DIRECTOR OF S & T ENGINEERING.
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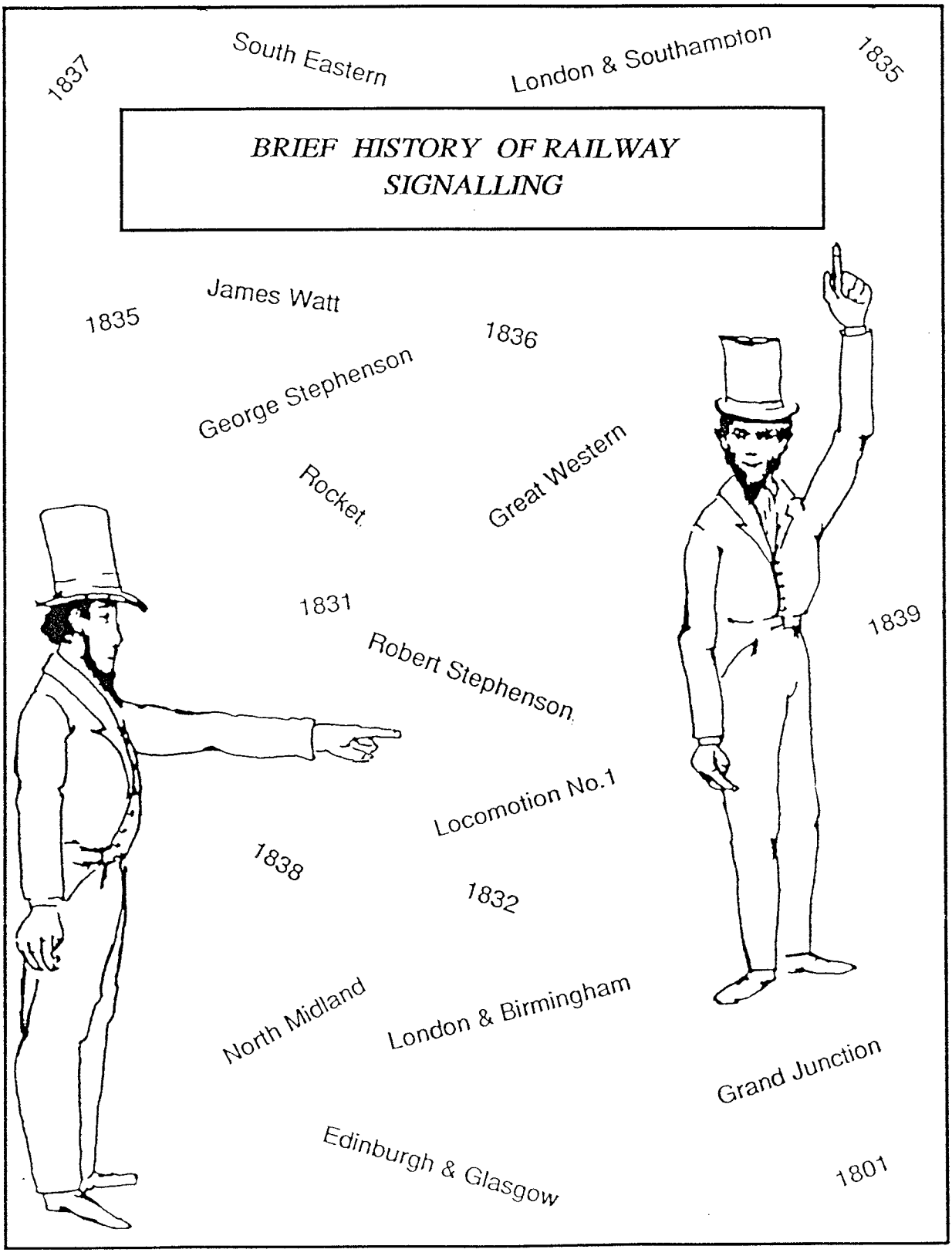

A BRIEF HISTORY OF HOW THE NEED AROSE FOR SAFE RAILWAY SIGNALLING ON THE RAILWAYS

At the end of the Napoleonic wars in 1815 Britain stood supreme in the world, both politically and industrially. There were three main reasons for this. Firstly, the Industrial Revolution had begun in Britain and the lead which had been given to the country by the great inventors of the 18th century was long retained. Secondly, Britain was supreme as a maritime power and there was no other great power to challenge her. She was in a position to capture the markets of the world. Thirdly, Britain was a united kingdom, which gave her a tremendous advantage over the fragmented countries of Europe. The main element that was missing to enable Britain to take full advantage of her favourable circumstances was a better system of inland transport, and there was plenty of capital available for the development of such a system if one could be devised.

In the 50 years before 1815 there had been a great era of canal building, chiefly to carry coal and iron, and roads had been improved by the establishment of turnpike trusts; but transport was still slow, expensive and unreliable. There was a tremendous pent-up demand for something better.

Railways had existed for many years in primitive form, particularly in colliery areas, and as long ago as 1758 an Act of Parliament had been passed authorising the construction of a railway from Middleton to Leeds. The Surrey Iron Railway obtained its Act in 1801 authorising the construction of a railway from Wandsworth to Croydon, for the conveyance of coals, corn, merchandise and commodities, and worked by horses. The promoters had originally envisaged a railway between London and Portsmouth.

Although the early railways used horse traction, steam engines were already in existence. The inventor of a practical steam engine is generally held to have been James Watt, an instrument maker of Glasgow, who patented his invention in 1769 but its application to railways was slow and confined to a few colliery lines. The development of the steam locomotive, which was to revolutionise not only 19th century Britain but also the rest of the world, was yet to come. However, the stage was now set. The means were available, and the money. All that was needed was the catalyst.

There is some dispute as to whether the railway was commenced in 1825 with the opening of the Stockton & Darlington Railway or in 1830 with the Liverpool & Manchester. In its conception the Stockton & Darlington was little more than a colliery railway, to be worked by horses, but even before it was opened the railway company obtained parliamentary powers to use "locomotive or movable engines", thanks to the intervention of George Stephenson, who became Engineer to the Railway. The line opened on 27 September 1825, when a procession travelled over the route, led by the company's only steam locomotive, the now famous Locomotion No.1. The S&DR did not at first provide passenger accommodation on its trains but allowed private contractors to run coaches on the line, pulled by horses. Difficulties soon arose in regulating the times at which trains and coaches should run, and in 1833 the S&DR bought out the contractors. However, by then a much greater railway had

continued

entered the stage. With the growth of the cotton industry the two important towns of Liverpool and Manchester were developing rapidly and the need for better transport facilities between them was becoming more and more pressing. After much hard work and persistence, and despite fierce opposition from landowners and canal interests, the promoters of the Liverpool & Manchester Railway obtained their Act in 1826. In order to decide upon the form of traction to be employed, a public competition was held at Rainhill in 1829, in which five steam locomotives competed. Rocket, made by Robert Stephenson, the son of George, was the winner; an epoch-making event which established the steam locomotive as the best means of haulage, a position it retained for over a century. The success of the Liverpool & Manchester was assured.

The L&MR opened with due pageantry on 15th September 1830 and was so successful that businessmen and promoters all over the country began to develop their own schemes. Plans already in process of development received a great boost, and there was an explosion of interest, as demonstrated by the number of railway bills that were introduced into Parliament in the 1830s (including amendments to existing Acts):

1831	15	1836	47
1832	11	1837	64
1833	12	1838	21
1834	16	1839	28
1835	21		

The number of Acts passed for new railways was as follows:

1831	5	1836	29
1832	4	1837	15
1833	5	1838	2
1834	5	1839	1
1835	8		

continued

Among the more famous companies authorised in this period were:

1831	Sheffield & Manchester
1833	Grand Junction
	London & Birmingham
1834	London & Southampton
1835	Great Western
1836	Eastern Counties
	Manchester & Leeds
	Midland Counties
	North Midland
	South Eastern
1837	London & Brighton
	Manchester & Birmingham
1838	Edinburgh & Glasgow

In the first days of railways there were no signals and there was no need for signalling. Trains were few and far between and travelled at low speeds. They were expected at definite times and the road was clear for them, for the time-tables made sure that trains were kept well apart.

This was not always the case and in September 1840 the Up morning train of the North Midlands Railway was derailed between South Wingfield and Ambergate, killing two passengers. The very next day a train overtook and collided with the train in front at Old Ford, near Bow, on the Eastern Counties Railway, killing a passenger. The driver was sacked and the Inspector, Lt-Col Thomson, recommended that there should be a school for enginemen; that there should be half-an-hour between trains starting and that mileposts should be erected at the lineside so that passengers could assess the speed of the train and complain to the railway company if they thought that it was excessive. If collisions were to be avoided in the absence of a signalling system it was essential firstly that trains ran to time and secondly that there was a sufficient interval of time between trains starting.

continued

A collision on 11 November 1840 in which two more passengers were killed occurred on the York & North Midland Railway at Taylor's Junction (also known as South Milford Junction) and added to the public alarm already being felt at the frequency of railway accidents. The 6.04 pm passenger train from Leeds to York and Hull, via Woodlesford, Castleford and Burton was standing in the station at Taylor's Junction when it was run into by a following luggage train. Sir Frederic Smith recommended that no train should be allowed to pass or leave a station within 10 minutes of the preceding train, during which time a red flag or lamp should be displayed. There were no fixed signals at Taylor's Junction and the Inspector-General called for a statement from all railway companies showing which stations were provided with revolving signal lamps placed on posts. It transpired that the passenger train did not have a tail lamp and that the breaksman had ridden upon the top of the fourth vehicle and had shown his red handlamp towards the rear. Once again the importance of trains running to time was stressed.

It is interesting to note that when Capt. Melhuish inspected the Birmingham & Gloucester Railway he discovered that Down trains used Birmingham time whilst the Up trains used Cheltenham time and that the clocks of those two towns varied by between 10 and 15 minutes. He recommended that all lines of railway leading to London should adopt London time, under the appellation of "railway time".

The railway companies were learning the importance of punctuality, and fixed signals (ie. mechanical signals in fixed locations) were coming into use. Stronger carriages were being built and there was a general adoption of the use of buffer springs to help to absorb an impact in the event of a collision.

Provided that trains could be guaranteed to run punctually, and provided that all trains that ran were in the timetable, there would have been little need for a signalling system, but it was becoming very obvious that these two conditions were unattainable in practice. Locomotives were not sufficiently reliable and were sometimes overloaded; also, they broke down in mid-section between stations, or lost time in running. The safety system that developed consisted of two essential parts: first, there was the principle that a train should not be allowed to pass a station until the previous train had had sufficient time to get well clear; and second, the principle that if a train broke down in mid-section the guard was to go back along the line at once showing a danger signal, such as a red flag or lamp, to warn the driver of the following train.

Primitive signals began to be erected at stations for the guidance of drivers, and staff were employed to operate them. After a train had passed, the signal was operated to show danger for a period of time, possibly 5 or 10 minutes, then the danger signal was replaced by one showing "all clear" (Figure 1). At some stations, and on some lines, a caution signal was displayed for a fixed period of time before the "all clear" was given. Where there were no fixed signals, a policeman gave the driver the different indications by means of hand signals. These policemen were properly sworn-in constables and were required to investigate accidents (Figure 2). They were arrayed in top hats and swallow-tail coats, and even though they were to be replaced by signalmen before many years had passed the

continued

name still lives on today in the form of "bobby", a term frequently used by drivers when referring to signalmen. Another expression still used by drivers, which dates back to those early days is the word "board", used to describe a semaphore signal. Early signals were often wooden boards, which were turned to face the driver to indicate "danger", and were turned end-on for "all clear" which was sometimes indicated by a disc. These disc and crossbar signals were very popular for a time but went out of general use over a century ago (Figures 3 to 5).

Detonators, which are small explosive devices clipped to the rail-head in an emergency and exploded by the wheels of a locomotive passing over them were invented in 1841, and rapidly came into use to enable guards of broken-down trains to give an extra warning to drivers of following trains. They were especially useful in fog, when the red light from the guard's handlamp was easily overlooked by a driver peering ahead into the gloom.

Early fixed signals varied considerably. At Whitwood Junction between Castleford and Normanton on the North Eastern, there was a board which was turned by day and at night a bonfire showed the driver where he was. On the Stockton and Hartlepool a candle is said to have been placed in the station window when a train was to stop, the driver assuming that the line was clear if there was no candle.

The Liverpool and Manchester introduced the recognisable ancestor of the modern signal in 1834 (Figure 6). This had a board of prescribed shape mounted on a vertical spindle on a post which could be revolved by a handle at the side. When the board, painted red, faced a driver he had to stop. When the line was clear the board was turned edge-on to the trains, and could hardly be seen by the driver.

A lamp on top of the post gave signals by night. In some cases flags were used, but as they tended to hang down in still weather and could not be seen, they were often mounted on metal frames. Some signals were extraordinary, such as those on the Eastern Counties Railway, where baskets on poles were used. A basket signal was in use at Windsor on the Great Western until at least 1889.

Some lines used a disc in a similar manner, but in 1838 the Great Western introduced a disc and crossbar signal (Figure 7). This had both a disc and long bar, mounted at right-angles to each other, on top of a post. When the disc was facing the driver and the crossbar edge-on, the line was clear. When the bar faced the driver he had to stop.

One disadvantage of the Great Western system was that the disc, which here meant "line clear", signified "stop" on other railways. It had, however, the great advantage that at last a positive indication was given that the line was clear. The Great Western signal was varied by the addition of "tails" to the board to distinguish up from down signals. Indications for main and branch lines were provided by duplicating the signal. These signals were often of great size, and the discs and bars had to be perforated to reduce the wind pressure on them.

continued

They were used widely until 1892 and the last was not removed from the Great Western system until 1938.

In 1851 the use of the time-interval system was routine. Generally it provided that the policeman (or signalman) gave a danger signal for 5 minutes after a train had passed, in order to stop a following train; then an all-clear signal. The fatal flaw in this system is obvious. If a train broke down in mid-section there was a clear risk of a following train running into it. If a train ran slowly the same risk arose. A means was needed of keeping a space between trains so that they could not collide, and this led to the slow development of a signalling system known as the block system.

The maintenance of a space interval, a much safer system, became possible with the invention of the electric telegraph. The basic principle of the "Block" system was that the line was divided into block signalling sections and a space was always kept between trains by allowing, normally, only one train at a time into a section.

Although the development of the electric telegraph by which messages could be sent electrically over a distance coincided with the early years of railway expansion, few companies made use of it, either because they could not afford the cost of installation or, because of its complexity, only a few railwaymen were sufficiently literate to be able to use it.

The signals themselves were still worked individually by hand, but for convenience they came to be attached in groups by wires to levers at a single point, enabling the policeman to tend more signals, as he no longer had to walk from one to the other. The originator of this idea is said to have been a policeman at Watford, who in 1846 attached a weight and a wire to a signal and worked it from his hut. The first authenticated use of signals worked at a distance by wire was in 1846 at Hawick on the Berwick and Edinburgh line.

A really important step forward was taken with the introduction of the "semaphore" signal, still one of the most familiar types of signal on the railways today. The name "semaphore" came from the use by the Admiralty and some commercial telegraph companies of moveable arms - or sometimes shutters - mounted on posts on high places to send messages. A chain of stations from hill-top to hill-top or high building, each station visible from those on each side of it, passed messages onwards at a speed unequalled by anything else in the eighteenth and early nineteenth centuries. The position of the arms or shutters indicated various letters of the alphabet or number much as semaphore signalling with flags does in the Navy of today. A very efficient chain of stations connected the Admiralty in London with the naval base at Portsmouth during the Napoleonic wars, but similar chains were in use throughout Europe and elsewhere.

continued

BRIEF HISTORY OF RAILWAY SIGNALLING

The railway semaphore, first seen in 1841 on the London and Croydon Railway, for which a signal was constructed by Charles Hutton Gregory (1817 - 1898) gradually replaced all the strange types introduced by various railway companies from time to time. It was generally a three-aspect signal. When the arm was horizontal it meant "stop"; at an angle of 45° it meant "caution"; and when the line was clear the arm was dropped right down into a slot in the signal post so that it could not be seen by the driver. This was a reversion to the earliest ideas - that when no signal was shown the line was clear (Figure 8).

By 1867 it was in general use on practically every railway except the Great Western and the South Western, but even the Great Western, in 1869, ordered most of its disc-and-crossbar signals to be replaced by the slotted post semaphore and no more disc signals were installed.

On 21 January 1876, however, there occurred an incident on the Great Northern Railway which was to have important repercussions on semaphore signalling. A coal train bound for London, running in sleet and snow, was to have been stopped and shunted at Holme to allow an express passenger train behind it to pass. The signalman at Holme set his signals, as he thought, to "stop" but the train ran past. The next place where the train could be shunted out of the path of the express was Abbots Ripton, and the signalman at Holme immediately telegraphed to that station. There the driver, although finding the signals clear for him, was expecting to be stopped. He obeyed a hand signal to do so and the train was shunted. The express was now very close. It ran past the signals intended to be set against it at Woodwalton intermediate signalbox and collided at about 50 mph with the last wagon of the coal train, which were still not clear of the main line. A passenger train approaching from the south could not be warned until it was less than half a mile from the wreckage. It was still travelling at 15 mph when it hit the other trains. In this double accident 14 passengers were killed and some 50 injured.

The accident happened because the signalmen concerned had moved their levers to put the signals to "danger" but the wires and arms were heavily loaded with snow and sleet and the signals could not move. The drivers of the coal train and the express, who were travelling carefully, therefore believed the signals to be at "clear" or "all right" as it was often called.

The failure of the old form of semaphore showed at once that something less liable to interference from the weather was needed. A rather complicated signal was devised by Edward French and introduced on the Great Northern the year after the Abbots Ripton accident. This was a semaphore with the arm balanced at the centre top, the pivot being on a long bracket attached to the post. Unlike some other forms of semaphore, the lamp spectacles (the coloured glasses which change the colour of the lamps at night) were not attached to the arm. The signal gave a very clear aspect to the driver of the train, for the arm stood well clear of the signal post. It also had the advantage that it was so balanced as to swing to "danger" if any of the mechanism immediately connected to it broke, whereas the earlier signals fell down to "clear" as their arms were not in themselves at that date counter-balanced to go to "danger".

continued

This so called "somersault" semaphore became standard on the Great Northern and a few other lines, here and overseas, but was somewhat expensive to maintain. Other railways contented themselves with carrying the arm in a spectacle casting heavy enough to counterbalance it even if loaded with snow, thus eliminating all risk should an operating rod break, a feature later officially insisted on.

In the earlier days it was always assumed that the line was clear unless a definite signal was shown to tell a driver that it was occupied or otherwise blocked. With the introduction of signals that went automatically to danger in case of failure, the idea, strongly advocated from the beginning by Cooke, that a line should be regarded as occupied unless shown by signals to be clear began to spread.

The present-day semaphore signals are of two types, lower-quadrant and upper-quadrant. Both give only two indications. For convenience we will deal with "stop" signals, as opposed to "distant" signals, first. The height of the signal post is not fixed, but is arranged to give drivers the best possible view in the local circumstances. It may be very high, so that drivers can see it over an obstacle of some kind, such as a bridge; or it may be quite low on unobstructed track.

The arm, always seen pointing to the left by an approaching driver, is painted red, with a white bar near the outer end, and the back is white with a black bar near the end.

In all types of semaphore, the signals indicate "danger" when the arm is horizontal. The lower quadrant drops down to make an angle of a little less than 45° with the post when it indicates "clear" and the upper quadrant rises to make a similar angle with the post. The pivot of the signal arm is part of a casting in a lower-quadrant signal. This is carried out to the opposite of the post from the arm and holds the coloured glasses, known as "spectacles". In the case of a stop signal these are red and green, with the glass in the lower half. When the signal is at "danger", the red glass is opposite the lamp. When the arm is lowered the green glass is brought opposite the lamp.

The spectacles of an upper-quadrant signal are embodied in the signal arm itself and formed of a stamping attached to a spindle above arm level, the green glass being nearer the post than the red. The action of raising the arm brings the green glass in front of the lamp. In this type of signal the arm naturally falls to the danger position by its own weight if any part of the mechanism breaks.

A small white light is visible from behind the signal, for the guidance of signalmen, when the arm is in the normal position, ie danger, and a "blinder", moving with the arm, obscures the light immediately it leaves the danger position. The signalman can thus check the action of the signal from its reverse side at night.

continued

A distant signal is generally similar in operation but there is a fish-tail to the arm and a black stripe of similar shape is painted near the end. Distant signals now have yellow arms and show green or yellow lights at night. At first, however, they were painted red and showed green or red lights - an unsatisfactory procedure because it meant that drivers had to pass a red light as a regular practice and might well, in conditions of bad visibility, have passed the red light of a "stop" signal believing it to be a "distant".

This was not so inconsistent at first when such signals were practically stop signals, but became so when they were used as approach warning signals. A distinction by day, in the form of the V notch in the end of the arm, was introduced in 1872 on the London Brighton and South Coast Railway and was generalised from 1877.

The electric telegraph was coming into widespread use by the mid - 1840s as a means of giving information about the running of trains. It was first brought into use on the Blackwall Railway and on the Great Western between Paddington and Slough, but by 1845 it was in use on the whole of the London & South Western Railway and the South Eastern Railway, on most of the London & Birmingham Railway, and was being ordered or installed on other railways. Electric telegraph block signalling was first installed in 1844 on the Norwich-Yarmouth line.

We must now go back to another important aspect of signalling. Although a signalman might put his signals in the correct position for a particular route at say, a junction, there was at first no means of ensuring that he had in fact also moved the points to the correct position although occasionally an indicator working in conjunction with the points was set up beside the line where a driver could see it. What was needed was something to make sure that signals and points were moved together, so that the track could not be set in one way and the signals in another. In 1843, Gregory, who had made a semaphore signal two years before for the London and Croydon, built a central frame from which both points and signals could be worked.

This had a partial interlocking system and was set up at Bricklayers Arms Junction. A complete system capable of interlocking the points and signals at a junction by simultaneous motion was patented in 1856 and was set up, also at Bricklayers Arms, by John Saxby (1821 - 1913). Modern interlocking, in which it is essential that one movement must be completed fully before another, dependent on it, can be begun was first seen at Kentish Town Junction, London, in 1859, where a system was installed by Austin Chambers, and Saxby then adopted the same fundamental principle.

Although the Board of Trade had powers from 1840 onwards to watch over the safety of railway passengers and these powers were expanded under the Regulation of Railways Act, 1871, it was not until 1873 that an Act was passed which took an interest in the rate at which the railways were installing block signalling and interlocking. Even this Act required only reports on progress. In fact, British railways had done much better than other countries. In 1873, the year of the Act, the London and North Western, which then began manufacturing

continued

its own signal apparatus at Crewe works, was working more than half its mileage of double track on the absolute block system, and well over half its points and signals were interlocked. Most of the other main companies were in a similar position. Three companies - the South Eastern, London, Chatham and Dover, London Brighton and South Coast - worked their entire mileage of double track on the absolute block system.

Until point and signal levers were concentrated in signal boxes, instead of being adjacent to the signals or points they controlled, little could be done to interlock their working. Concentration, however, proceeded rapidly in the 1870s and the Regulation of Railways Act of 1889 made both block working and interlocking statutory obligations. By that time, practically every major line was already being worked by block signalling and less than 10 per cent of the signals and points were not interlocked.

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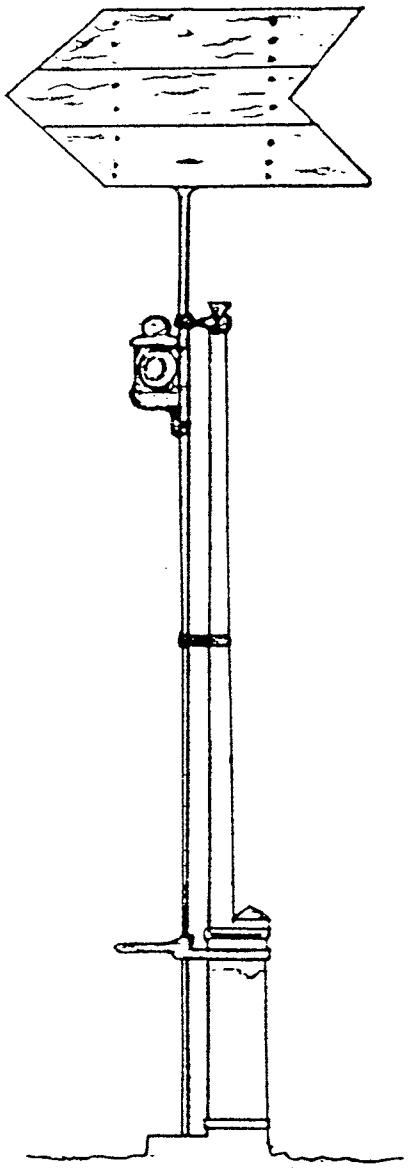


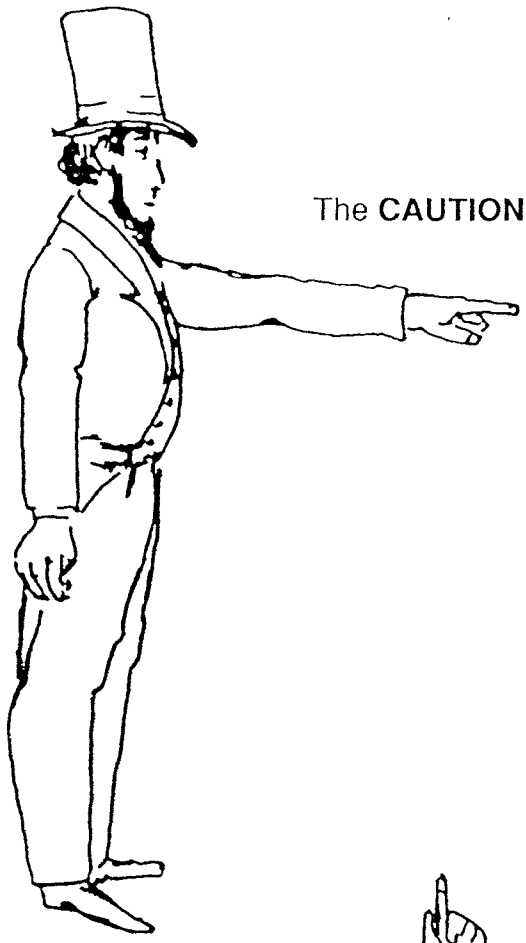
The Board or Ten Minute Signal

FIGURE 1.

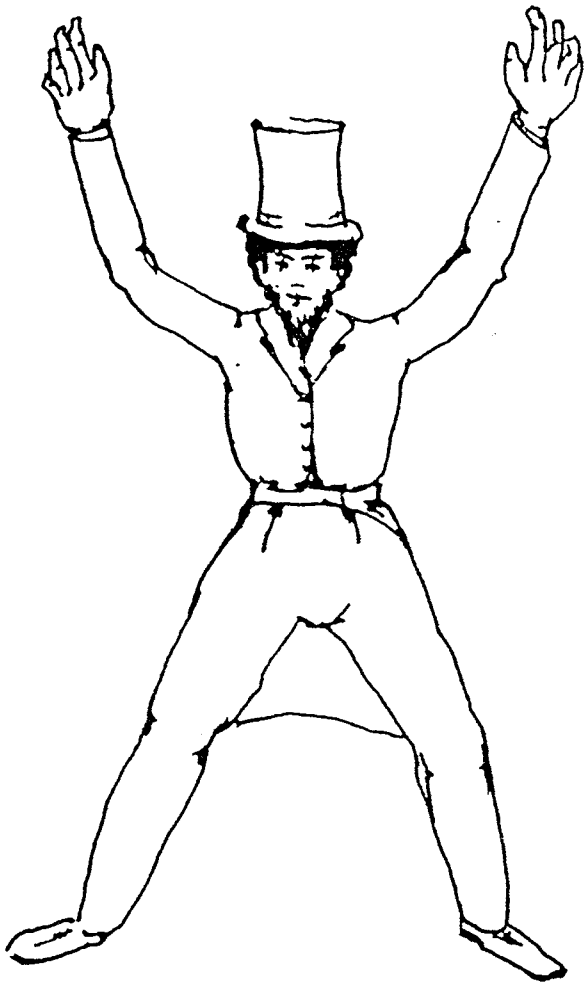
continued

BRIEF HISTORY OF RAILWAY SIGNALLING

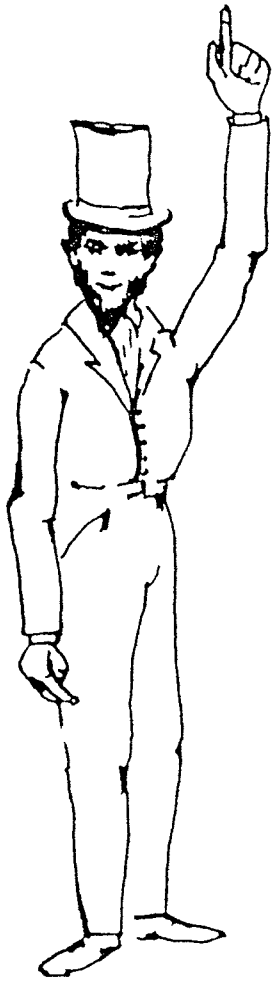
DAY SIGNALS



The **CAUTION** signal to slacken speed



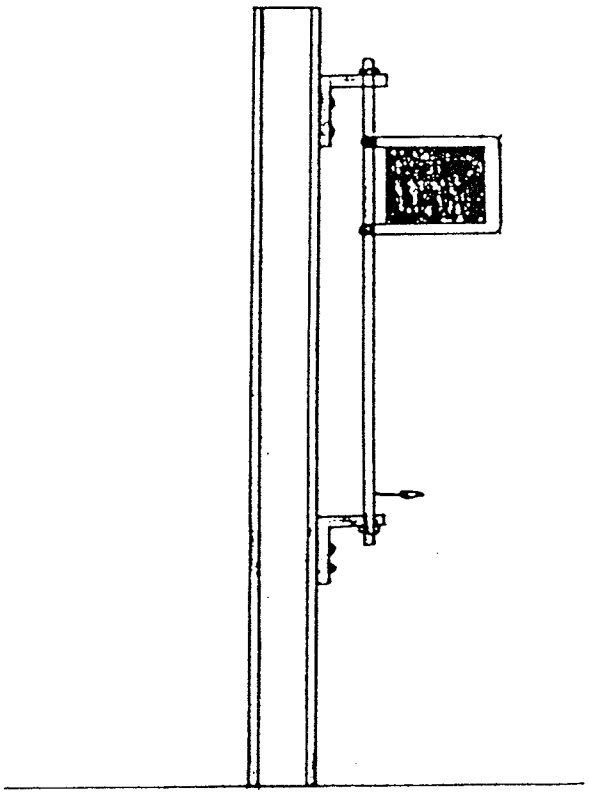
The danger signal **"TO STOP"**



The signal **"ALL RIGHT"**

FIGURE 2.

continued

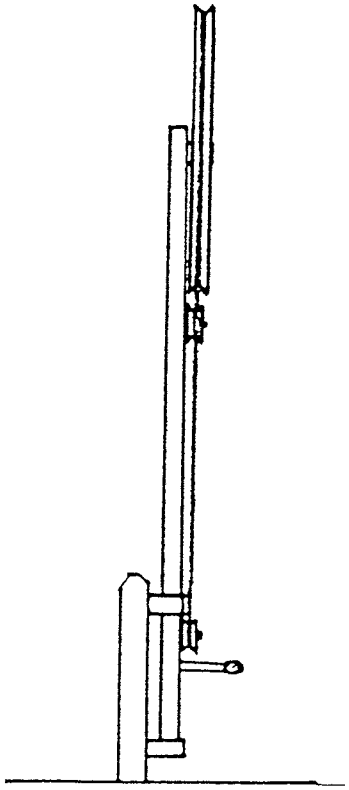


Flag Signal (1834).

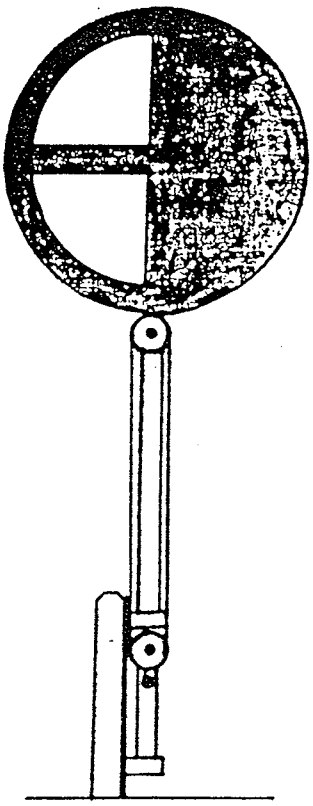
FIGURE 3.

continued

Signal on the London & South Western Railway (1840).



Showing Up & Down Line Clear



Showing One Line Clear
and the Other Blocked

FIGURE 4.

continued

Flag Signal in the **CAUTION** Position

Double Disc Signal (1846).

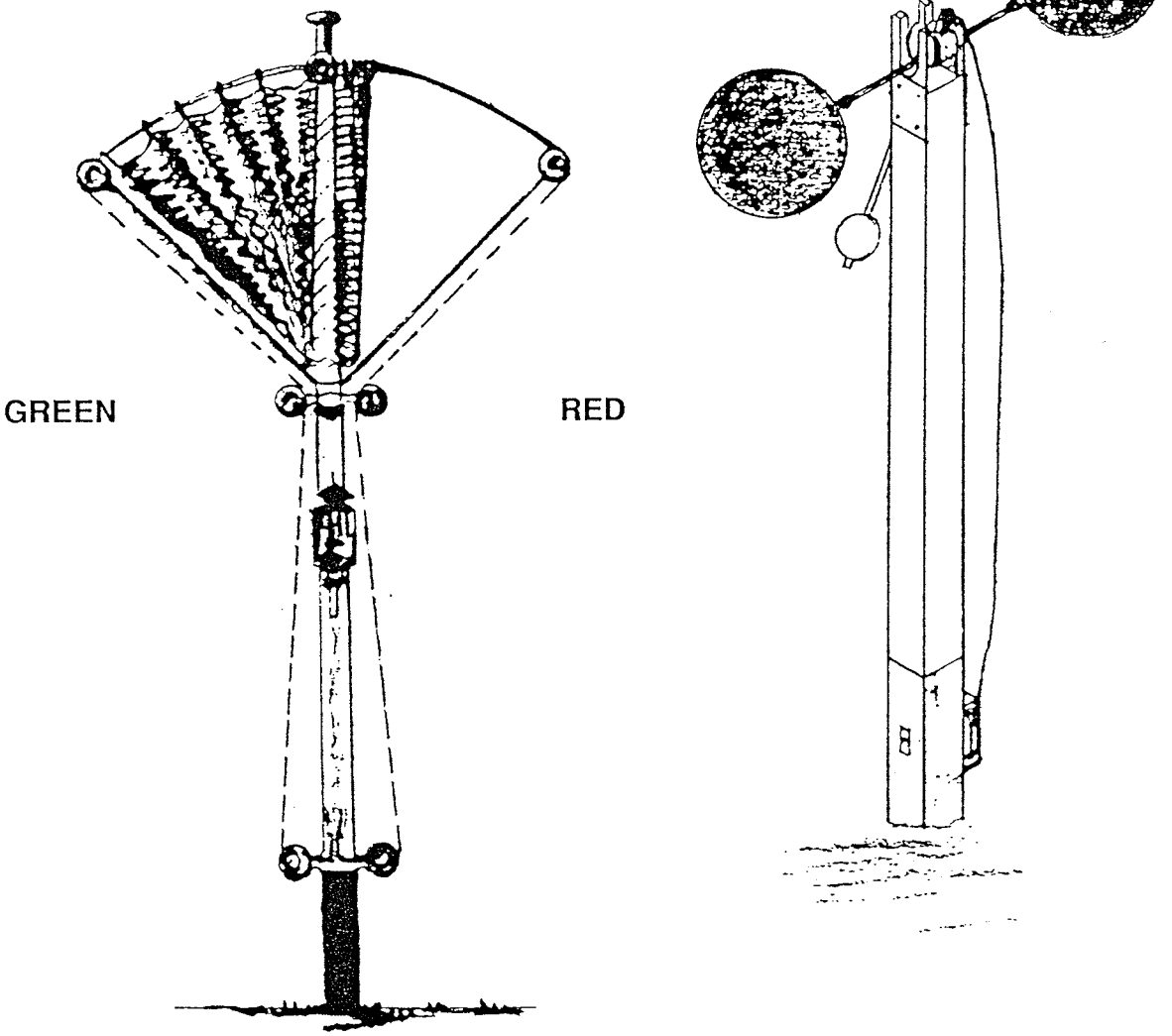
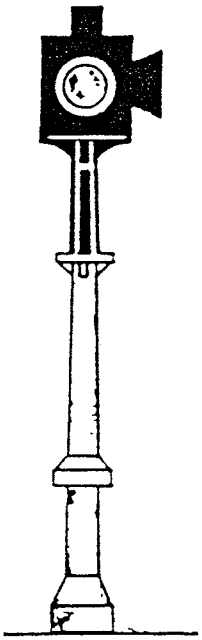


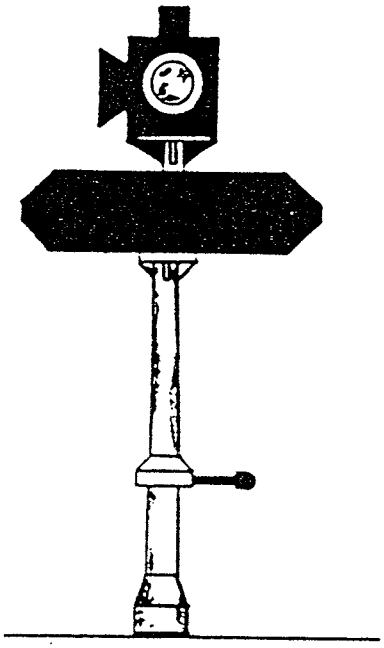
FIGURE 5.

continued

Signal on the Liverpool & Manchester Railway (1834).



ALL RIGHT Position

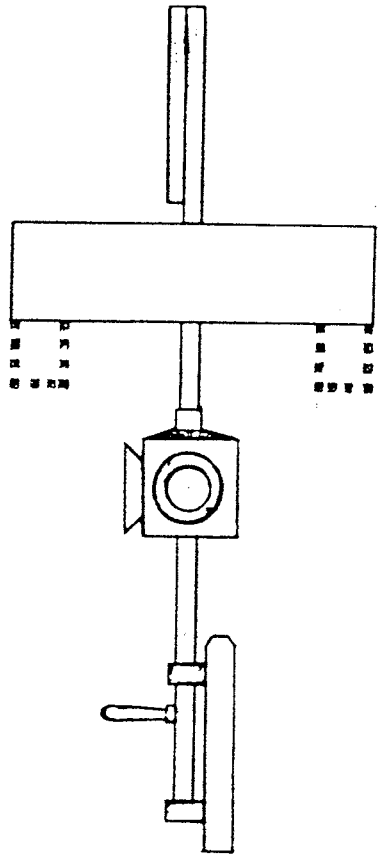


DANGER Position

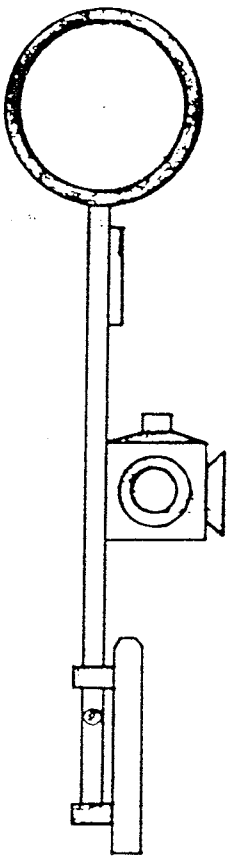
FIGURE 6.

continued

Disc and Crossbar Signal on the G.W Railway (1838 to 1892).



In **DANGER** Position

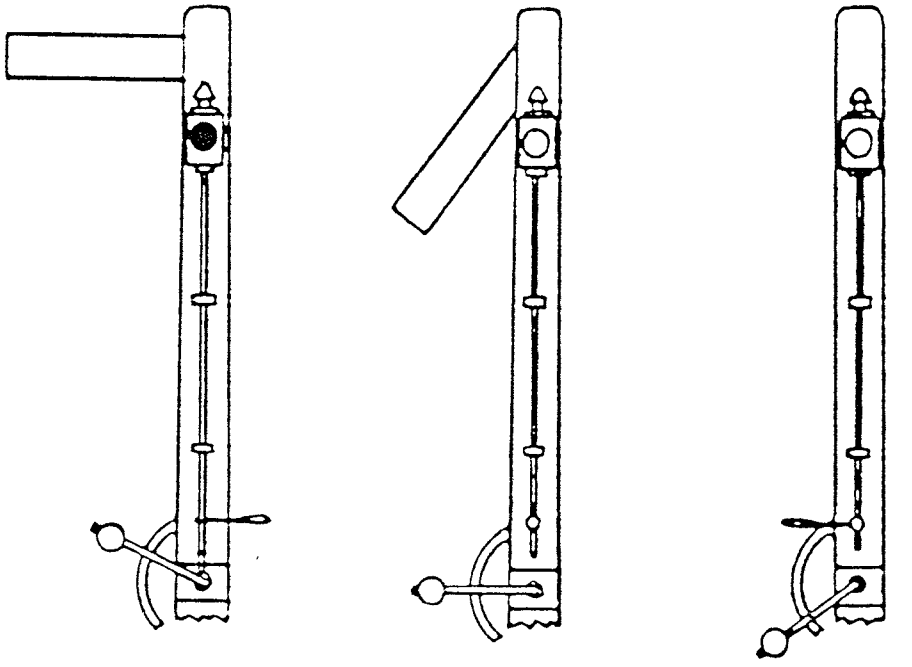


In **PROCEED** Position

FIGURE 7.

continued

A Slotted Post Three Position Semaphore Signal, first used by the London & Croydon Railway in 1841.



DANGER CAUTION CLEAR

FIGURE 8.

end