SIGNALLING

The essence of a robust timetable is that the plan is built on all trains running with ‘green signals’, in other words all trains have a clear pathway.

The first consideration is why do we need signalling and the two key words are SAFETY and DISCIPLINE. The protecting signals ensure that the train is SAFE and the safe railway is our number one principle at all times.

The DISCIPLINE imposed by signalling not only ensures the key safety aspect but helps Operational Planners towards the preparation of a ROBUST timetable which can be validated, published and then operated on a day to day basis to ensure performance targets are achieved.

So how does signalling affect timetabling?

The answer is that the signalling determines the margins and headways which in turn determines how we plan the trains, how close we can run behind the preceding train, how close we can pass across another train at a crossing/junction.

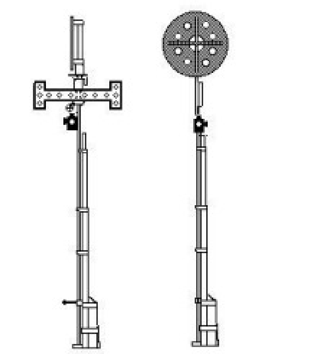
Pioneer Signalling

Back in the 1830s and 40s in the very early days of railways there was no fixed signalling - no system for informing the driver of the state of the line ahead. Trains were driven "on sight". Drivers had to keep their eyes open for any sign of a train in front so they could stop before hitting it. Very soon though, practical experience proved that there had to be some way of preventing trains running into each other. Several unpleasant accidents had shown that there was much difficulty in stopping a train within the driver's sighting distance. There were special problems on single lines; these were generally controlled by the exchange of telegraph messages between Station Masters at adjacent stations. Problems (and accidents) were caused by inexperienced drivers and firemen, bad brakes and the rather tenuous contact which exists on the railway between steel wheel and steel rail for traction and braking. The adhesion levels are much lower and vehicle weights much higher on railways than on roads and therefore trains need a much greater distance in which to stop than, say, a motor car travelling at the same speed. Even under the best conditions, it was (and is even more so nowadays with high speeds) extremely difficult to stop the train within the sighting distance of the driver.

The Time Interval System

In the early days of railways, it was thought that the easiest way to increase the train driver's stopping distance was to impose time intervals between trains. Most railways chose something like 10 minutes as a time interval. They only allowed a train to run at full speed 10 minutes after the previous one had left. They ran their trains at a 10 minute "headway" as it is called.

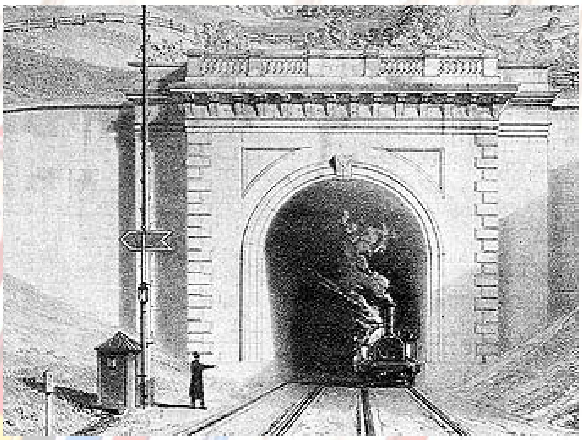
Red, yellow and green flags were used by "policemen" to show drivers how to proceed. A red flag was shown for the first five minutes after a train had departed. If a train arrived after 5 minutes, a yellow caution signal was shown to the driver. The full-speed green signal was only shown after the full 10 minutes had elapsed.



Late pattern Brunel disc and bar signal. This example is for a level crossing.

In 1841, but still using the Time Interval System, Brunel introduced the first recognisable signals at stations and level crossings where it was intended to regulate the running of trains by interval.

The running of these signalling posts was variously undertaken by Station Masters or Railway Policemen (thus the term “Bobby” can be equally applied to a police office or a signalman). The oldest police force in the world is not, as many believe the Metropolitan Police, founded by Sir Robert Peel in 1829. That honour goes to the British Transport Police; there is a reference to the Stockton and Darlington Railway Police dating back to 1825.



Not all policemen were reliable; Taff Vale Railway Police Constable No. 12, Thomas Venn, was stationed at East Branch, close to the north end of Cardiff East Dock. Venn appeared at Cardiff Police Court on the 2nd of October 1858, charged with neglect of duty having failed to prevent a collision between trains. He was convicted and fined 40 shillings and ordered to pay costs, with an alternative sentence of 14 days in prison. (*it is not recorded whether he paid the fine or opted for 2 weeks in* *prison!*) He was not the first railway policeman to face such charges; on the 24th January 1857 John Poynts a policeman and pointsman with Taff Vale Railway at Danyderry, was charged with neglect of duty by being absent from his post.

CLAYTON TUNNEL ACCIDENT

In trying to use the "time interval system", based on fixed headways to protect trains, was, and remains to this day, inherently dangerous. Especially in an era when trains were considerably less reliable than they are today and often broke down between stations. It also could not be guaranteed that the speed of the first train would be sufficient to prevent the second catching it up. The result was a series of spectacular rear-end collisions caused, in each case, because the driver believed he had a 10 minute gap ahead of him and had little or no warning if there was an erosion of that 10 minutes. Even if the time was reduced so much that he could see the train in front, he often did not have enough braking capacity to avoid a collision. Many of the problems arising from the lack of clear communications and procedures required for safe operation of a railway were highlighted by an accident at Clayton Tunnel on the Brighton line on 25 August 1861. This was the result of confusion between signalmen at each end of the tunnel, although other factors also contributed. This part of the Brighton line was still being worked by the time interval system and there were three trains booked to leave Brighton at 10 minute intervals. However, due to the late running of the first train, they actually left at 8:28, 8:31 and 8:35.

The procedure for signalling a northbound train through the tunnel was for the man at the south end to send a `train in' signal via telegraph to the man at the north end. When the train emerged at the north end, the man there sent a `train out' signal to the south end which rang a bell which would then be acknowledged by the south end. The southern end signal man could also operate a distant signal to give advance warning to approaching trains, this would be automatically reset to danger by passing trains. The same telegraph instruments were used in both directions and were not of the pegging type so there was no reminder to either signalman of which signals had been sent, nor were they required to keep record books of signals and times sent.

The first train entered the tunnel after passing the distant signal at CLEAR and was telegraphed to the north end as `train in'. Unfortunately the distant failed to reset to DANGER and the second train approached closely behind the first at full speed. Having received no indication from the north end that the first train was out of the tunnel, the signalman waved a red flag to the driver as he passed by. At that moment he received the `train out' signal and so immediately showed a white flag to the guard as the rear of the train passed him into the darkness of the tunnel and then sent `train in' to the north end. He then managed to restore his distant signal to DANGER.

The two signal men disagree on what then followed. The south signalman maintained that he asked the north end on the telegraph whether the second train had left the tunnel. The north end thought he was referring to the first train and replied yes. The northern signal man claimed that he received a message from the south end saying the train was not out, to which he replied yes, followed by a signal from the south end saying `they are running into each other'. Whatever the signals sent, as the third train approached the tunnel the southern end signalman thought the second train was out of the tunnel and accordingly showed the driver CLEAR signals. However, the driver of the second train had in fact seen his red flag and managed to stop with the back end of the train about 200 yards inside the tunnel. He then started to reverse slowly back out of the tunnel just as the third train entered at about 25 mph. The resulting accident killed 23 and injured a further 176.

Capt H. W. Tyler, appointed by the Board of Trade to inquire into the accident, was scathing in his findings, not so much of the signalmen's misunderstanding, but of the Brighton stationmaster who had not observed the 5 minute minimum interval between departures, the lack of block telegraph on the line, the inadequate telegraph equipment between north and south ends of the tunnel, and the lack of registers for recording times of telegraph signals and passing trains.

He recommended the adoption of the block telegraph system which would provide a means of operating a space interval system between trains and a minimum of three telegraph instruments to be provided for the signalmen at each end of a telegraph section, one for each track to act as a signal which could be pegged at line clear or line blocked and one for more general communications.

The reply from the LBSCR company shows the thinking prevalent to many railway boardrooms at that time: `*The Board feel bound to state frankly that they have not seen reason to alter the views which they have so long entertained on this subject, and they still fear that the telegraphic system of working recommended by the Board of Trade will, by transferring much responsibility from the engine drivers augment rather than diminish the risk of accident*'.
At this time the railway inspectorate could only recommend, not insist. New signalling and safety developments were only adopted reluctantly by cost conscious railway boards.

Controlling The Early Railways

All the early railway companies were established by Acts of Parliament which (usually) set out how the railway in question was to operated. The first general act aimed at ‘regulating’ the railways by (a) setting up initial inspections before they opened and (b) making routine reports was The Regulation of Railways Act 1840. In April 1858 the Commissioners of the Board of Trade published some guidelines which included the following provisions:

- Signals and distant signals in each direction to be erected
- The lever handles of switches and signal to be placed in the most convenient position, and to be brought as close together as possible, so as to be under the hand of the person working them.
- A fixed signal, either attached to the gate or otherwise, to be placed at every level crossing, and where the crossing is so situated that an approaching train cannot be seen for a sufficient distance, distant signals will be required.
- Main signals and distant signals for each line are required, at all junctions.
-

In the face of an increasing number of accidents and public concern, the time interval system, as seen by the Clayton Tunnel accident, was seen as archaic and basically unsafe so the Railway Regulation Act 1873 required railway companies to submit annual returns showing where Inspecting Officers had recommended the concentration of Signal and Point Levers and the interlocking of points and signals and where the company had still to comply. Also how much of each railway was under ‘Absolute Block’ control and how much was under simple telegraph (as at Clayton Tunnel).

Finally, it was not until the Regulation of Railways Act 1889 that railway companies were compelled to adopt the ‘Block System’ on all railways ‘provided for the conveyance of passengers’. That all signals and points be interlocked and that an automatic continuous brake be provided on all trains conveying passengers.

Fixed Signalling – Stop Signals

the basic rule of signalling was to divide the track into sections and ensure that only one train was allowed in one section at one time. This is still good today. Each section (or block as it is often called) is protected by a fixed signal placed at its entrance for display to the driver of an approaching train. If the section is clear, e.g. there is no train in it, the signal will show a "Proceed" indication. For many years in Britain it was usually a raised semaphore arm. There are a few of these left around the country but nowadays it is usually a green light or "aspect", as the railways call it. If, however, the section is occupied by a train, the signal will show a "Stop" indication, usually a red aspect. The next train will be made to wait until the train in front has cleared the section. This is the basis upon which all signalling systems are designed and operated.

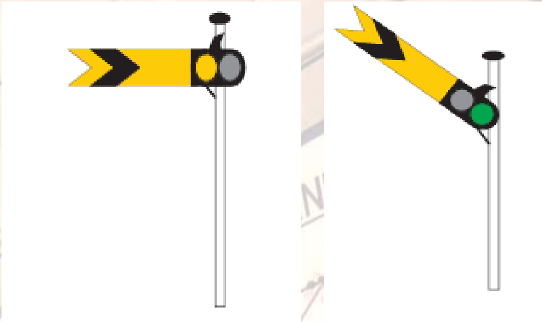
As previously described, mechanical signals first appeared in the UK in 1841 and the first purpose built ”Signal Box” with levers controlling remote signals and points was built in 1860 at London Bridge. Originally, the passage of each train through a section was tracked visually by the signalman. When the train had cleared his section, the signalman told the signal box on the approach side that his section was now clear and that he could, if required, "accept" another train. The messages between signal boxes were transmitted by a system of bell codes using the electric telegraph.

Distant Signals

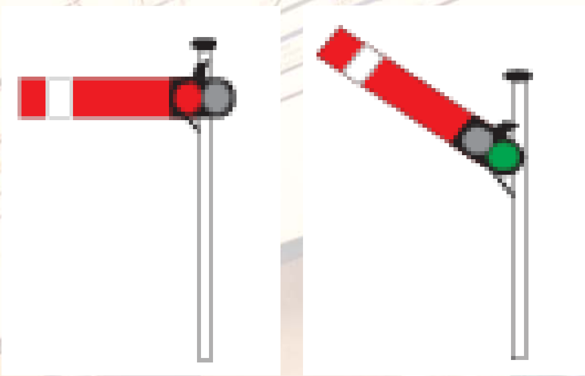
The basic stop/go signal used to protect each section of the line was OK as long as the driver of an approaching train was able to see the signal in time to stop. This was rarely the case, so a system of "distant" signals was provided in many locations.

Distant signals were placed in such a position that the driver could stop in time if the next stop signal was at danger. Positioning depended on the visibility, curvature, maximum permitted line speed and a calculation of the train's ability to stop.

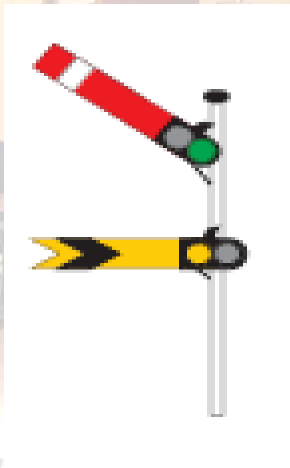
Originally, distant signals were semaphores, like the stop signals mentioned above. They showed a green light at night if their related stop signal was also green (or clear) and yellow if the stop signal was at red. The red-yellow-green pattern was adopted for colour light signals and eventually used to provide a more sophisticated form of train control.



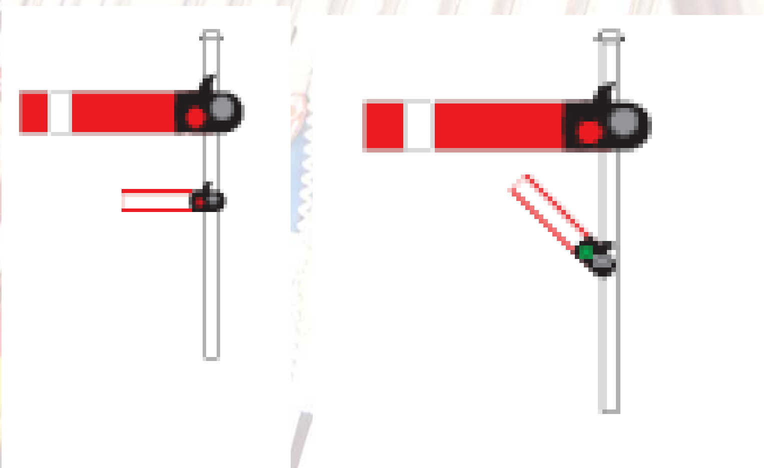
Semaphore Distant Signals



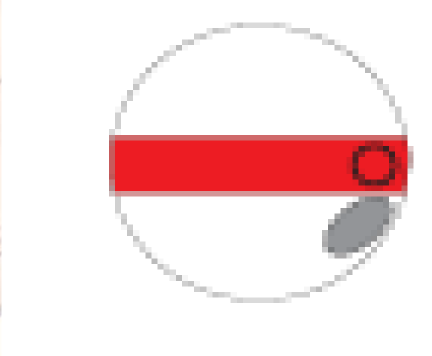
Semaphore Stop Signals

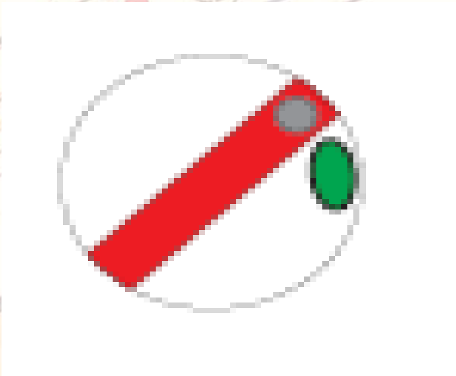


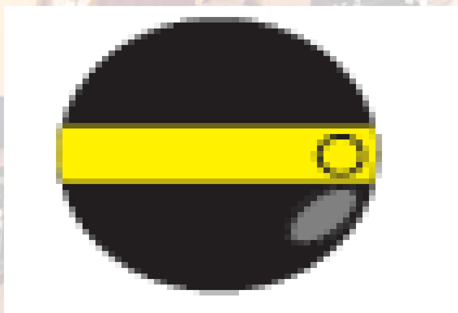
Combined Semaphore Stop and Distant Signals



Semaphore Shunt Signal (required when a movement beyond station limits is required into the next Block Section is required).







Ground 'Shunt' Signals.

Stop is indicated by the red light and horizontal red bar.

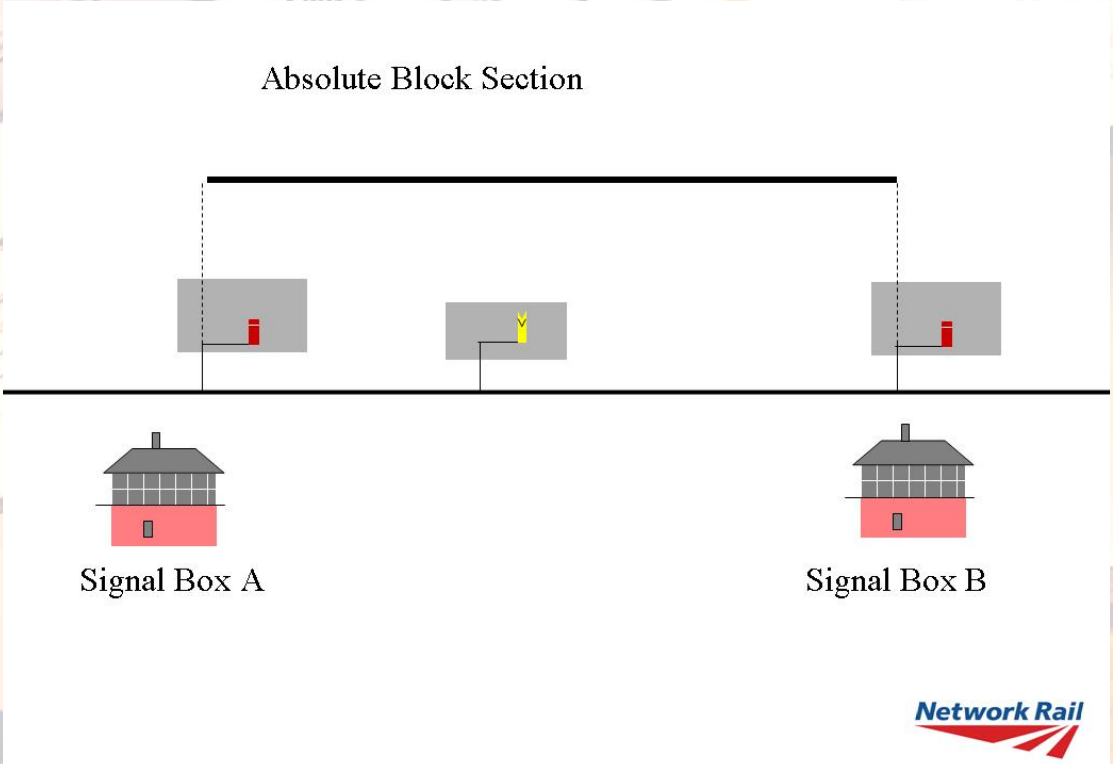
Proceed is indicated by a green light and a rotated disc showing a diagonal bar.

A 'Permissive' Ground 'Shunt' Signal.

In the normal position the signal can be passed if access to another part of the siding is required. To proceed out onto the running line the disc must be rotated diagonally.

Block Section

A block section is the section of line between two signal



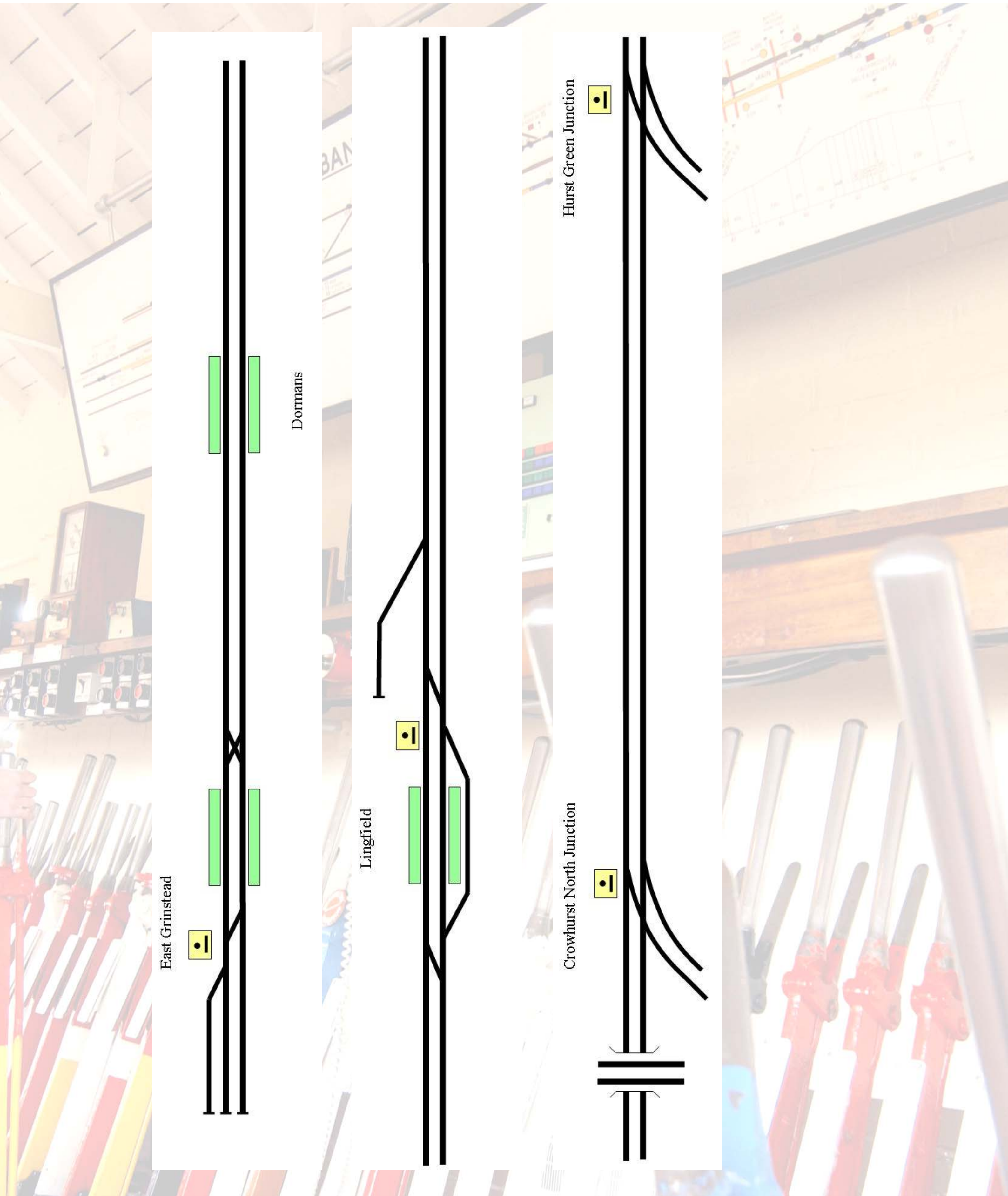
Station Limits

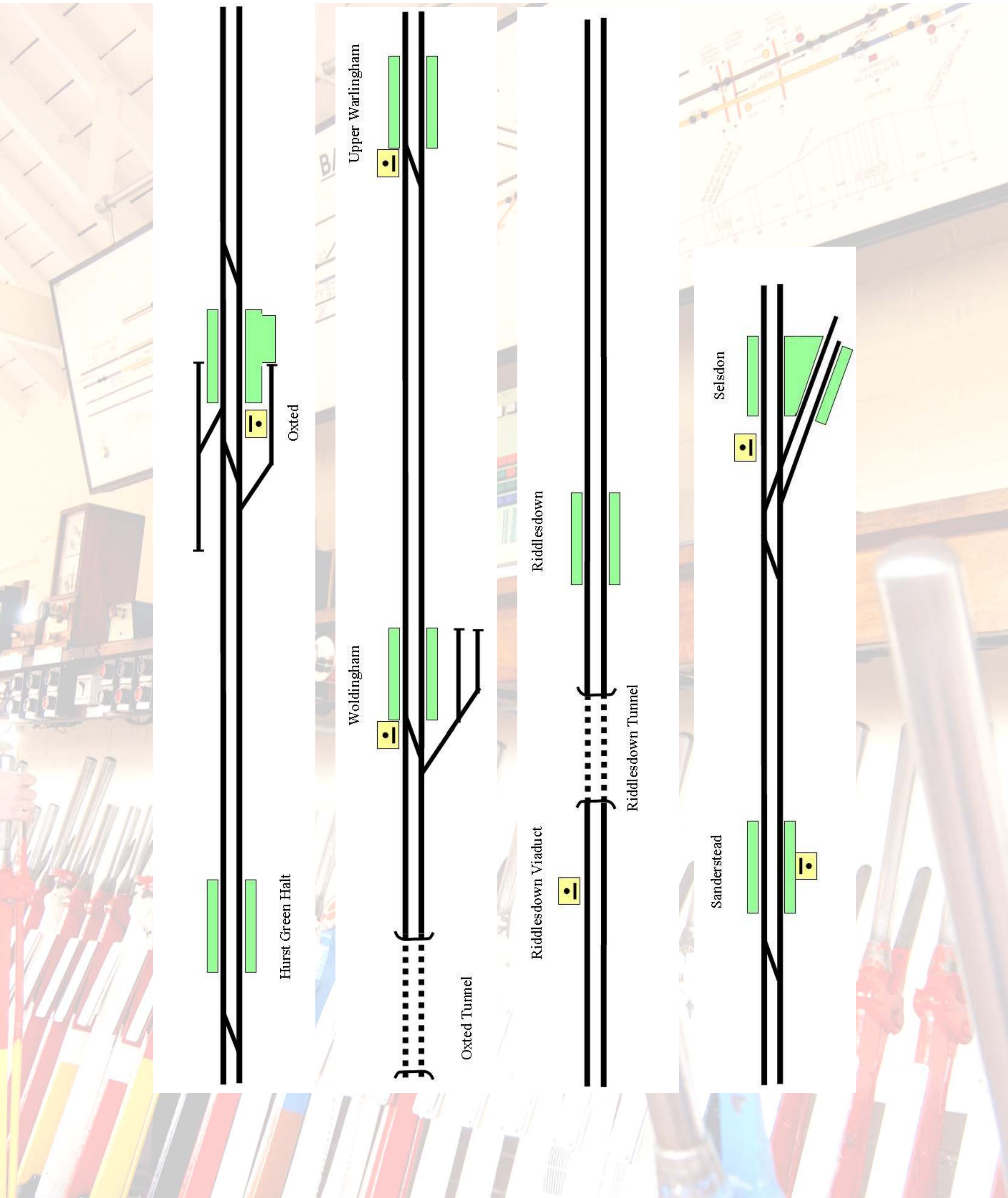
The section of line between the end of one block section and the start of the next block section.

SYNDICATE EXERCISE

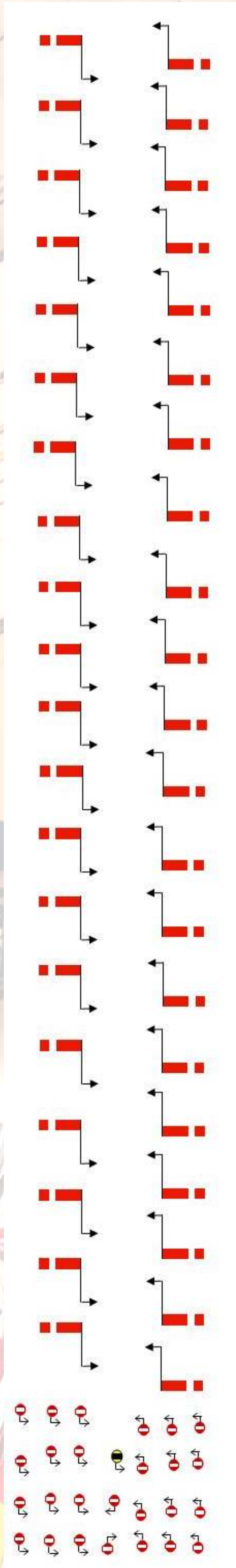
Using your skill, judgement and newly acquired knowledge, please put in the signals. Mark Station Limits and Block Sections.

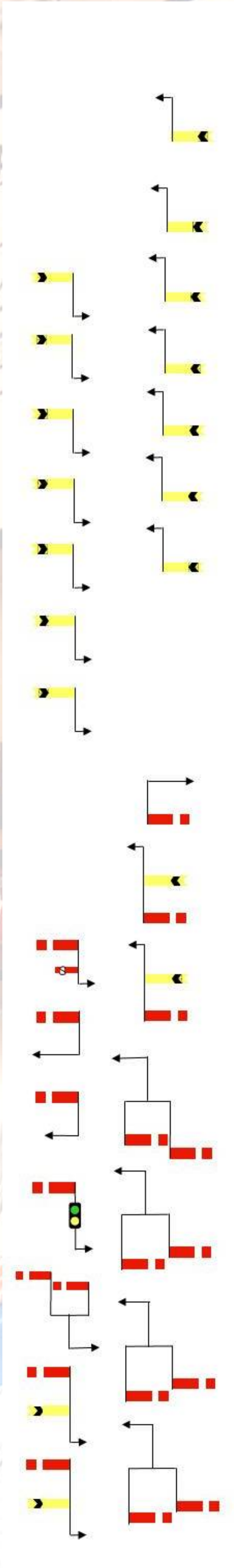
The basic Sequence of signals is Distant – Outer Home – Inner Home – Starter (placed at the end of platforms) and Advanced Starter


East Grinstead
Dormans
Lingfield
Hurst Green Junction
Crowhurst North Junction


Hurst Green Halt
Oxted
Oxted Tunnel
Woldingham
Upper Warlingham
Riddlesdown Viaduct
Riddlesdown Tunnel
Riddlesdown
Sanderstead
Selsdon

THESE ARE ALL THE SIGNALS YOU NEED

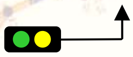




TRACK CIRCUIT BLOCK SIGNALS (BASIC)

Simple Systems replace semaphore signals with signals showing Red (STOP) or Green (Proceed) aspects. Each is preceded by a Repeater Signal showing a Yellow (Next Signal showing a STOP aspect) or Green aspect (Next Signal showing a Proceed aspect)

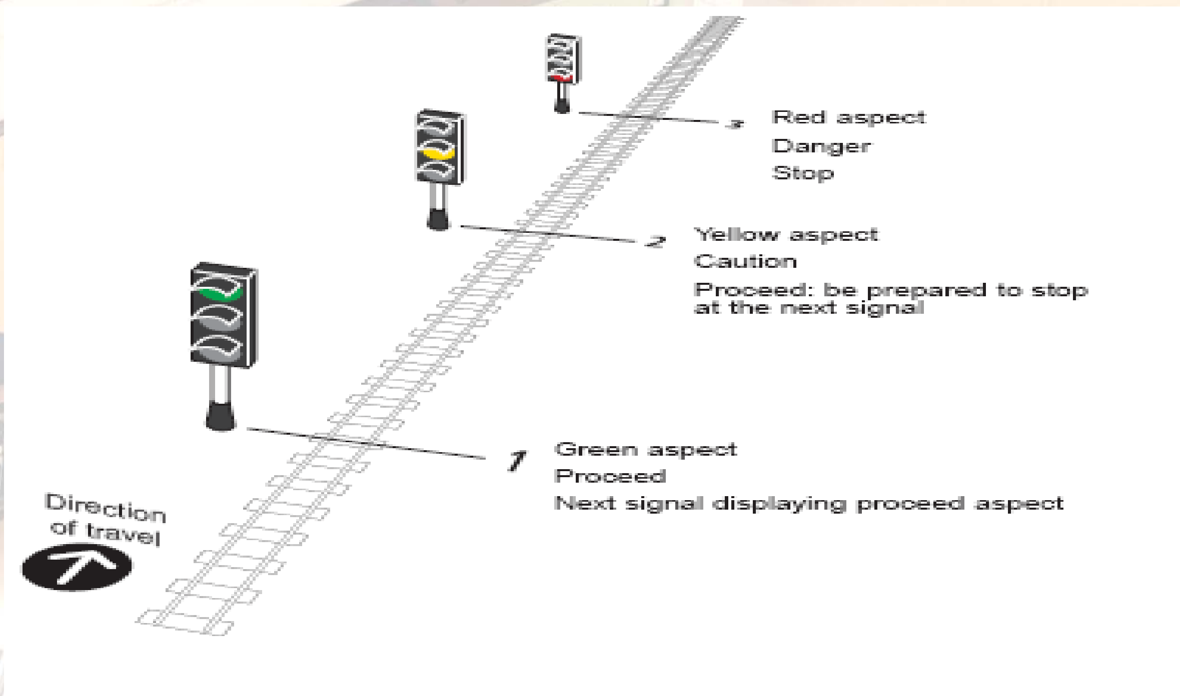
a 2-Aspect Stop Signal



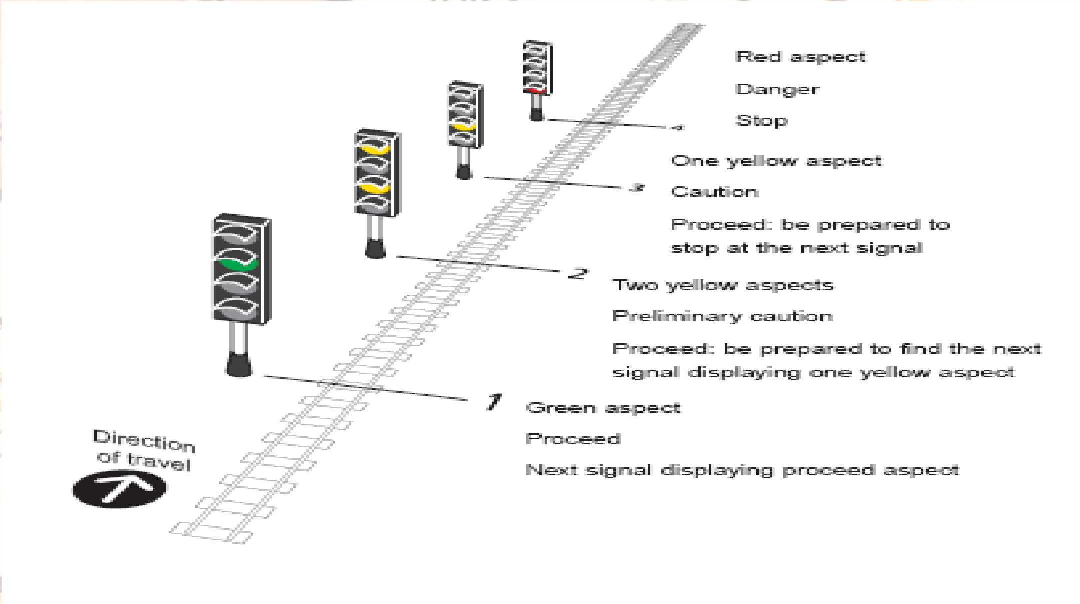
a 2- Aspect Repeater Signal

TRACK CIRCUIT BLOCK SIGNALS (NORMAL)

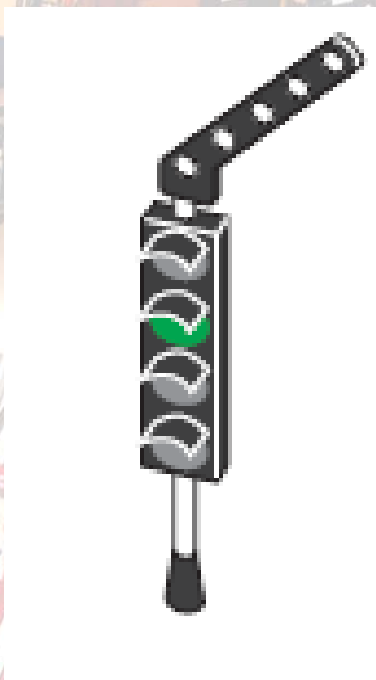
The standard (normal) Track Circuit Block Signalling system is designed to operate with 3-Aspects:

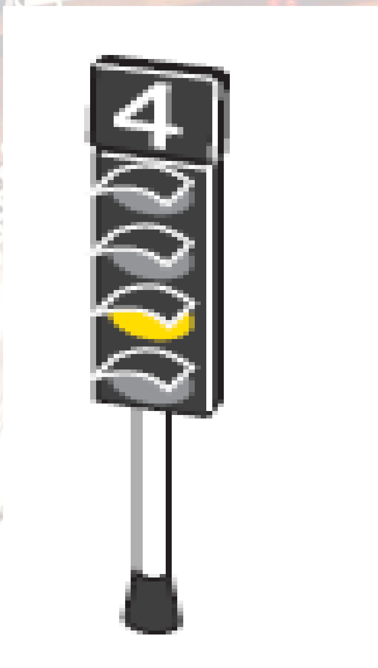


Whilst intensively used inner urban railways are likely to use the 4-Aspect system:



Signals located at Junctions are provided with an indicator of direction or a route number or letter:





GROUND SIGNALS are replaced with miniature signals which show 1 red light (stop – do not proceed) and 2 white lights (proceed only as far as it is safe to do so)

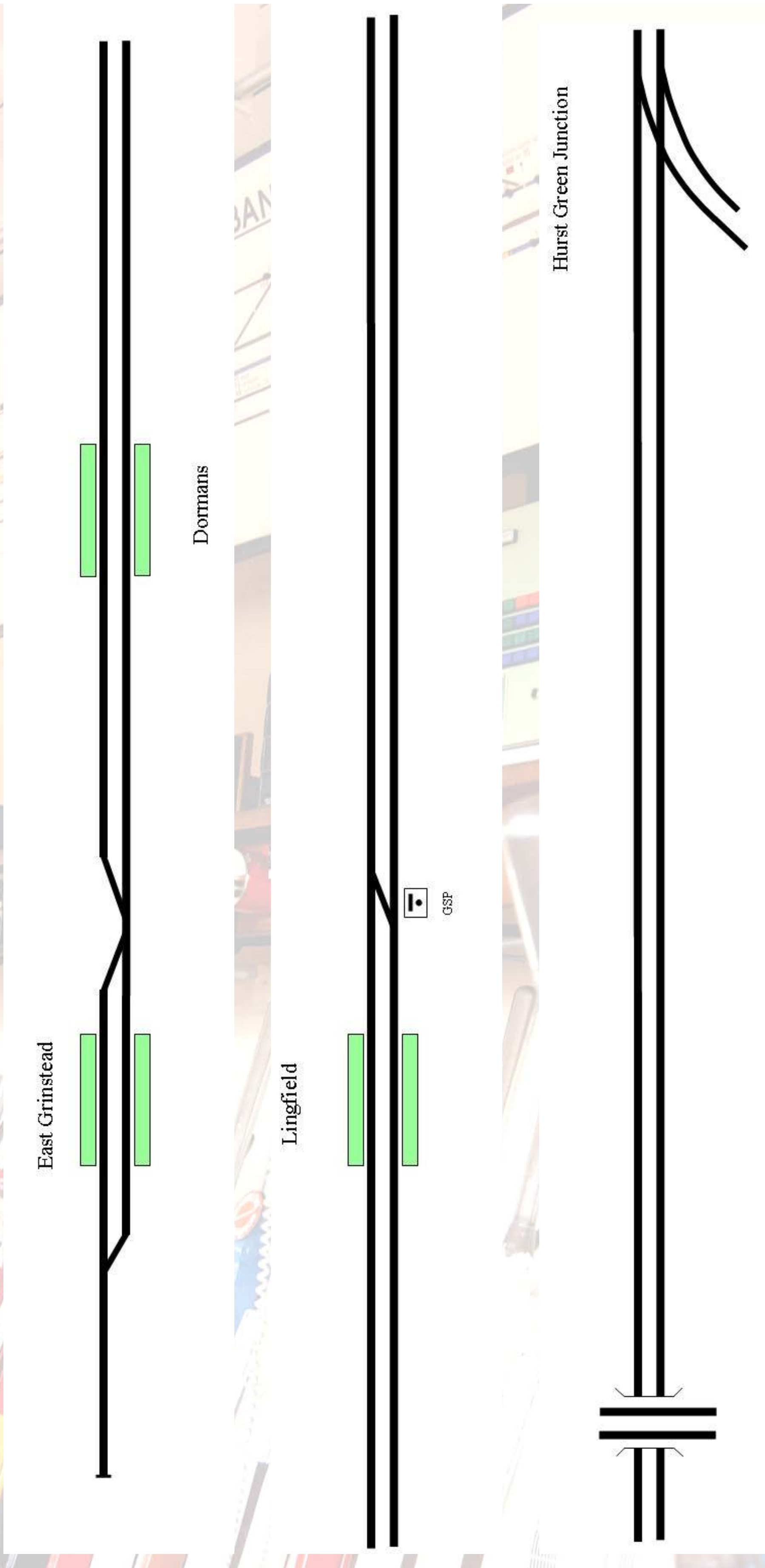
SYNDICATE EXERCISE

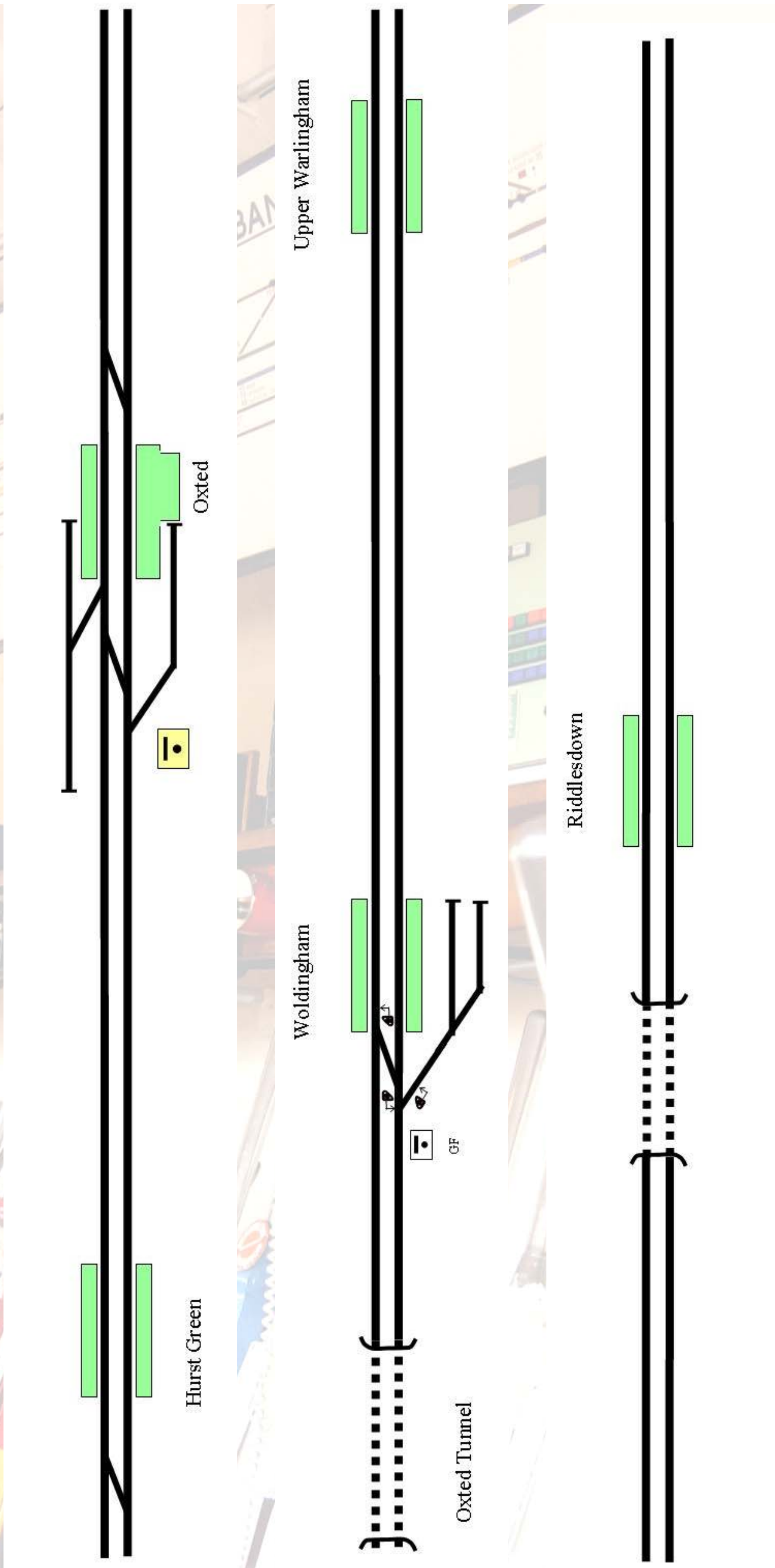
Using your skill, judgement and newly acquired knowledge, please re-signal the Oxted Line with Automatic Colour Light Signals.

2 – Aspect Signals are provided between Dormans and Hurst Green.

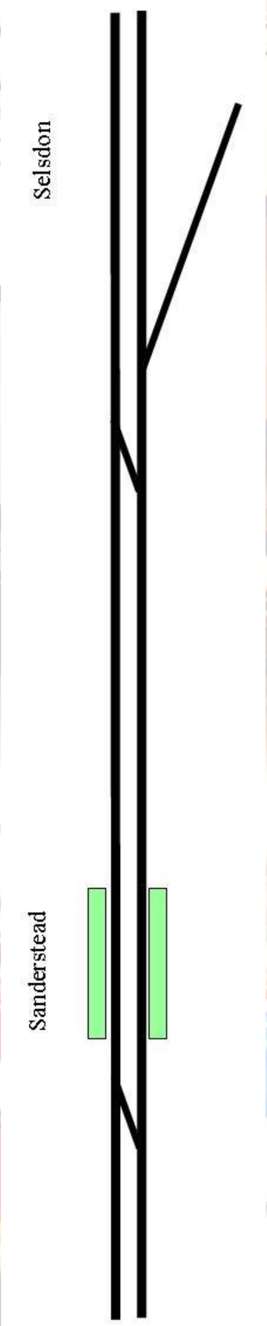
3 – Aspect Signals are provided between Hurst Green and Selsdon.

A 4-Aspect signal is provided at Selson as trains join the Brighton Main Line.


East Grinstead
Dormans
Lingfield
GSP
Hurst Green Junction



Upper Warlingham
Oxted
Woldingham
GF
Riddlesdown
Hurst Green
Oxted Tunnel



These are the Signals you require