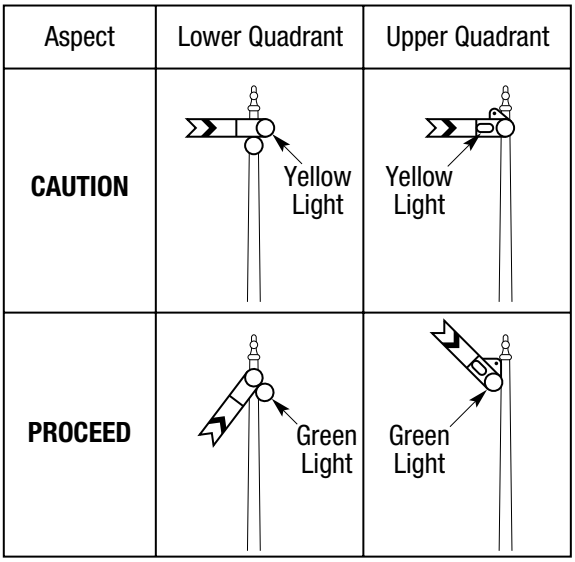

FIGURE 1-4
Distant signal aspects.

Stop signals are painted red with a vertical white band and, at night, show a red light for stop and a green light for proceed. Figure 1-3 shows the aspects displayed. Home, starting and advanced starting signals are of this type.

Distant signals have notched ends and are painted yellow with a black horizontal Vee. At night they show a yellow light for caution and a green light for proceed. Figure 1-4 shows the aspects displayed.

Whichever type of semaphore signal is employed it is normal practice to refer to the signal as being **'off'** to indicate the proceed aspect. Similarly signals are said to be **'on'** when showing a stop or caution aspect.

1.2.1 Stop signals

The simplest of block posts will consist of a single stop signal for each direction. Where more than one stop signal is required to control movements within a block section, the additional stop signals are referred to as home or starting signals. The home signal is usually located in rear of a signal box. Home signals are positioned an overlap distance (400 metres or 440 yards) from the point they protect to provide adequate braking distance if the signal should be overrun. Where a home signal is protecting a converging junction or similar fouling point, there is a safety overlap beyond any home signal which must remain clear before a train can be accepted from a box in rear. To avoid 'sterilising' a busy junction or station, outer home signals are provided. (see 1.2.3)

Starting signals are provided to authorise movements from the block post. through the block section to the home signal of the next signal box ahead and from this are also known as section signals. Figure 1-5 shows a simple arrangement of home and starting signals at a station.

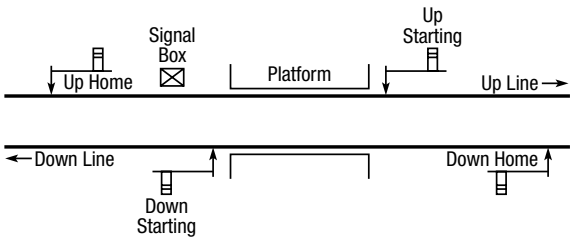

FIGURE 1-5
Station protected by Stop Signals.

1.2.2 Advanced starting signals

Advanced starting signals allow shunting movements to take place within their protection and also allow trains to be held, pending their acceptance by the next signal box, in a position where they are not blocking the station or junction. Figure 1-6 shows the location of advanced starting signals at a station, positioned to provide sufficient accommodation for the maximum length of train normally using the line, to stand between the signals and the crossover or siding entry.

Advance starting signals become the section signals and are used to authorise movements through the block section to the home signal of the next signal box.

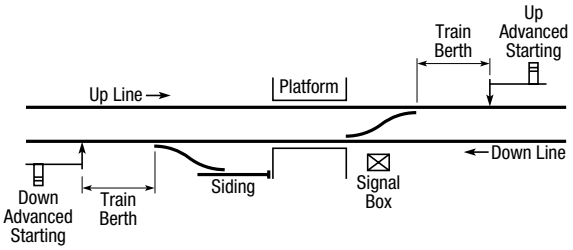

FIGURE 1-6
Advanced Starting Signals.

1.2.3 Outer home signals

Outer home signals are provided, normally 400 metres or 440 yards in rear of the home signal, so that a train can be accepted from a block post in the rear when the safety overrun inside the home signal is occupied, e.g. by a train standing in the station. See Figure 1-7.

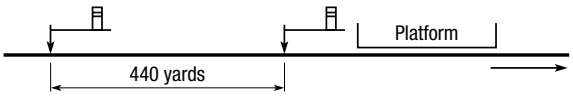

FIGURE 1-7
Outer Home Signals.

1.2.4 Distant signals

Distant signals give drivers a warning of the aspects of all the stop signals for that line controlled from the same box. They may be passed at caution but the driver must be prepared to stop at the next stop signal, or should he find that clear, at the starting or advanced starting signals. Signal box interlocking is so arranged that the distant signal can only be pulled off when the stop signals have all been previously pulled off. When the distant is off, the driver is given an indication that the line is clear as far as the home signal of the next signal box in advance.

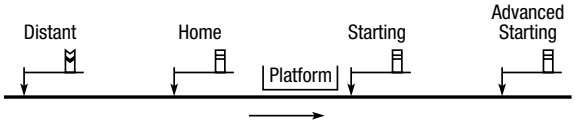

FIGURE 1-8
Distant, Home and Starting Signals.

Figure 1-8 shows a distant with its associated home and starting signals. The distant signal is located sufficiently far from the home signal to allow any train to be brought safely to a stand at the home signal. The location will vary with gradients and anticipated speeds and could require 1 kilometre (or 1000 yards) between the distant and the home signals. The distant signal covering the approach to a terminus would be fixed at caution.

1.2.5 Slotted Signals

At complicated stations and junctions the distance between successive signal boxes is often greatly reduced; this brings the distant signal of the box in advance back towards the section signal (i.e. the last stop signal) of the box in the rear. In circumstances when these two signal would be close to each other, the distant signal of the box in advance is mounted on the same post as the section signal of the box in the rear, typically 6 feet below it. The two signal arms are interlocked by a simple mechanical device fitted to the post and known as the 'slot', which prevents the distant signal from moving to the **off** position unless or until the section signal above it is also **off**. Usually the section signal is the first to be cleared, followed by the distant when the signalman in advance pulls **off** all his signals. When the train has passed the signal the signalman in rear will return his section signal to danger. The interlock mechanism will simultaneously return the distant signal to caution. Figure 1-9 shows the aspects of a combined section and distant signal and the slotting device.

In extreme cases where boxes are very close, for example, at each end of a station, a stop signal could be the starter of one box and the home of the next. In these cases it would be operated by a similar slotting arrangement requiring both signalmen to pull their levers off before the signal shows the proceed aspect. Referring to Figure 1-9 (d) the stop

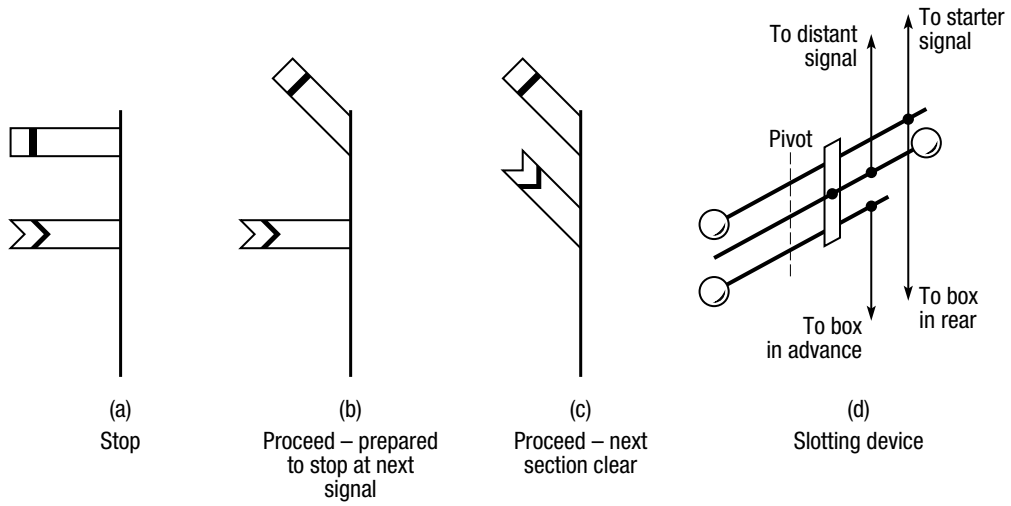

FIGURE 1-9
Combined Stop and Distant Signals.

signal would be operated by the rod marked distant signal and the rod marked starter signal would not be required.

1.2.6 The block system

Semaphore running signals are operated in conjunction with the block system where the line is divided into a number of block sections, each controlled by a signal box. Communication between signal boxes is by means of block instruments, one for each running line, the block bell and the telephone and is dealt with more fully in Section 4. A block section between two boxes, A and B, having home, starter and distant signals is shown in Figure 1-10.

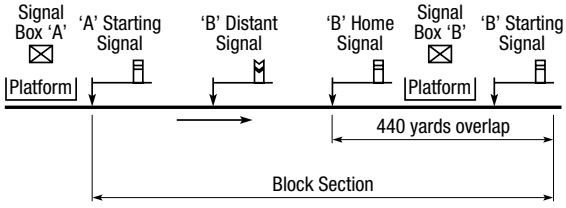

FIGURE 1-10
Simple Block Section.

1.2.7 Diverging junctions

Figure 1-11 shows a simple diverging junction with the signals arranged to indicate the relative importance of the two routes; the higher speed route signal is mounted higher than the other signal.

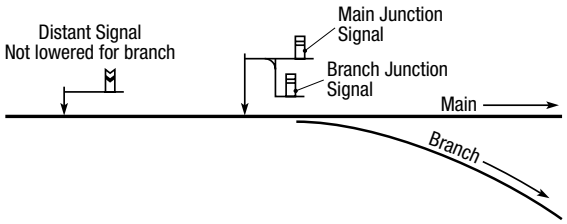

FIGURE 1-11
Simple Diverging Junction.

With regard to the distant signal, practices vary. Ministry recommendations are that only one signal be provided and this is only pulled **off** for the high speed route, not the diverging route. Hence the driver of a train intended to take the branch route would, seeing the distant at caution, reduce speed. If both routes were suitable for high speed, two separate or splitting distants would possibly be provided. If the diverging junction formed part of an approach to a terminus the distant would be fixed at caution.

1.2.8 Converging junctions

The simplest arrangement of signals at a converging junction is shown in Figure 1-12. The home signals would be placed at a suitable distance from the fouling point (400 metres or 440 yards) and

separate distant signals, which can only be pulled **off** when their associated home signal is pulled **off**, are set at braking distance in the rear.

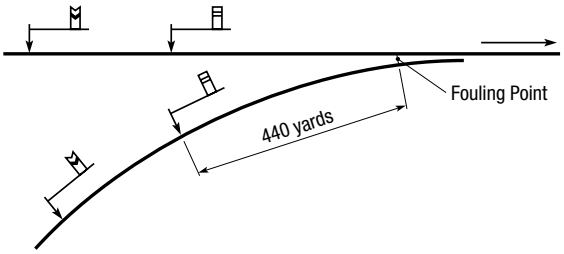

FIGURE 1-12
Signalling at a converging Junction.

1.3 Non-main Line Signals

1.3.1 Main line to siding signals

These are designed to control facing movements from a main line to a non-running line or siding; a miniature arm semaphore is used. (see Figure 1-13). At night these signals display a miniature red light for stop and a green light for proceed. Practice varied between companies; some, notably the GWR and SR, used normal arms carrying a ring and some mounted the arm on a separate bracket.

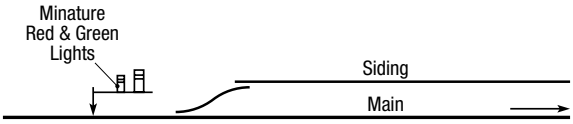

FIGURE 1-13
Main Line to Siding Signal.

1.3.2 Siding outlet signals

The outlet signal from a siding or goods line controlling movements on to the main line would probably be a miniature arm semaphore having a small red light for stop and a green light for proceed. Some railways, the GWR in particular, used white rings attached to the arm to avoid confusion between siding outlet and main line signals. If, however, the main line had an advanced starting signal, movements from the siding would generally be controlled by a ground signal. (see Figure 1-14)

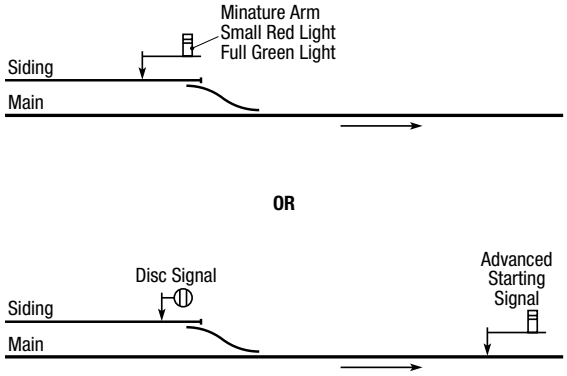

FIGURE 1-14
Siding Outlet Signals.

1.4 Subsidiary Signals

Subsidiary signals are designed to be easily distinguishable from running signals and are usually miniature arm signals fixed below the relative stop arm. They are intended to authorise low speed movements.

1.4.1 Shunt ahead signals

Where provided, these signals are located below the section signal controlling the entrance to the block section ahead. When pulled **off** they authorise the section signal to be passed when **on**, but for shunting purposes only, e.g. to allow a goods train to draw forward into the next block section prior to reversing in to a siding.

1.4.2 Calling on signals

Calling on signals are usually placed below a home signal and indicate to the driver that, either the line between the calling on signal and the next stop signal is occupied, or that he is required to stop at the signal box for instructions. In the former case it would permit a second train to move into an occupied platform road as far as the line was clear. Similarly, it is used to bring a loco onto a train or for a second portion to be attached to a train.

1.4.3 Warning signals

Warning signals are very rare and are only used in special locations. They are installed below the sec-

tion signal controlling the entrance to the section ahead and, when lowered, indicate to the driver that the section is clear to the next home signal but that the station or junction is blocked.

1.4.4 Subsidiary signal aspects

As described above, signals controlling the entry to and exit from sidings normally take the form of semaphores with reduced dimensions. Calling on, shunt ahead and warning signals are usually miniature red arms with a white horizontal stripe and an associated sign to display the appropriate letter C, S or W. At night the stop indication would be either a small red or a small white light and the proceed indication by a reduced green light. Figure 1-15 shows a subsidiary signal and Figure 1-16 shows how they may be employed at a station.

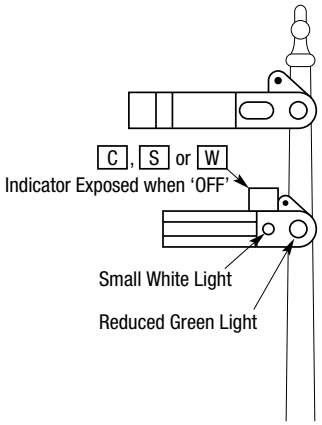

FIGURE 1-15
Subsidiary Signal.

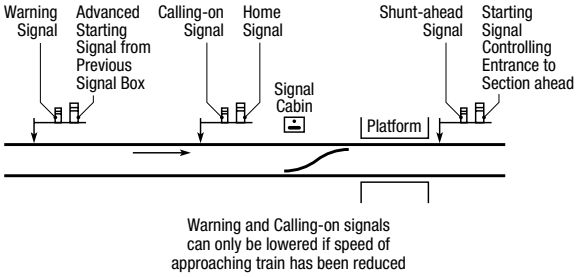

FIGURE 1-16
General layout of Warning, Calling-on and Shunt Ahead Signals.

1.5 Shunting or Ground Signals

Shunting or ground signals are used to control low speed movements within station limits, often where a reversing movement over a crossover is required. They are also used to control the exit from sidings on to the main line where an advanced starter is provided (see 1.3.2 above). There are a number of different designs, the commonest being a disc signal with a red band on a white ground. (see Figure 1-17). To display the proceed aspect they normally rotate in the same direction as the running signals employed on the line, i.e. clockwise to correspond with upper quadrant and anti-clockwise to correspond with lower quadrant signals.

Other forms of these signals have miniature arms, which may be of rubber in confined situations, or the whole signal may rotate through 90° on a vertical axis displaying a red face normally and a green face for **off**. Although shunting signals are normally situated on the ground, they are sometimes mounted on a small bracket on a larger signal or even on the platform of a bracket signal.

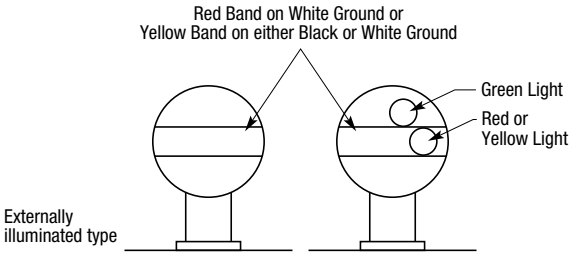

FIGURE 1-17
Ground Signals.

Ground signals having a yellow band, on either a black or a white ground depending on the company, are permissive signals restricted to specific operations and, under certain operating conditions, may be passed when **on**. A typical example would be the siding exit signal referred to above where the siding is extended beyond the exit crossover to form a headshunt. Movements into and out of the headshunt may be carried out while the signal is at danger but exit to the main line requires the signal to be at proceed.

Where there are several routes to be controlled the methods employed include: a separate signal for each route: a single signal with an associated route indicator: one signal only without route indication. If more than one signal is provided and space is restricted it may be necessary to mount

them one above the other, in which case they are read in order from top to bottom; the top arm referring to the extreme left route and the bottom arm to the extreme right route.

1.6 Repeating Signals

Running signals cannot always be located in such a position that a driver of a train approaching is able to sight them in sufficient time to obey their instructions. This could be due to intervening structures or the curvature of the track. Where this situation occurs a repeating signal may be provided.

1.6.1 Co-acting signals

In this form, often seen where there is an overbridge, two arms are provided on the same post, one high up using the sky as a background, to give the driver a long range view of the signal, and the second low down at driver's eye level that may only come into view at short range. (see Figure 1-18).

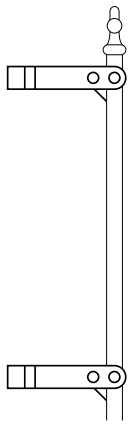

FIGURE 1-18
Co-acting Arms.

1.6.2 Banner repeating signals

These take the form of a black banner on a white ground which is illuminated to preserve the similarity of the day and night aspects. They are normally located from 50 to 200 metres (55 to 220 yards) in the rear of the signal they are repeating, depending on the type of obstruction. They are also used on station platforms where the guard and platform staff cannot see the indication of the starting signal. In this latter case they often take the form of a light box which reads OFF when illuminated. Figure 1-19 shows the typical appearance of stop and distant banner repeaters. Their rotation clockwise or anti-clockwise mirrors the movements of the running signals they are repeating.

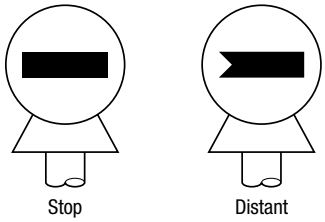

FIGURE 1-19
Banner Repeating Signals.

1.7 Colour Light Running Signals

The earliest colour light signals were two aspect signals showing red or green for stop signals and yellow or green for distant signals. They were, in effect, colour light versions of semaphore signals and were employed in much the same fashion.

On lines carrying mixed traffic such as express trains and medium speed trains, the introduction of multi-aspect signals gives improved indication of the condition of the line ahead and allows trains to run with reduced headway. Figure 1-20 compares the headway distances of two, three and four aspect signalling systems.

The overlap distance for colour light signalling is to allow for braking errors and corresponds to the 400 metres (440 yards) allowed on most semaphore lines. With modern braking systems, and depending on local traffic conditions, this would be reduced to 185 metres or 200 yards, or much less at lower speeds.

Where the colour light signals are controlled automatically by the train activating the track circuits it is known as track-circuit block signalling. This is the norm with modern signalling on plain line. At stations and junctions the operation can be fully manual or semi-automatic. In the latter case the signals are pulled off by the signalman in accordance with the route selected, however, the actual movement of the points and clearing the signals to the appropriate aspect is under the control of the track circuit occupation and once a train has passed the signal will return to red.

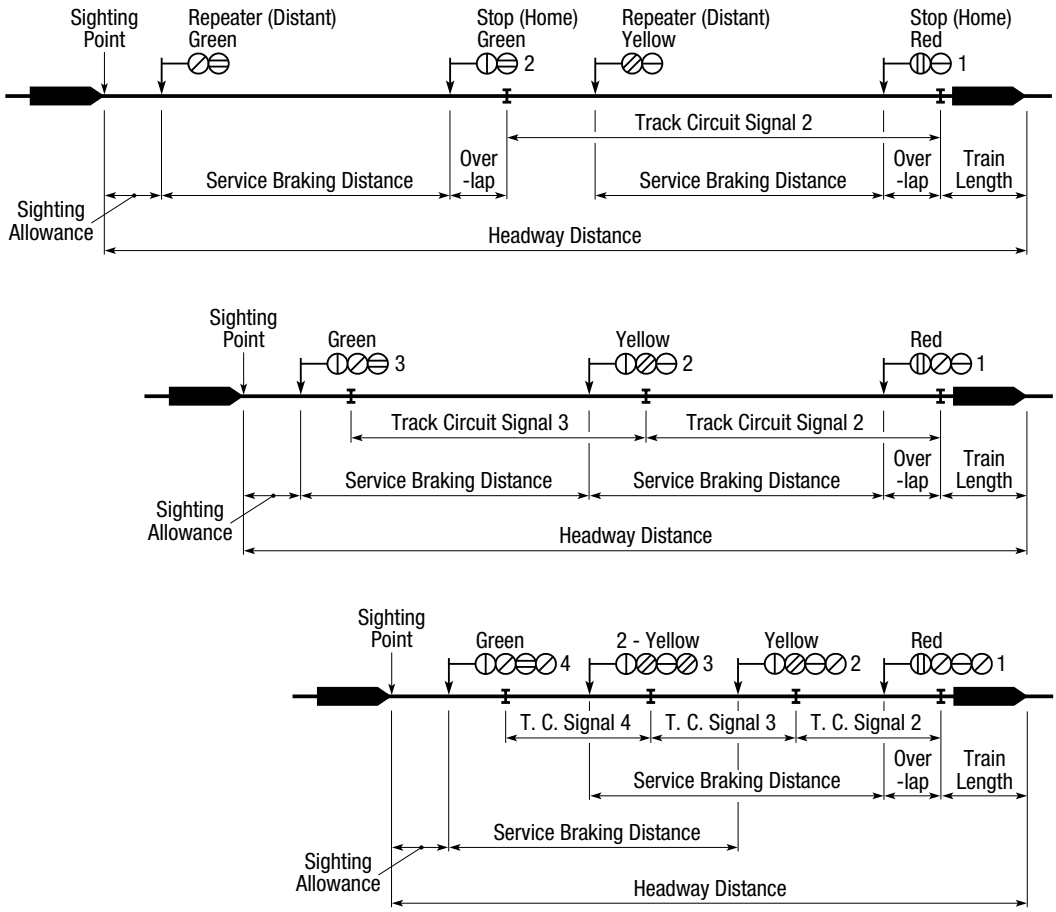

FIGURE 1-20
Comparison of 2, 3 and 4 Aspect Signalling.

1.7.1 Colour light signal aspects

a) Three aspect signals display the following aspects:

- Green Proceed.
- Yellow Caution, be prepared to find the next signal at stop.
- Red Stop.

There are two types of three aspect colour light signal, the searchlight signal and the multi-lens signal. In the former (now obsolescent) there is a single lamp and lens with coloured filters, located between the lamp and the lens, which determine which aspect is displayed. In the multi-lens signal, each aspect has its own lamp and lens. They are mounted vertically in the order, Green - top, Yellow - middle and Red - bottom.

b) Four aspect signals display the following aspects:

- Green Proceed
- Double Yellow Warning, be prepared to find the next signal at caution.
- Single Yellow Caution, be prepared to find the next signal at stop.
- Red Stop.

The aspects of a four aspect signal are so arranged that the two yellow indications are spaced sufficiently far apart to be easily distinguishable at a distance. This is achieved by arranging the lenses in the order, Yellow - top, Green - 2nd, Yellow 3rd and Red - bottom.

1.7.2 Signals at diverging junctions

With the growth of colour lights it has become the practice is to arrange the signalling so that a driver is not required to pass a red light in the normal course of running unless authorised by a subsidiary signal to proceed. To assist towards this end it is the practice to provide only one signal at a diverging junction and augment its indication by means of a junction indicator. A junction indicator takes the form of a row of five white lights, known as 'feathers' or 'lunar lights', arranged above the signal at angles of 45˚ or 90˚ to the vertical. Figure 1-21 shows the arrangement of junction indicators for several possible locations. Note that the junction indicator is not lit for the high speed route but, if it is considered unsafe to traverse the junction at high speed, junction indicators would be provided for all routes.

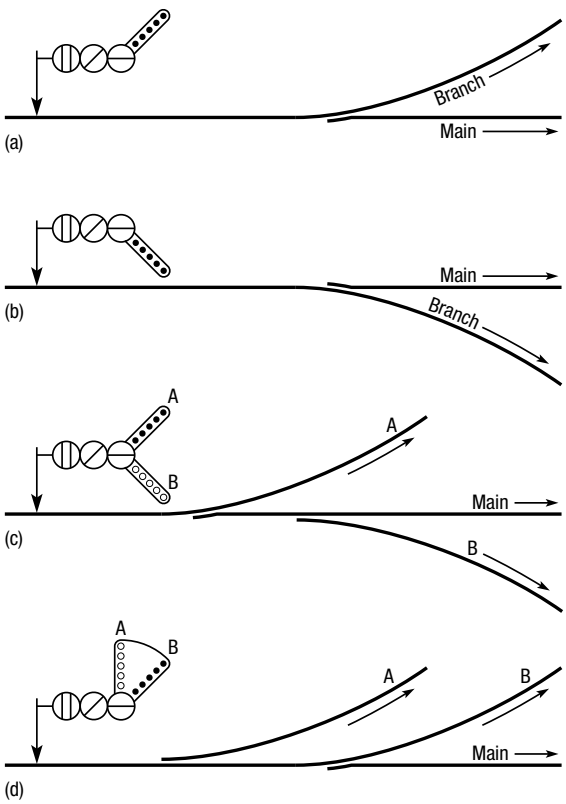

FIGURE 1-21
Junction Indicators
(a) Left Branch (b) Right Branch
(c) Left and Right Branches (d) Two Left Branches

1.8 Colour Light Subsidiary Signals

These perform the same task as their semaphore counterparts. They normally consist of either a miniature colour light or a white position light signal together with an illuminated sign indicating C (Calling On) or S (Shunt Ahead). No stop aspect is displayed with this type of signal. Figure 1-22 shows the two types of signal described.

1.9 Colour Light Ground Signals

Ground signals in colour light areas are usually of the position light type. Some miniature two aspect signals are used and the Southern Region still retains many floodlight disc signals. The aspects used are a white light and a red (or yellow) light horizontally for stop and two white lights in the upper quadrant for proceed. (see Figure 1-23) The use of a ground signal having a yellow light for the stop aspect is similar to that of the yellow banded ground signal described in 1.4 above.

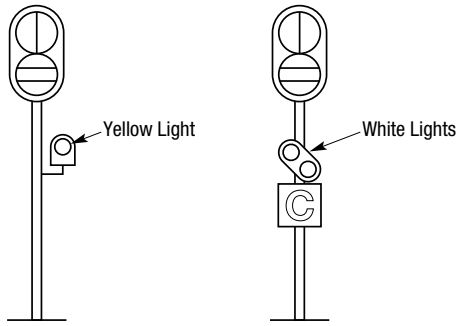

FIGURE 1-22
CL Subsidiary Signals.

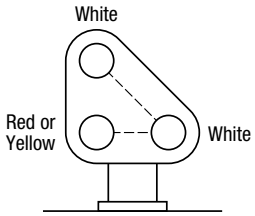

FIGURE 1-23
CL Ground Signal.

1.10 Brief Notes on Signal Development

A summary of the notes supplied by a number of contributors.

Upper Quadrant signals: apart from some experimental US type units put in after 1914 by the GWR, GCR, GNR and the SECR, they did not appear generally until the early 30s and did not form the majority until about 1950. They were never adopted by the GWR or BR(WR).

Distant Signals were first notched about 1870. They were given yellow lights by the GCR after 1916 and were required to be painted yellow with black chevrons on both sides after January 1929, the change having been ordered in 1925. Before that date, though red and white were the normal colours, company practice varied considerably, some using vertical bands, others' chevrons, some round white and black circles or, on the MR, a white dot on the front and a horizontal black line on the white rear face. The practice of the chosen company must therefore be studied in detail, bearing in mind that small changes were taking place all the time.

Rings on full-size arms were found on many companies signals. They indicated a secondary running line, but on the SR, could control entry to a goods loop, yard or depot. Rings went out with the arrival of upper quadrant arms, except on the SR and, of course, the BR(WR). They were usually painted white, except for the LNWR who painted them black.

Metal arms for semaphore signals came into use gradually from circa 1900. They needed stiffening and were often corrugated, usually to a distinctive pattern. In the late 1930s the plain vitreous enamelled arm (for easy cleaning), flanged top and bottom, appeared. This has remained standard up to now, although the BR(SR) makes much more use of the double corrugated form.

The earliest **signal posts** were of wood. Iron then steel lattice posts came in before 1900, concrete in the 20s. **Tubular metal posts** began to replace these in the late 30s, becoming standard for BR, but not BR(SR) which mostly continued to use rail-built posts, a practice which originated on the SECR.

Colour light signals first appeared about the turn of the century. They were known as tube or tunnel signals and were used where a semaphore arm would be invisible or the clearances would be very small. Work on a comprehensive colour light scheme first began on the Liverpool Overhead Railway in 1922 and then on the LNER(ex GC) in 1923. After the report on Three-position signals in 1924 which rejected the former but recommended three and four-aspect CL signals, they spread widely on the SR, along with electrification. By 1930 all four groups had large schemes in use. The LNER had long stretches of the East Coast Main Line thus equipped by 1940, also the LMS. The GWR used a distinctive form of colour light with two 2-colour searchlight heads which showed the same aspects as the night-time indications of combined stop and distant semaphore arms, viz., red over yellow, green over yellow, or green over green. These were confined mainly to the Paddington and Bristol areas as that company's form of Automatic Train Control already achieved a high level of safety. By 1990 the principal main lines were controlled by colour light signals, but many miles of secondary and less heavily used main lines remained under semaphores.

Colour light aspects were usually arranged vertically, but at Manchester Victoria cluster 4-aspect signals were installed in 1926, the green being on the left and the two yellows top and bottom. In 3-aspect signals the red aspect in a railway signal is always the lowest and the Green the top, the reverse of road practice. In the first 4-aspect signals the second yellow was placed below the red, BR practice now places it above the green.

Searchlight colour light signals were used extensively by the LNER in the 30s. They had a single light and a movable shutter with red yellow and green filters between the lamp and a powerful lens.

Colour light junction aspects were at first arranged like their semaphore predecessors, a head being provided for each route. In station approaches and areas of low speed, single heads with route number or letter displays, as used in later semaphore installations, were the norm. In the 30s single heads with route-indicating feathers for diverging routes became standard for signals passed at speed. At first each feather had three lunar white lights, later four, and now five.

Approach-lit colour lights were used in open country, mainly by the LNER, to save power. Batteries provided the power and the lights were only lit when the train operated the associated track circuit.

Banner signals were used for early automatic signalling schemes, particularly in remote spots, where their low power consumption was an advantage. The arm consisted of a red fabric stretched on a wire frame inside an iron casing with clear glass to the front and opal glass to the rear. It was illuminated to give the same indication by day and night. **Banner repeater signals**, with arms of black fabric on wire frames, repeating the aspects of for stop and caution signals came into use in the 30s, usually as part of a colour light installation, but the LNER and GWR also used them with semaphores.

Further reading

A Pictorial Survey of Railway Signalling	Allen & Woolstenholmes	OPC
A Pictorial Record of LNER Constituent Signalling	A.A. Maclean	OPC
A Pictorial Record of Southern Signals	G. Pryer	OPC
A Pictorial Record of Great Western Signalling	A. Vaughn	OPC
A Pictorial Record of LMS Signals	L.G. Warburton	OPC
A Pictorial Record of LNWR Signalling	R.D. Foster	OPC
British Railway Signalling	G.M. Kitchenside and A. Williams	Ian Allen
BR Signalling Handbook	S. Hall	Ian Allen
Signals for the Railway Modeller	D.L.Mundy	

The Institution of Railway Signal Engineers booklets Numbers 1 to 13 cover the general aspects of British practice. Nos 1 to 4 and No 12 cover most modellers requirements.

The Railway Detectives	Stanley Hall	Ian Allen
Danger Signals	Stanley Hall	Ian Allen
Red for Danger	L.T.C.Rolt	
Obstruction Danger	Adrian Vaughn	Guild Publishing
Signalman's Reflections	Adrian Vaughn	SLP