Block Signalling on the Ceylon Government Railway

By Mr. C. R. ANKETELL, B.Sc. (Lond.), B.Sc. Eng. (Lond.), A.C.G.I.
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After I had chosen the title of this paper I was a little undecided as to whether I should deal with the subject in a general manner or enter into technical details of the various instruments and apparatus used for the signalling of trains in Ceylon. I have chosen the former alternative and have tried to make this paper interesting to the majority of members of a general body of engineers, as is the Engineering Association of Ceylon.

The principles, both mechanical and electrical, employed in the working of the different instruments are, however, among the simplest imaginable; the most important considerations being, of course, that the instruments should be sensitive and at the same time robust and reliable in operation. Necessary practice of railways also arranges that should an apparatus become faulty or fail to function, the failure is always on the safety side.

THE BLOCK SYSTEM

Trains in Ceylon are signalled on what is known as the Block System. The principle underlying this system is that no train shall be allowed to proceed from a station unless a certain length of clear track is known to exist ahead, limited by a signal of some sort, so that if the line still further ahead is not clear the train may be detained at such signalling point until it is. In this way a definite minimum space interval or "block section" is maintained at all times between following and converging trains.

The block system is put into effect by telegraphing the arrival and departure of trains from station
to station; and the asking for, and giving of, by means of an authorised code of bell signals, and appropriate manipulation of the instruments, permission to send a train into a section. The telegraph instruments used for this purpose—Block Instruments, as they are called—have incorporated in them visual indications, such as "Line Clear," "Train on Line," etc., one of which is brought into view corresponding to each particular manipulation of the instruments by the signalman. The signalman at each end of a block section has, therefore, at all times a visual indication as to the condition of the block section.

To prevent errors on the part of the signalmen, two important safety measures are incorporated in the block instruments—a corporation feature, which requires the co-operation of the signalmen at both ends of a section for admission of a train into the section; and a locking feature, by which the block instruments are interlocked with the fixed signals and controlled by the movements of the trains themselves. This is known as Lock-and-Block, and is used in Ceylon for the signalling of trains on the double-line sections of the railway. On single lines, the form of block system used is the Electric Tablet System. Figure 1 shows the method of working over the different sections of the railway.

**BLOCK WORKING ON DOUBLE LINES—LOCK-AND-BLOCK**

*Fixed Signals.*—As stated earlier the principle of the block system is the maintenance of a definite length of clear track between trains at all times. It is essential therefore that the whole of the track should be sub-divided into Block Sections. The length of these sections are in most cases arbitrarily fixed by the existence of a station. The entrance to and departure from each block section is controlled by "fixed signals." They are given by semaphore arms or colour lights on fixed posts, and are so called in contradistinction to "block signals" which are the code signals given on the block instruments.

Fixed signals, as far as the signalling of trains from section to section are concerned, consist of Distant signals and Stop signals.
The Distant signal is a caution signal and is distinguished from the Stop signal by means of a fish-tailed end to the arm, whilst the latter is square ended. (Fig. 2).

When a Distant signal is lowered it means that all the Stop signals ahead for the line to which it refers, worked from the same signal cabin, are in the "all-right" position and the line is clear into the section ahead. If on the other hand the signal is at danger it is a warning to the driver to slacken speed and proceed cautiously, being prepared to stop at the next signal. For this purpose the Distant signal is placed sufficiently far back, usually about 800 yards, from the next signal. The signal levers are also interlocked so that it is impossible to lower the Distant signal until all the Stop signals to which it refers have been lowered.

Stop signals may be "home" or "starting" signals. The former as its name implies governs the entrance to a station and protects the first fouling point encountered by a train. Sometimes two home signals are provided, called the "outer home" and the "inner home" respectively. Starting signals control the entrance of trains, into the block section in advance. They are usually located at the end of the station platform, about 350 yards ahead of the home signal. At places where there is a fouling point beyond the starting signal it is usual to provide an advanced starting signal.

For the purposes of block working, a Lock-and-Block section is defined as that length of track between the starting signal (or advanced starting signal, where provided) at the station or signal cabin in the rear and the starting signal (or advanced starting signal, where provided) at the station or signal cabin in advance. (Fig. 3).

**Lock-and-Block Instruments and Signals.**

Lock-and-Block instruments are fitted in the signal cabins and are worked by the signalman. One such instrument is required at each end of a section, i.e., supposing A, B and C to be adjacent signal cabins, Cabin B has an instrument connected by line wires to an instrument at cabin A
for the section AB, and another instrument connected to an instrument at C for the section BC.

Block signals are exchanged between cabins by means of a block bell fitted alongside the block instrument. These are single stroke bells or gongs and are operated by means of a tapper key. There is an authorised code of bell signals (Table 1) for communication between cabins. A record of all signals sent or received by him is kept by the signalman in a Train Register Book (Fig. 4), which he must first consult before preparing to send or receive a train, out of or into his block section.

Two-position Lock-and-Block Instrument.

The type of lock-and-block instrument in general use on the double line sections in Ceylon is the two-position type. It is, however, being replaced gradually by the three-position type, which has several advantages over the former as will be seen later.

The two-position instrument consists of an oblong case fitted perpendicularly on a pedestal behind the levers in the signal cabin. It has three apertures on the front side showing visual indications of the condition of both up and down lines in the block section to which it applies, a plunger for the purpose of operating the internal electrical connections, and a cancelling key. The diagram (Fig. 5) shows the normal positions of the visual indications in the instruments at each end of a block section, and the alternative indications which are brought into view on the operation of the instruments.

The method of signalling is as follows:

Suppose A wishes to send a passenger train to B. A gives the "Call Attention" signal on the bell (·) and after receiving acknowledgment thereof (·) sends the "Is Line Clear" signal for a passenger train (·····).

B gives permission for the train to approach by repeating the signal (·····) and then pushes in his plunger. This will change the bottom indication of his own instrument from "Closed" to "Train Coming," and at the same time release the lock on the starting signal at A, and also alter the middle indication of A's instrument from "Locked"
to "Free," and the top indication from "Closed" to "Train Going."

A is now able to pull over his starting signal lever and on departure of the train he sends the "Train Entering Section" signal (⋯) which B acknowledges (⋯).

On passing over an automatic signal reverser fixed just beyond the starting signal, the train automatically replaces the arm of that signal at danger. On the signal lever being put back to normal, the middle indication of A's instrument will change back to "Locked" and it will not be possible for A to lower the signal again until released by B, an operation which B cannot perform until the train has passed out of the AB section over a clearing treadle fixed at B.

When the train has passed over the clearing treadle at B, the bottom indication of B's instrument and the top indication of A's instrument both changed to "Closed."

B now replaces his Up signal to danger and sends "Train Out of Section" to A (⋯⋯⋯) which A acknowledges. This completes the operation and the section is ready for another train.


The method of working explained above, recognises only two conditions of the line, viz., Line closed and Train coming (or going). There are, however, three stages in the signalling of trains from section to section, viz.,

(1) The asking and giving of "Is Line Clear."

(2) The sending and acknowledgment of "Train Entering Section."

(3) The sending and acknowledgment of "Train Out of Section."

The indication "Train going" in the two-position instrument, therefore, represents two conditions of the block section, (1) that a train is ready to go from A to B and (2) that a train is already on its way from A to B, i.e., it indicates both that the block section is about to be occupied by a train as well as that the section is actually occupied by a train.
Three-position instruments are clearer in that they give three indications, viz.,

(1) Line Blocked.

(2) Line Clear—(showing that permission has been received to send a train into the section).

(3) Train on Line—(showing that a train is actually in the section).

The instruments being brought into use in Ceylon are shown in the diagram (Fig. 6). Each instrument is contained in an oblong case and consists of a block indicator dial (in which are incorporated the visual indications mentioned above), a commutator for operating the internal electrical connections, a visual indicator to show the position of the commutator, a commutator release plunger, and send and release cancelling plungers. The code bell with signalling key is mounted alongside the block instrument. The commutator indicator and the lower needle indicator are interconnected to show the same indications. In the normal position of the instruments the pointer needle indicates "Line Blocked," it being a principle of the block system that sections are always closed or "blocked" until permission has been given for a train to approach or the train is actually in the section.

The method of signalling is as follows:

Suppose A wishes to send a passenger train to B.

A gives the "Call Attention" signal (·) and on receipt of acknowledgment sends the "Is Line Clear" signal for a passenger train (·····).

B gives permission for the train to approach by repeating the signal, and after pressing the commutator release plunger on the left, turns his commutator in a clockwise direction from "Line Blocked" to "Line Clear." This causes the lower needle of his own instrument and the top needle of A's instrument to change from "Line Blocked" to "Line Clear," and also releases the lock on the starting signal lever at A.

A can now pull over his starting signal for the train to proceed to B. On departure of the train, he sends the "Train Entering Section" signal (··) to B, who acknowledges it (·) and turns his
commutator "Line Clear" to "Train on Line." This causes the up needle of both instruments to change from "Line Clear" to "Train on Line."

The last wheel of the train, on passing A's starting signal, automatically replaces the arm of that signal at danger, and the signal lever on being put back is also locked and cannot again be lowered until released by B, an operation which B cannot perform until (1) the train has passed out of the section A-B over the block clearing treadle at B, (2) the home signals at B have been put back to danger and (3) the commutator at B has been turned to "Line Blocked."

In the case of the "Train Entering Section" not being given by A, or not acknowledged by B, the reversal of the starting signal at A automatically changes the needle indications of both instruments to "Train on Line" and a warning bell rings at B, until he has turned his commutator to "Train on Line." When the train has passed the clearance treadle at B, B puts his home signals to danger, turns his commutator to "Line Blocked," and sends the "Train Out of Section" to A (·-·-) which A acknowledges. The pointers of both instruments now indicate "Line Blocked" and the section is ready for another train.

Cancelling Apparatus.—In practice it is impossible always to adhere to the rigid sequence of movements imposed by the lock-and-block system. It may happen that after "Line Clear" has been obtained for a train, the train requires to be cancelled; or that a train in passing over the clearing treadle fails to reset the instruments. The signals may get locked due to wrong manipulation of the instruments. It is therefore necessary for use in an emergency to have some method of resetting the block instruments.

Cancelling and resetting of the lock-and-block instruments is done by means of the "Send Cancel" and "Release Cancel" plungers. These are normally padlocked, the keys being retained in the possession of the Station Masters, who alone are permitted to reset the instruments. The procedure is as follows:

The padlocks on the corresponding cancelling plungers are removed by the Station Masters at either end of the section, and the
cancelling signal is given and acknowledged. The Station Masters then immediately press their respective cancelling plungers for five seconds. This operation removes the lock on the commutators which are then reset to normal. The plungers are then repadlocked by the Station Masters and the keys removed.

Shunting operations with Lock-and-Block.—In the system of working explained above it will be seen that the lock-and-block section extends from the starting signal at one station (A) to the starting signal at the next station (B). The cabinman at B cannot therefore give permission for a train to approach unless the line is clear up to his starting signal. This is applicable to the smaller stations—such as Bambalapitiya, Wellawatte, etc.—which are merely stopping stations and at which no shunting operations take place on the line. In the case of the larger stations, the above requirement that the line must be clear up to the starting signal may seriously limit shunting operations in the station section. These stations are therefore provided with two Home Signals—Outer and Inner (both track circuit controlled)—and the block section AB is defined as the length of track between the starting signal at A, and the Inner Home signal at B. Here the clearing point is fixed at the Inner Home signal. Shunting operations are permitted in the station section within the Inner Home signal. It is laid down, however, that "after permission to approach has been given, no shunting movement must take place inside the Inner Home signal on the line on which it is intended to receive the approaching train until it has been brought to a stand at the Outer Home signal, or unless such shunting movement can be completed ten minutes before the due arrival of the train." This ensures that should the driver accidentally over-run the Home signals at danger he would still have an adequate clear space within which to bring his train to a stand.

Safety of Lock-and-Block System.—It will be seen from the foregoing that the block indications automatically give the signalman at all times the condition of the lines in the sections on either side of his cabin. The upper indications show the condition of one line and the lower that of the
other line. The fixed signals and the block instruments are locked after each operation, and cannot be further manipulated without the co-operation of the signalman at the other end of the section. All of these contribute to the safety of lock-and-block working, and mistakes seldom occur, if ever.

**BLOCK WORKING ON SINGLE LINES—TABLET SYSTEM**

*Token Instruments.*—As a general rule trains on single lines are worked by what are known as "token" instruments, the manipulation of which releases a token in the shape of a tablet, which is handed to the driver as a tangible authority to proceed into the next block section. One such instrument is provided in the station at each end of a block section, and contains a number of tokens applying to the particular section. The two instruments are electrically connected together in such a way that if the Station Master at one end of the section (A) extracts a token from his instrument, which he can only do with the co-operation of the Station Master at the other end of the section (B), he cannot extract another from his instrument nor can B extract one from his, until the token from A's instrument is either placed in B's instrument or replaced in A's instrument. No train may leave A for B or B for A unless the driver has in his possession one of these tokens applying to the AB section, and provided he has one it follows that no other train but his can be on the block section.

*The Tablet System.*—The type of token instrument in use on single line sections in Ceylon is the Tyer's Tablet Instrument No. 7 (Fig. 7).

Two adjacent stations, A and B, each have one of these instruments electrically connected together. They have twelve tablets each enclosed in the magazine of the instrument. Above the magazine is a galvanometer, which by its deflection indicates the bell signals exchanged between A and B according to an authorised code. Below the galvanometer are two plungers, Bell and Switch, the former for giving bell code signals and the latter for purposes of releasing the tablet. Immediately below the plungers is the top slide for restoring tablets in the magazine. In front of the instruments is a visual indicator, having three indications — "Line Closed," "Down (or Up) Train Approach-
ing” and “Up (or Down) Train on Line.” Below the indicator is a glass shutter through which can be seen the tablets resting one against the other, thus affording an indication when the number of tablets are reduced to a small number. At the base of the instrument is the bottom slide by which tablets are withdrawn from the instrument. On the side of the instrument is fitted the bell to receive the code signals.

The method of working is as follows:

Suppose A wishes to send a train to B.

A gives the “Release Tablet Signal” by means of the bell plunger, and on B replying by repeating the signal, holds down his bell plunger, thus causing B’s needle to deflect.

B then depresses his switch plunger with his left hand and draws the bottom slide half out with his right hand. This will bring the indication “Down Train Approaching” in view. B will then hold down his bell plunger for a few seconds.

A, on receipt of this signal, will hold down his switch plunger with his left hand and withdraw the bottom slide full out with his right hand. This will bring the indication “Down Train on Line” into view.

A now depresses his bell plunger once, to indicate to B that he has obtained the tablet. He then removes the tablet and hands it to the driver as his authority to proceed. When the train has left the station A gives the “Train Entering Section” Signal, which B acknowledges.

On arrival of the train at B, the driver gives up the tablet, which B inserts in the top slide of his instrument and pushes it home. This unlocks the instrument, enabling B to push home his bottom slide thus restoring his usual signal to “Line Closed.”

B then gives the “Train Out of Section” signal to A, and holds down on the last beat for a few seconds. On receipt of this signal A depresses his switch plunger and pushes home his bottom slide which will at the same time restore his usual indication to “Line Closed.” Both instruments are now normal.
During the transit of the train from A to B no second tablet can be withdrawn, the apparatus at both stations getting locked. The Station Masters at each end of the section have thus an absolute record of what has been done on both instruments, which cannot be disturbed until the tablet has been restored to the apparatus at one end or the other.

_Tables._—The tablets are made of brass and have engraved on them the code names of the stations at each end of the section to which it applies. In addition to the engraving the tablets for the different sections are distinguished by having cuts in them of different shapes, so that a tablet can only be placed in the instruments of the section to which it is applicable. Each tablet also bears an individual number for purposes of record in the Train Register.

The tablets are placed in a pouch with a hoop for passing the arm through and are handed to the driver in the way with which all train travellers are familiar.

**CONTROL OF TRAIN MOVEMENTS WITHIN STATION LIMITS**

In the foregoing paragraphs, I have dealt with the block signalling of trains from station to station. The block system, however, is also meant for the safe working of trains within station sections. In large stations, simultaneous movements of trains, engines, etc., are always taking place. It is of the utmost importance that at no time should there be a possibility of conflicting or fouling movements being permitted by the officer or officers controlling the various movements.

Detailed descriptions would make this paper unduly long. I may briefly state, therefore, that safety in station section working is ensured by interlocking all the signal and point levers so that it will be impossible to lower the signals for a certain movement unless all the points are correctly set for that movement, and further that once the signals and points are thus set it will not be possible to lower other signals which would permit of a conflicting movement. Where the same signal is controlled from two signal cabins, the corresponding signal levers are "slotted," so that the lever
in one cabin cannot be pulled over until it is released by the signalman in the other cabin.

Interlocking of signals prevents conflicting movements of trains from taking place. It is also necessary to ensure that once a certain length of track is occupied by a vehicle it should be impossible to lower the signals controlling entry to this track and thus admit another vehicle into the section. This is done by means of electrical locks on the signal levers. These locks are controlled by electrical track circuits, of which the track rails form a part, so that the signal lever is free to be pulled when the track is unoccupied and locked when the track is occupied.

Illuminated diagrams are provided at some of the important stations. They show at a glance whether a section of the track is occupied or otherwise. They are controlled by the electrical track circuits mentioned above, free track sections in the diagram remaining illuminated while occupied sections become dark.

A Station Master's control is provided at Colombo Fort, Ragama, Polgahawela and Maradana stations. This takes the form of a miniature lever frame complete with miniature levers or plungers controlling the various routes within the station limits. A signalman cannot lower the signals for a route until the appropriate lever or plunger is released by the Station Master. This ensures that the Station Master has control of all trains entering the station.

CONCLUSION

In the system of working described above, failure of the human element as represented by the signalman is altogether eliminated. Should, however, the driver of a train willfully or otherwise ignore a danger indication, the safety of the system fails entirely. An ideal system would, of course, ensure that in such cases the train brakes are automatically applied in ample time to prevent any danger ensuing. Such systems, known as "Cab Signalling," "Automatic Train Control," etc., are necessary on railways where trains run at high speed and follow each other at close intervals. They have been tried in Ceylon and found to be satisfactory, but their use could not be extended owing to the economic depression.
<table>
<thead>
<tr>
<th>Signals</th>
<th>No. of Beats</th>
<th>Given Thus</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Call Attention&quot; (and reply to same)</td>
<td>1</td>
<td>.</td>
</tr>
<tr>
<td>&quot;Is Line Clear&quot; for express train?</td>
<td>4</td>
<td>. . .</td>
</tr>
<tr>
<td>&quot;Is Line Clear&quot; for a service train running through the section?</td>
<td>5</td>
<td>. . . . .</td>
</tr>
<tr>
<td>&quot;Is Line Clear&quot; for a service train stopping in the section?</td>
<td>5</td>
<td>. . . . .</td>
</tr>
<tr>
<td>&quot;Is Line Clear&quot; for a rail motor?</td>
<td>5</td>
<td>. . . . .</td>
</tr>
<tr>
<td>&quot;Is Line Clear&quot; for a light engine or engines coupled together?</td>
<td>5</td>
<td>. . . . .</td>
</tr>
<tr>
<td>&quot;Is Line Clear&quot; for a trolley?</td>
<td>5</td>
<td>. . . . .</td>
</tr>
<tr>
<td>&quot;Train Entering Section&quot;</td>
<td>2</td>
<td>.</td>
</tr>
<tr>
<td>&quot;Train out of Section&quot; or &quot;Obstruction Removed&quot;</td>
<td>3</td>
<td>. .</td>
</tr>
<tr>
<td>&quot;Blocking Back&quot;</td>
<td>6</td>
<td>. . . . .</td>
</tr>
<tr>
<td>&quot;Shunting Beyond Last Stop Signal&quot;</td>
<td>7</td>
<td>. . . . . .</td>
</tr>
<tr>
<td>&quot;Cancelling&quot; signal</td>
<td>8</td>
<td>. . . . . .</td>
</tr>
<tr>
<td>&quot;DANGER&quot;</td>
<td>6</td>
<td>.</td>
</tr>
<tr>
<td>&quot;Stop and Examine Train&quot;</td>
<td>7</td>
<td>. . . . .</td>
</tr>
<tr>
<td>&quot;Attend Urgently to Telephone&quot;</td>
<td>6</td>
<td>. . . . .</td>
</tr>
<tr>
<td>&quot;Testing Block Instrument and Bells&quot; (Transportation)</td>
<td>16</td>
<td>. . . . . . .</td>
</tr>
<tr>
<td>&quot;Testing Block Instruments and Bells&quot; (Telegraph)</td>
<td>16</td>
<td>. . . . . . .</td>
</tr>
</tbody>
</table>

Table 1—Authorised Bell Signal Codes for Lock-and-Block Working.
AS SEEN BY DRIVER OF TRAIN TO WHICH IT APPLIES

RED GLASS
RED
BACK LIGHT
BACK LIGHT SHUTTER
GREEN GLASS

"ON"

"OFF"

STOP SIGNAL INDICATIONS

AS SEEN ON THE OTHER SIDE

BLACK
YELLOW GLASS
BACK LIGHT
YELLOW
BACK LIGHT SHUTTER
GREEN GLASS

"ON"

"OFF"

DISTANT SIGNAL INDICATIONS

FIG. 2
<table>
<thead>
<tr>
<th>Date</th>
<th>Number of Train (as per working time table)</th>
<th>Description of Train (enter authorized reads)</th>
<th>Trains Approaching</th>
<th>Trains departing</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

This Train Register is to be used in connection with the signalling of all Trains, irrespective of Block System in force.
For signalling by ordinary Telegraph instruments, columns 1, 2, 5, 6, 7, 8, 9, 10, 14, 15, 16 and 18 are to be used.
For signalling by Electric Train Tablet System all columns are to be used.
For signalling by Lock-and-Block Telegraph System, all columns except 9 and 13 are to be used.

On taking charge of the Station or Cabin the person responsible for the signalling of the Trains must make the following entry right across the page, and immediately above the figures relating to the trains dealt with by him: "Took up duty at (time) (full signature)."
Similarly, on giving up duty the following entry must be made right across the page under the figures relating to trains dealt with: "Duty completed at (time) (full Signature)."

Fig. 4
ALTERNATIVE INDICATIONS

TRAIN GOING

FREE

TRAIN COMING

CABIN A  CABIN B

Fig. 5. Two Position Lock & Block Instruments
CABIN A

CABIN B

Fig. 6. Three Position Lock & Block Instruments
Fig. 7 Tyer's No 7 Tablet Instrument