RAILWAY INTERLOCKING.

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Among the various branches of Engineering, as applied to Railways, there is none of more importance than that of efficient Interlocking and Signalling. Without this valuable adjunct, economic and safe working would be impossible; not only would the carrying capacity and rapid transit now demanded be hopeless, but, as no security would be insured for the millions of people who travel by train, no railways could be practically or commercially worked. In fact, such a condition as would exist without an interlocking system is inconceivable. What has brought this about we shall see later.

HISTORICAL SKETCH.

In the early days of the introduction of railways in England, the birthplace of this great and indispensable means of transport, the question of adequate signalling never occurred to the pioneer engineers. All their skill and attention was directed to tractive power, and the construction of earthworks, bridges, tunnels, and the laying of the track, now designated as the Permanent Way.

At the opening of the Stockton and Darlington Railway, in 1825, the first railway signal was used, and consisted of a red flag, held by a horseman, who rode on the track in front of the engine—which, by the way, was driven by the immortal George Stevenson—rather a risky proceeding in these modern days. Even in this instance, the system was short lived, as "George," to show what his engine could do, "shook her up," and the equestrian signalman had to clear out, and was soon left far behind as the train attained the speed of 15 miles an hour. (Fig. 1.)

One of the next advances in signalling was the "Handbell" System, whereby a man preceded the train, which only travelled about the speed of a traction engine, swinging a handbell. It was in use as late as 1888 on the Victorian Railways, between Spencer Street and Flinders Street. The bell was subsequently fixed on the engine and operated by the driver, and was largely in use in America for years, and up to the present date. I believe, on the South Australian Railways, where the rails are laid in the public streets of Adelaide and Port Adelaide.

It was soon found, however, after many accidents had occurred, that something would have to be provided in the way of fixed, visible signals, as speed increased and the engines and trains being rigidly confined to iron tracks, there was no getting out of the way, and the rule of the road adopted by coachmen and drivers of horse-drawn vehicles could not be adhered to. One rule was, however, adopted, in the case of double lines of track, and that was the adherence to the "left-hand side," and with the exception of America, Canada, Russia, and one or two other countries, where this principle is reversed, all nations have adopted the original English practice in this respect.

For some time, when the trains on each line were few, there were either no signals at all or signals of a very primitive description. These were given in daylight by flags or by a man holding up his arms, and at night by hand-lamps. These signals, which are called "hand-signals," still remain in use, particularly in shunting. (Fig. 2.)

In passing, I may remark that the New South Wales Railway Department is the only one that has adopted a standard size for hand-flags. The ordinary "hand size," measuring 18 inches by 24 inches, and that used by guards 9 inches by 12 inches.

As traffic increased, a better system of controlling the movement of trains became a necessity, and signals fixed on posts by the side of the railway came to be universally adopted. (Figs. 3, 4.)

The views show a few of the various types used. I can well remember many of them being in operation in my own time. Even after interlocking was introduced, they were retained for a long while, as drivers had become accustomed to them, and railway managers were very conservative, and anxious to avoid taking any risks. But though these are now merely matters of history, at the same time they are interesting, as showing the origin and gradual development of the interlocking system.

Not only were English managers afraid to alter the design and form of the signals their men had been educated to, but the continental lines, too, retained their original primitive signals

for many years, and the author well remembers the antiquated "chess boards," in operation in France and Belgium as late as 1882. The Chemins de fer de l'Etat Belgique were the pioneers of the interlocking systems on the Continent, France, Germany, and Russia following later.

In 1841, the signal known as the "Semaphore," now almost universally adopted on railways, was introduced by Mr. C. H. Gregory. Although some Companies have adopted the "central pivot," and others the "end pivot," some arms working to two or even three positions, up or down, the general principle of the "Semaphore" signal is the same. (Fig. 5.)

The early types of this class of signal, which were in use for many years, provided for the arms working between two plates or boards, or rather "blinkers," as they were called, but on one particularly stormy and snowy winter's night a terrible series of collisions occurred on the Great Northern Railway, of England, where the signal arms had been lowered and had become frozen and jammed in their "off" positions, notwithstanding that the operating levers were reversed, with the result that two awful collisions occurred, resulting in a fearful loss of life and destruction of property.

This brought about the "outside" and "central pivoted arms," which could not be obstructed by snow or frost, the Great Northern Company being the first to adopt the system now universally followed.

The light at night was originally given by a revolving lamp, with white, red and green bull's-eyes, operated mechanically by the movements of the "Semaphore arms," and corresponded with its position. For instance, if the arm were horizontal, meaning danger, or stop, a red light was shown, if lowered to 45° a green light was shown, indicating caution, or proceed cautiously, and if to 90°, or vertical, the light shown would be white, or "all clear." Revolving lamps for this class of signal have now, however, been universally abandoned in favour of the "Spectacle," which is attached to the arm, and indicates red or green. It was found that the white light was a source of danger, as the red glass, which indicates "danger," might be broken, and thus lead to serious accidents.

Consequently, the modern rule on all railways now is that a white light, exhibited by a fixed signal, must be treated and observed absolutely as DANGER.

After some considerable time had elapsed in the early days of railway working, it became evident that something more was wanted in the direction of location of the signals, and the practice (now in general use) of the Distant and Home was introduced. (Figs. 6, 7.) The Up and Down Home signals consisted of a two-armed semaphore, fixed usually on the passenger platform, erected in the middle of the station yard. The Distant

signals were fixed from 800 to 900 yards out beyond the Home signals, but there were no mechanical means provided to compel the signals being worked in a systematic manner. Modern rules provide for the Home signal, which are now fixed outside the first facing points, being pulled off first, and the Distants afterwards. The Semaphore home signals were worked by hand levers on the post, and the Distants by wire connections, manipulated by ship wheels, with ratchets and pawls. I have frequently seen, in the old days, cases where the signalman or Station Master has pulled off, say, the Up Distant and the Down Home, and vice versa, rather a loose way of providing for safe working.

About the year 1846 it had begun to be the custom to concentrate as many signals and point levers together as could be conveniently worked by one man, and for this purpose the points and signals were connected to the levers by rods and wires. (Figs. 8, 9.) This system, however, introduced the danger of the signalman pulling the wrong lever by mistake, which might easily happen if he had ten or twenty levers before him. To counteract this danger, Mr. Stevens, in 1847, invented a plan by which the signalman worked the points with an ordinary point lever, and the signals by means of stirrups, placed immediately adjoining the point levers to which the signals applied. There was, however, no mechanical obstacles to the signalman making serious mistakes. Various modifications of this system were introduced from time to time by railway officials and mechanics, but the first system of controlling the motion of rods by pins working in slots (Fig. 10) was the germ of the system of interlocking invented by the late Mr. John Saxby (whose death has only been recently reported, at the ripe age of 95 years). Since the introduction of the interlocking system enormous progress has of course been made, and the well-known firms of Messrs. Saxby and Farmer and Messrs. McKenzie and Holland are still household words among all railway men. Numbers of different designs of interlocking machines have been brought out and patented at various times by different inventors, but, so far as what is known as the manual principle is concerned, the machines designed and made by the two eminent firms mentioned have hitherto held their own against all competitors, and although the apparatus used on different railways throughout the world may vary in detail, the vital principles are the same as those that have been introduced and manufactured by these firms for many years. (Figs. 11, 12, 13.) For a long time every Railway Company in Great Britain and the Continent had all their interlocking work done by contract, but as the years rolled by their own officials became sufficiently familiar with the principles involved that they devised and insisted on certain designs and special types of machines, so that, in modern times,

each Company has its own manufacturing shops. Each engineer has his own particular fads, and the old adage is exemplified that railway men and fools like their own company best.

This brings us to the question which is frequently asked by the laymen, "What is meant by 'Interlocking System?'"

The interlocking system, as applied to railways may be partly described as the concentration of the manipulation of point and signal movements for a station yard or junction, e.g., Fig. 14, with all their necessary gear, into one apparatus, the levers of which are so interlocked with one another that conflicting movements cannot be made. The apparatus is placed in a frame on the station platform or in a signal-box, of which Figs. 15 and 16 show typical outside and inside views.

As an illustration, assume an interlocking apparatus to contain 60 levers. If these were not interlocked, the number of combinations of movements would run into thousands, whereas probably about 300 of these combinations are safe. These are rendered possible, but any over and above 300 are impossible.

The Engineer, who has to prepare plans for the safe and efficient signalling and interlocking of station yards, junctions and sidings, has indeed a difficult and highly responsible task to provide for the various train movements and shunting operations, so that the traffic may be conducted with safety and despatch, and arrange his signals and locking mechanism of the apparatus so that no conflicting combinations can be given, and the element of human fallibility guarded against, requires all the brain power of thought and patient concentration that it is possible to exercise. In fact, it somewhat resembles a game of chess. He must imagine that the train workers are capable of making innumerable mistakes, intentionally or otherwise, and the Engineer must checkmate them all.

British Board of Trade Regulations (150—283 yards).

Not only this, but when his designs are carried out he must also satisfy himself, by practical test and inspection of his work, that nothing has escaped his notice, nothing is left unprovided for that is needed to ensure safe working.

I am quite sure that my learned colleagues of the Railway and Tramway Department, present here to-night, fully appreciate this, as their knowledge of the subject has been of great assistance to them in carrying out designs, especially in the more important railway centres.

The introduction of the Interlocking Machine, or apparatus, as it is now usually termed, was a considerable advance on all previous systems required for safe working on railways, but this it must be understood only applies to the provision of levers for the manipulation of points and signals and their restricted combination of movements, their practical utility be-

gins and ends at the signal-box. But it is outside this circumscribed area that the real visible business of interlocking points and signals is manifest.

Signals are the means by which instructions are given to the engine-driver, or other person in charge of the train, in order to regulate the progress of the engine, or train, from place to place, and it is of the utmost importance that signals should be unmistakable, and that they should, in the simplest and clearest manner possible, convey only such instructions as are proper to be observed, and as will, when obeyed, ensure "safe working."

TYPES OF VISIBLE SIGNALS.

Until the principle of interlocking levers was introduced, only the simplest form of signal was possible, and even then the number was much restricted, and hundreds of signals had to be given by hand. As the interlocking mechanism provided for practically an unlimited number of fixed signals being used, advantage was soon taken to provide, not only DISTANT and HOME Signals, but STARTING, SHUNTING and AUXILIARY Signals (Fig. 17), with the object of eliminating as far as possible, the use of hand signals, except for purely shunting operations, outside the interlocking limits of a yard. These signals have, in modern times, become still further indictive, including "Wrong Road Shunts," "Dead End," "Setting Back," and "Calling On" Arms, "Disc Signals" (Fig. 18), and a host of others, the object being, as far as possible, not only to give the driver of an engine an absolute signal to proceed, but to show him what road he is to travel on.

The tendency of modern railway authorities is rather to increase than diminish the number of visible signals, and, in the author's opinion, it is questionable if this multiplying may not be carried too far.

The Engine-driver of to-day has a much more responsible duty than he had even a few years ago. There is considerably more gear and mechanism to be watched on a modern locomotive than formerly; high speeds are required and must be maintained, schedule time must be kept, complicated junctions and station yards have to be negotiated at varying speeds, different grades and curves have to be carefully watched, and all kinds of weather, both day and night, have to be contended with, so it stands to reason that the simpler the signalling and the fewer the number to be observed, the better for the driver, and the less risk of accident to himself or to those of the travelling public, whose safe transport he is largely responsible for.

A marked improvement in this direction was introduced a few years ago by Mr. Annett, the Signal Engineer of the

L. & S.W.R., and is known as the ROUTE INDICATOR. (Fig. 19.) These have been installed in the Sydney Station Yard in connection with the Electro-pneumatic System, and certainly possess excellent features. Suppose, for instance, that a train approaching the station, and the road is clear, which may lead, say, to six separate platforms, there is only one arm to be looked for instead of six different ones, and as this arm is lowered the number of the platform road to which it is to run is exhibited below. This is accomplished by the required number of opal glass slides, with numbers painted thereon, corresponding with number of separate arms that would be required under ordinary conditions, and illuminated at night. Track locking is also provided, which prevents an incoming train being sent into an already occupied platform road by electrically controlling the release of its Home Signal.

The same principle applies to the outgoing main line and shunting signal. This system has enabled scores of separate signal arms to be dispensed with, which considerably assists in the quick observation needed.

Different forms and shapes of signal arms provide all that is required by day, but one of the difficulties to be contended with is the exhibition in SIGNALS AT NIGHT of a particular form or colour of light that will unmistakably show the driver what the signal indicates, so that he may obey it. Experience proves that the only two colours satisfactory for signalling at night are red and green; no other simple or compound colour can be made satisfactory, although purple has been found in some cases suitable for permanent way repair signals.

For instance, it is important that drivers should clearly understand which is the "Distant," or "outlying warning signal," which he is allowed to pass at danger under certain defined rules, as compared with the "Home signal," which, if at danger, means absolutely STOP.

Serious accidents have occurred where the Distant Lamp light has been extinguished, and the first signal light the driver has noticed has been the Home, which he mistook for the Distant, and has crashed into the rear of another train standing under its protection.

There is little or no risk at outlying or country stations, where the signals are few, but in large and complicated yards or junctions, where a number of signals are collected together, the clear exhibition of the Distant signal is a matter of the utmost importance.

Various devices have been tried with more or less success, one of the best types being what is known as the "Coligny-Welsh," which shows an arrow-shaped white light alongside the red or green spectacle.

Perhaps the best arrangement is, where practicable, to combine the Home or Starting signal with the lower or Distant arm for the next section below it, which, if capable of universal adaptability, would always indicate that the lower arm must of necessity be by the Distant, but this cannot always be done.

Shunting on the wrong road, that is in face of a possibly unchecked train or shunting engine, possesses some risk by night, and an ingenious arrangement is in use here which has been a great success, and has been largely adopted. It consists of a hole, about ¾ inch diameter, in the centre of the green spectacle, backed by a perforated disc of metal, which by night has the effect of showing a bright white star in the middle of the green field, and is absolutely unmistakable.

In the early days of interlocked signals, the arms were arranged one above the other. For instance, a post with, say, three arms, the top one would apply to the left-hand road, the next lowest to the second nearest left-hand road, and the next lowest to the nearest left-hand road of the three, and so on. These, with the exception of lower or distant arms, have now been discarded, and the signals are usually of the BRACKET (Fig. 17a.) or bridge type, where more than one arm is required.

One disadvantage of the BRIDGE SIGNALS (Fig. 20) is undoubtedly, however, that they have to be erected, in many instances, particularly as Starting Signals, of an undesirable height for clearance purposes, and the arms and lights are thus not so readily distinguishable by drivers, so that designers of station yards and junctions should always arrange, where possible, their roads so that sufficient space can be provided for the erection of the single masts, carrying the bracket supported arms. Signal bridges are very costly to construct and maintain, and, in the author's opinion, are not nearly as satisfactory as those of the single or bracket post design.

TYPES OF INTERLOCKING SYSTEMS.

The various kinds of signalling and interlocking systems now in use include (i.) the Manual, (ii.) All Electric, (iii.) Electro-Pneumatic, (iv.) Lock and Block, (v.) Semi-Automatic, (vi.) Automatic, (vii.) Hydraulic, (viii.) Electro-Mechanical.

On the Railways of the Commonwealth, nearly all the Colonies have generally adopted the Manual System, where the power for working the points and signals is supplied by the operator, as the Signalman, Station Master, or Officer-in-Charge.

In this Colony the Manual System is mostly in use, about 80% of the Station Yards, Junctions and Sidings being Interlocked. The Electro-Pneumatic System is installed in the Sydney Station Yard, and will extend to Illawarra Junction;