CS & TE DEPT - SCOTTISH REGION

"SINGLE LINE SIGNALLING AND TOKENLESS BLOCK"

INTRODUCTION

These notes give some background to the methods devised and used over the years for the operation of single line and concentrate thereafter on a description of the Scottish Region system of Tokenless Block operation.

A fair percentage of the route mileage in this country still consists of single line railway, although in recent times many such lines have been closed. Up to the 1930's this percentage was something like 35%. Prior to the invention of the electric token system 1878, single lines were operated by train staff, electric telegraph or a combination of both. In spite of many potential dangers in both of these methods, mishaps were relatively uncommon. In fact up to 1874 there had only been one accident where loss of life had resulted and only one person at that. The fact that such dangers existed seemed to provide an extra vigilance to the staff concerned. In the mid 1870's, however, several serious fatal accidents occurred and this hastened the development of electric token apparatus, the purpose of which was, as always, to remove much of the responsibility and security of operation from human hands.

EARLY METHODS

Operation by electric telegraph was the method which placed most reliance on human attention and the chain of accidents referred to occurred almost wholly on lines operated by this method. By this method the station staff at one end of a section could authorise the despatch of a train from the other end by means of the telegraph. A train order form was then made out, for issue to the train crew, by a responsible member of the staff at the sending end and this act recorded in the train order book. Generally, however, this system worked well because it was carried out in a strictly disciplined way and, as mentioned before, because of the realisation that such discipline was essential for safe operation.

The other method mentioned, by train staff, was intrinsically much safer. Some object, generally in the form of a staff, was held as the auth ority for proceeding into the single line section. As there was only one staff for each section, only one train could be in the section at any one time, providing the method of working was honoured. The disadvantages of this system are obvious, however, as train movements would have to take place in alternate directions for continuous operation. Any deviations from this pattern would require manual transfer of the staff. Two adaptations of this method were later devised which removed some operating inconvenience but train movements had to take place in a prescribed order, any changes in this resulting in the same difficulties as with the train staff proper. These were the staff and ticket and divisible train staff methods. By the first-mentioned, several trains could be despatched in the same direction, with the last in such a sequence carrying the train staff, all others preceding it being issued with a form or ticket which, together with the witnessing of the presence of the staff at that station, told the driver that he was in possession of the necessary authority to proceed through the section. In some cases the tickets were normally attached to the staff. The divisable train staff in effect used metal tickets but these when joined together, formed the complete staff. The staff could be split into perhaps four parts, making possible the successive despatch of a similar number of trains in one direction. The staff would be split up as necessary according to traffic conditions, the last train in a sequence carrying the remainder of the staff through the section and a train could not proceed from the opposite end until the complete staff had arrived there.

ELECTRIC TOKEN WORKING

With/...

ELECTRIC TOKEN WORKING

With the introduction of the electric token, the train staff method was largely discarded except for unimportant lines where traffic conditions would permit of trouble-free operation, as on a line operated under "one engine in steam" conditions. In spite of the token system's many advantages it did not universally supersede telegraph working until an Act of Parliament in 1889 which virtually compelled its introduction on most categories of single line. The types of token used, each with an associated type of instrument, were the key token, tablet and train staff. The electric train staff method, which appealed to many railway officers and operators in that it retained the train staff as the token, came on the scene sometime after the first electric token method was introduced, and this fact along with the inherent bulkiness of the staff and associated instruments precluded its universal adoption. The later development of a miniature train staff system came too late on the market to make a real impact.

Whether employing key tokens or tablets, the electric token system gives a means of guaranteeing co-operation between Signalmen at both ends of a section when despatching a train and provides a tangible symbol for the driver of such a train signifying his authority to proceed. It also prevents the sending of another train into the same section in either direction until the first has been received at the distant point. Signals can be electrically interlocked with the instruments so that a release on the starting signal cannot be obtained until an electrical release is received for withdrawal of a token from the instrument. Similarly the distant, home, and starting signals concerned can be proved normal before a release can be given. The token system is thus in effect the absolute block system applied to a single line in a positive way, as only one train is permitted to be in a section at any one time. Both key token and tablet systems employ a pair of token instruments, one at each end of the section, and once a token has been withdrawn from an instrument no other token can be obtained until the first has been deposited in the other instrument or, in the event of a train cancellation, etc., returned to the instrument from which it was taken. Generally there are about thirty tokens for each section, these being suitably inscribed with the limits between which the token applies and are of such a shape or configuration that they will only fit into their own instrument to avoid false operation of other instruments where two or more sections adjoin. There are generally a total of five configurations to cover such circumstances. The tokens can also be painted in distinguishing colours conforming with the configurations.

Basically the instruments consist of a block instrument combined with apparatus for issuing and receiving tokens. The usual bell signalling components are included together with an indicator showing the state of the line. In addition there is a galvanometer which shows all electrical signals sent or received on the instrument. Its main purpose is to indicate to the Signalman if the instrument is receiving the steady current from the other instrument which instigates the token issuing process. It also records each pulse sent or received during bell signalling. A polarised relay forms the main controlling function and under normal circumstances current can be sent from one instrument to the other where it will operate this polarised relay, which in turn completes a circuit to the releasing lock.

Once/...

Once a token is withdrawn the polarity of the current through the relay is reversed and no other can be withdrawn, either at this end of the section or at the other, and the instruments are then said to be "out of phase". To restore the original line polarity the token must be returned to one or other of the instruments. Thus normal operation or train cancellation produces the same effect and the instruments will once more be "in phase". The key token and tablet instruments vary substantially in shape, design and operation but this principle is common to all types. Where signal proving is incorporated, a resistor is connected across any associated contacts, thus still allowing current to flow in the circuit so that bell signals can be exchanged while the signal proving contacts are not made up. The polarised relay will however only energise at the higher level of current, thus proving that the signal controls have been proved correct. This method is known as increment working and the controlling relay is then termed an increment relay.

This then is the basic pattern of the electric token system and some of the operational difficulties and amendments to the basic arrangements should now be mentioned. Firstly, there is the problem of switching out. Obviously this just cannot be done at will, as the fact that tokens for two adjacent sections have different configurations, itself a necessity for safe-working, precludes this. The method devised was to install a second pair of instruments between the two points forming the limits during long section working and these instruments had to make use of a different configuration from those already in use in adjacent instruments. Where more than one box is to be switched out to form the long section all boxes involved must switch out together and all tokens must be "in" at each box, i.e., there are no trains in the long section at that time. Often, where a line was operated by key token, tablet instruments would be installed for long section working or vice versa. Obviously this is a very rigid system, as long section working can only be instituted over the actual section where such instruments are installed.

The operation of intermediate sidings and ground frames was another problem to be overcome. In this case, where a train was to be shut in at such sidings, an intermediate token instrument was installed. When the trainmen placed the token in such an instrument this action reversed the existing line polarity, so returning the main instruments to an "in phase" condition, allowing a further token to be withdrawn. As the ground frame was invariably released by inserting the token in a lock, the movement had to be completed before clear conditions were restored. Often a track circuit was installed to provide additional safety, as the fact that the token is inserted in the instrument does not necessarily prove that the train is clear of the running line. A further method is to provide a separate pair of instruments of the same configiration, between the G.F. and one end of the section. This pair of instruments is normally out of phase so that when the train arrives at the G.F. and the token placed in the instrument there, that system is put in phase, allowing the signalman to remove a token, and insert it in his main instrument, allowing the latter system to be returned to an "in phase" condition. The two methods are termed as utilising "in-section" and "auxiliary" instruments respectively.

The exchanging of tokens at passing places or stations where trains are not required to stop for other purposes gave rise to the introduction of automatic token exchange apparatus. This involved both lineside equipment and apparatus attached to the cabside of the locomotive which held the tokens in a suitably designed pouch and which exchanged tokens in passing by means of extending arms. This system hower was only operative at speeds up to 60 m.p.h.

TOKENLESS OPERATION

Tokenless/...

TOKENLESS OPERATION

Tokenless single line operation offers many advantages over token working and greatly increased efficiency of working will result. It must be remembered that the conditions governing any system of single line working are that the section must be proved clear and that, once a train does enter the section, no other can be admitted until the first has cleared the single line. It is realised at once that the most satisfactory way of doing this is to install continuous track circuiting throughout the section. This, combined with some form of directional lever control can enable token working to be dispensed with. For signals to be cleared for a train to enter the section all intervening track circuits must be proved clear and a release obtained from the adjacent box, whose admittance signals are proved in the "on" position before such a release can be given. The installation and maintenance costs of such a system have precluded its universal adoptance in this country, although many isolated schemes exist, notably where a single line section is controlled at one end from a power signal box, where such provision can be incorporated with the major scheme.

CENTRALISED TRAFFIC CONTROL

Where the line is single for a great length, with many intermediate installations, the next logical step is to instal power signalling at the passing places and control the whole line from one point. Such a system is known as Centralised Traffic Control (C.T.C.). This system has found great popularity in many overseas countries notably the U.S.A. and the British Commonwealth where many of the main lines between important centres are single line because of the accepted principle or running a few very heavy trains to cover the necessary service instead of a large number of smaller trains as in this country, mostly because the distances involved are so great. In such countries the cost of such a system is overruled by the difficulty of providing signal boxes in what will often be undeveloped country. Control is generally effected over a single pair of wires from the central office to each passing place or intermediate installation, either by relay coding or by more modern electronic means. It will be noted that the name C.T.C. does not mention single lines and obviously the system is merely power signalling with remote interlockings applied to a single line. C.T.C., with code operation however was in use extensively before remote interlockings became an accepted part of modern signalling practice and so it is still often used to describe such control of single lines, particularly in overseas countries.

The current Highland Lines scheme is the only example in this country of such an installation, although it has perhaps never been referred to as C.T.C. In this case Reed FDM remote control is [redacted] used between the control point (Aviemore) and the outlying passing places. The promise of increased traffic and ever-rising staffing costs have, in this instance at least, made such a scheme viable.

TOKENLESS BLOCK OPERATION

To achieve tokenless operation without the need for full track circuiting between passing places, various designs of tokenless block systems have been evolved. The key to the Scottish Region system is that the section is proved clear indirectly by proving that the last train to proceed through the section has arrived at the other end of the section by its occupying and clearing a track circuit there and operating a treadle, as well as observance by the signalman that the train has arrived complete with tail lamp. The former condition is incorporated in the starting signal lock at both ends of the section and signal proving of home, distant and starting signals is incorporated. There are many advantages to be gained from tokenless block operation, while basic installation or conversion costs are kept reasonably low. The average speed of the line can be substantially increased by the elimination of the need to reduce speed for token exchange.

Layouts/...

TOKENLESS BLOCK OPERATION (Cont'd)

Layouts can then be altered to provide a high speed path for through traffic with a two-way loop for crossing purposes. The most important advantage of the system however, is the case with which the opening and closing of intermediate signal boxes can take place. With token operation, separate pairs of instruments, with tokens of different configuration, had to be provided for the introduction of long section working. With the tokenless block, switching in and out is greatly simplified and can be compared to that on an ordinary double line block section. Boxes can be switched out, circuit wise, under all conditions of line occupation except where this would result in two trains being in the extended section at one time, although this is permissible if both trains are proceeding away from the box to be closed. Switching out is made much more flexible than with the fixed installation of long section instruments. Such economies could enable the conversion of existing double line sections to single line without reduction in traffic. It could also be applied to existing double lines for such lines to be operated as two reversible roads to obtain greater track capacity at peak periods.

The system operates as already intimated briefly in that the previous train must have occupied and cleared a track circuit at the far end of the section. A treadle is also installed to provide an additional safeguard, in the event of the track circuit clearing momentarily while a train is on it and to provide a directional detection facility. The method described is similar to the Welwyn Control feature on a double line. As with token working a polar relay again forms the main controlling feature and the polarity of the voltage applied to it is selected from the existing track conditions through the associated control relays.

A copy of the circuit arrangements is shown on the accompanying diagram with a simplified sketch of signalling arrangements. When a train is to be despatched through the section, the Signalmen exchange bell signals in the normal way and the distant Signalman turns his acceptance switch to the reverse position. The sending Signalman then holds down his bell plunger for about 5 seconds. Under normal conditions the N.L.R. relay is up and the R.L.R. down, and so a voltage is applied to the lines, positive to line one. When this voltage is received at the other box, the polarised relay is operated, which with this polarity applied, makes up its normal contact. The repeat relay for this contact, the N.P.R., will then energise. Providing that the relevant signals are proved "on" and that the relays indicated have released after the last movement, as will be seen later, a feed will be directed to the R.L.R. The N.L.R. relay which has previously been stick held over the R.L.R. down, de-energises and its back contact sticks up the R.L.R. When the Signalman at the receiving box notes on the galvanometer that this pulse has been completed, he in turn sends a similar plunge back to the first box. The polarity of this pulse however will be reversed, i.e. positive to line 2, owing to the new positions of the R.L.R. and N.L.R. relays. At the sending box this incoming signal will operate the polarised relay in the reverse position which now enables the R.P.R. relay to pick up, sticking up over the N.P.R. down. The reason for the 5 second plunge, is to give the N.L.R., R.L.R. or R.P.R. relays, as applicable, adequate time to stick up. The lock on the starting signal is now released via the R.P.R. up, N.P.R. and R.L.R. down, and its associated stick relay up. The latter relay is normally up, providing the track circuit is clear and the treadle unoperated, having been picked up when the N.P.R. was energised, this being accomplished at the end of the previous movement, as will be seen later.

When/...

TOKENLESS BLOCK OPERATION (Cont'd)

When the train arrives at the receiving box, the track circuit is occupied and the directional treadle operated, jointly causing the Z.S.R. relay to energise over the N.L.R. down. The latter contact is included to ensure the Z.S.R. only operates when traffic is in this direction, this also being ensured by the directional treadle. Once the train is inside the home signal, the Signalman sends the call attention signal which, when acknowledged, is followed first by the returning of his acceptance switch to normal, then the train out of section signal, on the last beat of which he holds down [illegible] for five seconds. When he returns the acceptance switch to normal, the N.L.R. is picked up over the Z.S.R. up and the track relay clear, signifying that the train has arrived and is inside the track circuit. Consequently the R.L.R. relay is de-energised and any subsequent pulse sent to line will now be the normal positive to line one. With the changeover of positions of the N.L.R. and R.L.R. the Z.S.R. relay again releases. As intimated earlier, a back contact of this relay is included in the pick up circuit of the R.L.R. along with a back contact of the R.P.R. relay. The five second plunge given by the receiving signalman, with the N.L.R. up and R.L.R. down, will energise the N.P.R. at the sending box, so energising the stick relay controlling the starting signal. This box then sends a further long beat which concludes the cycle and is included merely to maintain the pattern of bell signalling and is not required for circuitry purposes. It may have been observed that the acceptance switch does not serve any real purpose in the circuitry and it is included merely to indicate the receiving box's acceptance of a train and as such could be dispensed with if a "right of way" was first established. Illuminated indications are given, i.e. red ("train coming from"), green ("train going to") and white ("normal"). These indications are selected via the appropriate relay positions. In earlier instruments a polarised centre-bias indicator was used instead, and this arrangement is shown on the schematic diagram for simplicity.

Cancelling facilities are provided on the system and owing to its inherent nature, i.e., stick control of the starting signal, these must be of two separate kinds, viz., where the train has not passed the starting signal, and where it has and requires to be drawn back. For the first named, or "open cancel", the more usual occurrence, a cancel switch is provided. This is reversed in the sending box after the acceptance switch is normalised in the receiving box and the starting signal returned to danger, and a subsequent long plunge is exchanged to return the control relays to their normal position after cancelling bell signals have been exchanged. Contacts are included where required to ensure that this cancelling procedure can only take place in its correct sequence, i.e., after normal acceptance conditions have been set up, as false operation could otherwise result.

Where a train has passed the starting signal and dropped its associated stick relay, a different method of cancelling is indicated, known as closed cancel. A sealed cancel plunger is provided in this case and cancellation is achieved by co-operative action, once the relative acceptance switch and starting signal have been returned to normal as before. The cancel plunger in the receiving box is now pressed at the same time as the bell plunger in the sending box to normalise the control relays in the receiving box and a subsequent long beat on the bell plunger at the latter achieves a similar purpose at the sending box.

Switching/...

Switching-out is very easily accomplished with the Tokenless Block. As with double line block a block switch principle is used which in this case diverts the incoming current to the adjacent instrument which then sends the local battery feed onwards to the next box. The actual switch used takes the form of a switching or King Lever. For this lever to be free it must first prove that there are no trains in the station area; that any trains proceeding away from the box have passed the starting signals; and that the road is set for the "through" line. The King Lever pulled to the "C" position in turn releases the opposing locking (normally electrical, but possibly mechanical) between normally conflicting signals, and once these are proved reverse, the King Lever can itself be fully reversed. Proving contacts of repeat relays associated with the latter are then use to simulate all manual functions in conjunction with the XR and LR contacts so that all conditions are transferred from one "side" of the switched out boxes block to the other. The advantages here are that the local power supplies are picked up, with no need for long section batteries, and that the relays and instruments at the intermediate box function fully so that the state of the line can be seen immediately on entering a switched-out box. One side-effect however is that a local failure, e.g. of a track circuit can cause a failure of the extended section, which is not the case with double line block. This does however mean that the equipment is continuously monitored.

Provision is made in the system for the issue of an Annett's Key for the purpose of shunting ahead of the starting signal. The controls are similar to the starting signal but with the added facility that the key can be released following a previous train proceeding into the section, the Regulations calling for the driver/person in charge of the shunting movement to have been suitably instructed in such cases.