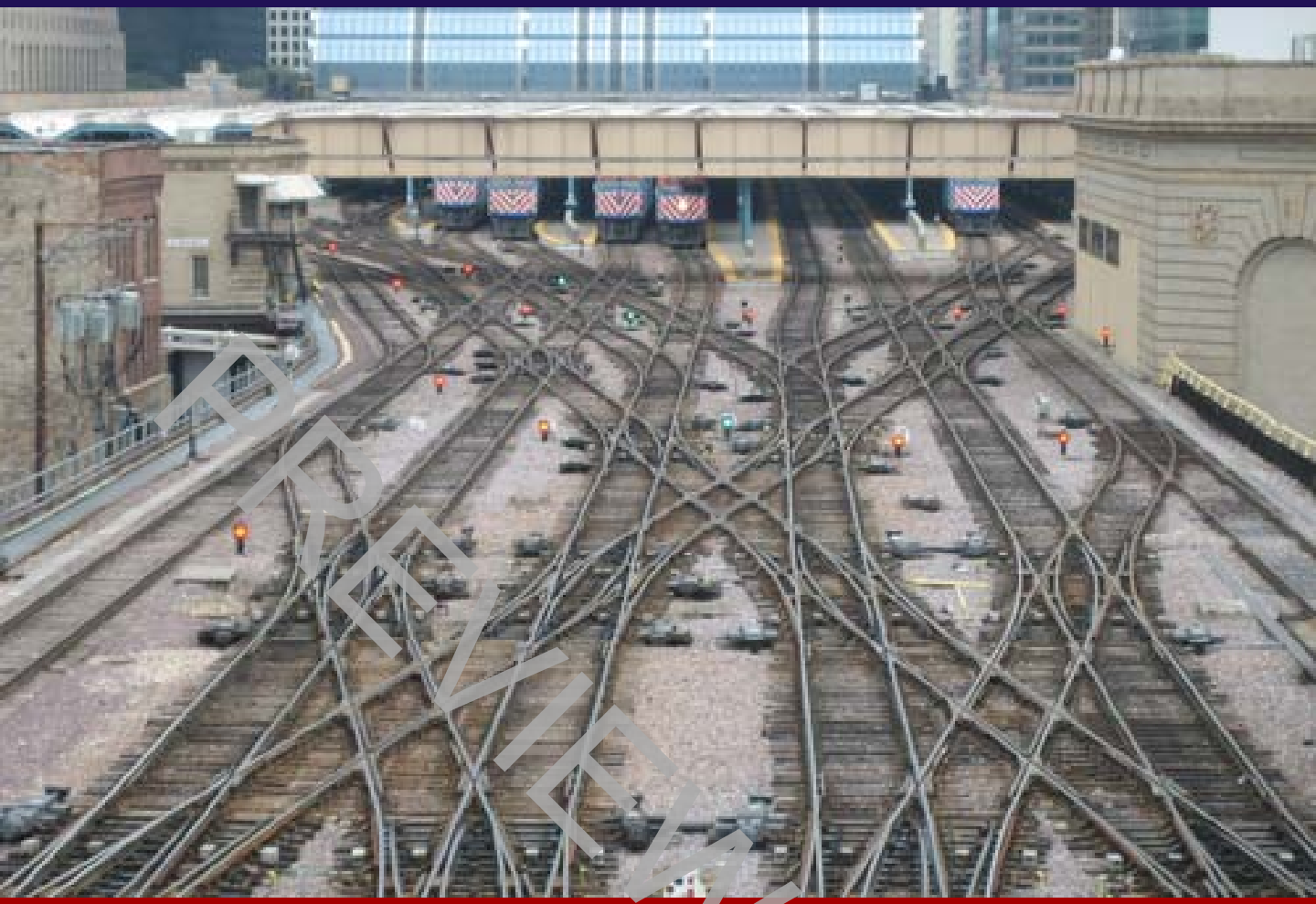

Introduction and Overview to Interlockings

Course 106

PARTICIPANT GUIDE

SIGNALS TRAINING CONSORTIUM

Introduction and Overview of Interlockings

Participant Guide

Signals Maintenance Training Consortium

COURSE 106

September 2019 Version

Disclaimer: This module is intended to educate employees of transit agencies that have agreed to voluntarily participate in the Signals Maintenance Consortium. It is intended only as informal guidance on the matters addressed, and should not be relied upon as legal advice. Anyone using this document or information provided in the associated training program should rely on his or her own independent judgment or, as appropriate, seek the advice of a competent professional in determining the exercise of care in any given circumstances. The Signals Consortium, it's participating agencies and labor unions, as well as the Transportation Learning Center, make no guaranty or warranty as to the accuracy or completeness of any information provided herein. The Signals Consortium, its participating agencies and labor unions, as well as the Transportation Learning Center, disclaims liability for any injury or other damages of any nature whatsoever, directly or indirectly, resulting from the use of or reliance on this document or the associated training program.

NOTE: All images contained within this document were contributed by Signals Training Consortium members unless otherwise noted.

TABLE OF CONTENTS PAGE

LIST OF FIGURES

How to Use the Participant Guide

Purpose of the Course

The purpose of the *Introduction and Overview of Interlockings* is to assist the participant in demonstrating proper safety procedures and gaining an overview of the functions of interlockings and their associated apparatus.

Approach of the Book

Each course module begins with an outline, a statement of purpose and objectives, and a list of key terms. The *outline* will discuss the main topics to be addressed in the module. *Learning objectives* define the basic skills, knowledge, and abilities course participants should be able to demonstrate to show that they have learned the material presented in the module. A list of *key terms* identifies important terminology that will be introduced in each course module. *Review exercises* conclude each module to assist the participants in reviewing key information.

Module 1

OVERVIEW OF INTERLOCKINGS

Outline

Purpose and Objectives

The purpose of this module is to provide the participants with an introduction to rail interlockings. This introduction will include basic interlocking terminology and regulations, as well as the purpose and function of different types of interlockings and their operation in rail signaling.

Following the completion of this module, the participant should be able to complete the exercises with an accuracy of 70% or greater:

- Define interlocking
- Define basic interlocking terminology
- Identify the applicable FRA and agency-specific standards related to interlockings
- Describe FRA and agency-specific interlocking-related safety guidelines
- Describe theory of operation and purpose of interlocking
- Describe different types of interlockings
- Describe how signal apparatus interacts in an interlocking system

Key Terms

- Appliance
- Aspect chart
- Automatic vehicle identification (AVI)
- AVI Loop
- Automatic route setting
- Block station
- Centralized traffic control (CTC)
- Control lengths
- Control station
- Cross locking
- Crossover
- Double crossover
- Entrance-Exit (NX)
- Electrical interlocking
- Electro-mechanical interlocking
- Interrogator
- Interlocked switch
- Interlocking machine
- Interlocking limits
- Interlocking relay
- Interlocking signal
- Intermittent control
- Lined
- Locking bed
- Loop scanner
- Mechanical interlocking
- Mechanical levers
- Microlok
- Model board
- Movable bridge interlocking
- Over Switch (OS) circuit
- Plant programmable logic Controllers (PLC)
- Relay interlocking
- Supervisory Control and Data Acquisition (SCADA)
- Sectional route release
- Single switch
- Station dwell
- Tag
- Tower
- Train wayside communication (TWC)
- Transponder
- Track blocking
- Universal interlocking
- Vital cut off relay (VCOR)
- Vital Logic Controller (VLC)
- Vital kill circuit
- Vital microprocessor interlocking system (VMIS)
- Vital processor interlocking (VPI)
- Vital Relay Driver (VRD)
- Yard switch
- Vehicle identification VETAG (Vehicle TAGging)

1-1 OVERVIEW

The interlocking is considered the most complex portion of the signal system. Signal maintainers need to have a thorough understanding of an interlocking as it is important to ensuring rail traffic safety. The official North American railroad definition is: "An arrangement of signals and signal appliances so interconnected that their movements must succeed each other in a proper sequence and for which interlocking rules are in effect.[1]" An interlocking is a routing point for trains and is designed to prevent conflicting movements through an arrangement of tracks at junctions or crossings. The interlocking signaling system is designed to prevent the displaying of a clear signal to trains unless the designated route is safe for the movement of the train.

Interlockings are located at crossovers, junctions and the end of sidings and moveable bridges in order to safely and efficiently control train movement. Typically, they utilize power operated switches. Train dispatchers remotely request changes to routes and switches while signaling system circuitry and/or microcontrollers will determine whether the request is safe to execute. The system may also automatically line routes and throw signals based on the built-in logic. Each track entering an interlocking must be protected by a signal or electrically locked derail. The complexity of an interlocking varies, for example single switches, double crossovers also known as a universal crossovers, diamond crossovers, scissor crossovers, or drawbridges, to those which may have dozens of signals and many powered switches.

History and Evolution of Interlockings
To gain a better understanding of today's interlockings, a brief history of how interlockings were developed is useful. In the early days, a signalman had to walk the plant to manually operate the switches and signals located around the rail station. To become more efficient, switch levers were connected at one point, by rods with their switches, and located on an elevated platform or cabin for a better view. Signals on top of the platform were operated by levers, so that constant effort was required to maintain them clear. Though this concentration was effective, dangerous conditions were highly possible. For instance, a switch or signal could be operated in error, since it was not evident which lever or lever went with which switch or signal. The signalman was not able to observe the points of switches he operated, to see that they fit properly and were set for the proper route, since they were located remotely from him. Or, if more than one man was required to operate the switches and signals, they might work at cross purposes. And, even if a driver correctly identified the train's signal, he could still be in doubt of the proper place to stop if the signal commanded it. With all the possible ways to operate the levers, there was no system in place to protect against human error. In summary, the interlocking system developed to interconnect the switches and signals to prevent dangerous conditions. Interlockings also make operation more consistent and logical.

Since the first American mechanical interlocking experiment in 1875 in New York there have been major advancements over the years, however, the basic purpose of interlocking remains. An interlocking is a location where tracks join (i.e. switches) and denotes the switches, the surrounding signals and the control machinery which connects them and enable their operation, usually via a tower operator, or sometimes automatically; and ensures that the operation is safe, regardless of the operator's action. Figure 1.1 depicts a **tower** at an interlocking.

[1] Volume 6 - Signals & Communications APTA RT-SC-S-041-03, 07/26/04 p. 41.2

1-5 INTERLOCKING TYPES AND FUNCTIONS

Types of Interlockings

Interlocking Machines

Up until the mid-twentieth century, almost all the interlockings were controlled from **interlocking machines** that had **mechanical levers** which were physically interlocked with each other (hence the name) to prohibit unsafe configurations. A better understanding of an interlocking can be done by describing such machines. Their underlying models of safety and operation apply to all railroad and subway interlockings, including the latest computer-controlled interlocking machines. Note that there are also machines with small electrical switches for levers, which are not mechanically constrained at all, but whose operation is de-energized under unsafe circumstances.

The levers controlling switches and signals are arranged in a row as depicted in Figure 1.5. Each has a number, which also appears on the actual signal or switch, and serves to identify it when discussing the interlocking. Often the machine had a **model board** showing the track layout, with red lamps at various points in the tracks to indicate track occupancy. The levers may be equipped with lights indicating when they are free to be operated (not locked).

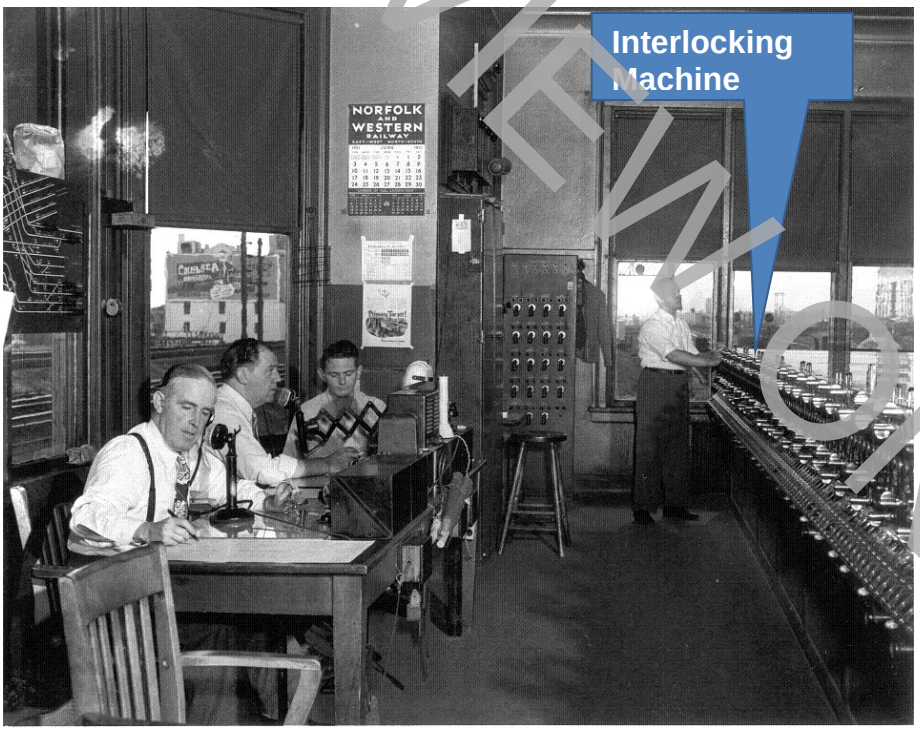

Figure 1.5 Interlocking Machine and 1951 Tower Operators - Courtesy LIRR

On a lever machine, each switch (or pair of switches constituting a crossover) is controlled by a lever that can (under permissible conditions) cause that switch to move. A switch lever can be in the "normal" position or "reverse" position, which moves the switch to its own normal ("straight track") or reverse ("switch tracks") position respectively. As with all levers, the switch lever is mechanically interlocked with other levers to prevent any operation under unsafe conditions.

Each signal that is part of the interlocking is controlled by a lever. Sometimes more than one signal is controlled by a single lever. A signal lever, however, cannot make a signal clear (be other than

Module 2

INTERLOCKING TERMS & CONCEPTS

Outline

Purpose and Objectives

The purpose of this module is to provide the participant with an overview of interlocking specific nomenclature, basic routing and traffic control.

Following the completion of this module, the participant should be able to complete the exercises with an accuracy of 70% or greater.

- List nomenclature specific to interlockings
- Describe basic routing processing
- Define interlocking relays
- Identify the interlocking relay logic and their functionality on the locking process on associated diagrams

Key Terms

- Approach locking
- Automatic train operation (ATO)
- Detector locking
- In advance of
- In rear of
- In approach
- Indication locking
- Locked up
- Relay locking
- Remote access terminal (RAT)
- Route locking
- Route check (RC)
- Switch indication locking
- Switch correspondence (WC)
- Time locking
- Traffic line circuit
- Traffic locking
- Traffic rectifier
- Traffic stick circuit

2-1 OVERVIEW

As explained in module one of this course, interlockings are used to control train movement over switches in many directions. They are designed to prevent conflicting or unsafe train movement. They are installed where multiple routes are possible, usually where there are multiple tracks and switches, or rail crossings. They are also installed where trains must not be allowed to proceed under certain conditions, such as at moveable bridges. This module focuses on nomenclature specific to interlockings and reviews basics routing concepts and traffic control. Much of the information presented here can be found in the publication, *Introduction to North American Railway Signaling*.

Be reminded that various rail agencies use different terminology and various interlocking procedures. As always refer to your agency's specific guidelines and regulations.

Follow Agency Specific Guidelines!

Always refer to your organization for specific guidelines and regulations.

Traffic Stick Circuits

Traffic Stick Circuits (Figure 2.10) relays set the traffic between interlocking and along with the directional route sticks provide traffic locking. They work in conjunction with the traffic block repeaters and the traffic line circuits.

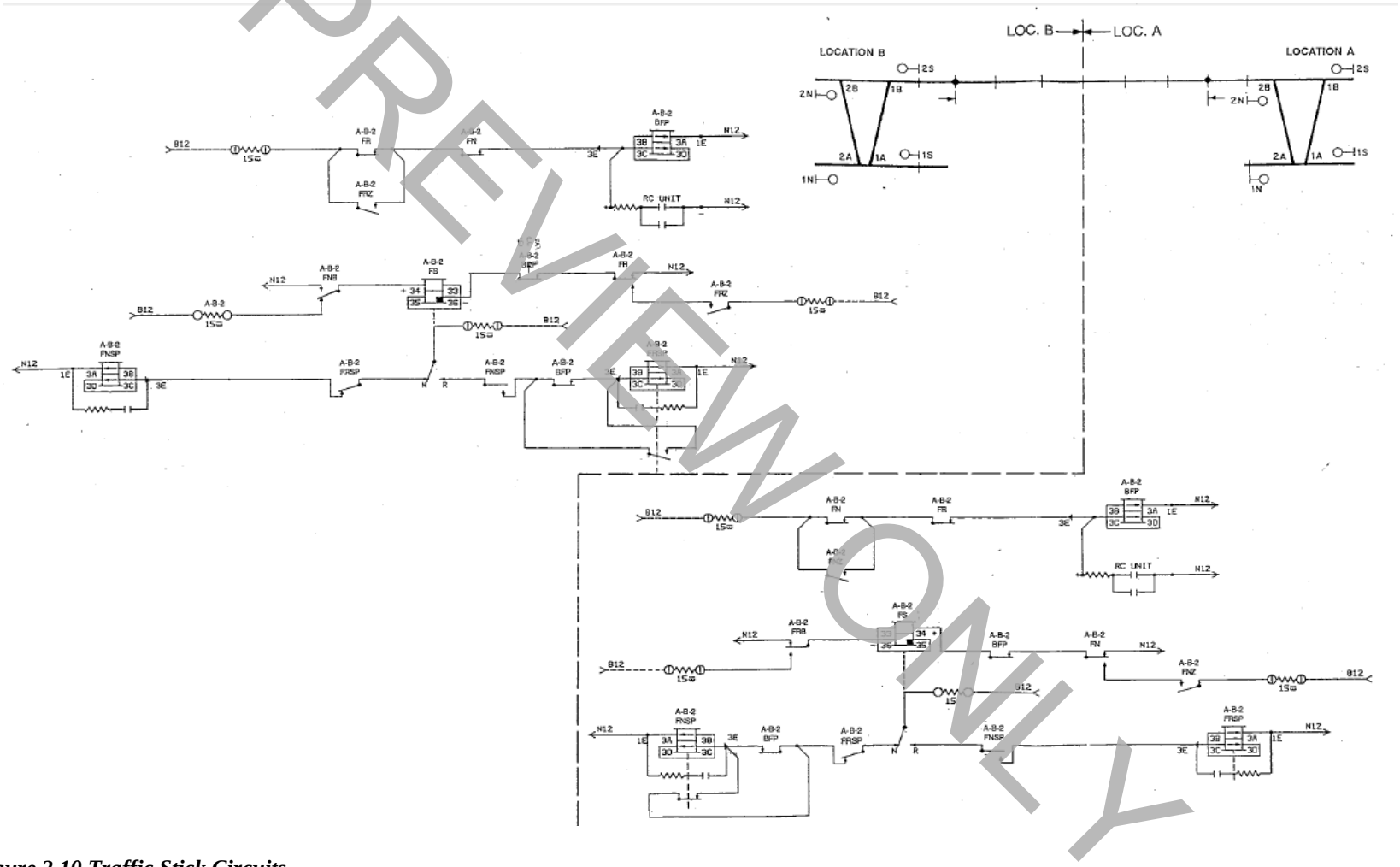

Figure 2.10 Traffic Stick Circuits

Module 3

INTERLOCKINGS & RELAY LOGIC

Outline

Purpose and Objectives

The purpose of this module is to provide the participant with an overview of functions and types of locking along with associated prints and a review of the basics of establishing routes.

Following the completion of this module, the participant should be able to complete the exercises with an accuracy of 70% or greater:

- Define locking
- Describe different types of locking circuits and their function
    - Switch Indication
    - Traffic
    - Signal Indication
    - Route
    - Detector
    - Approach
    - Time
- Identify types of locking on a given print design/layout and their main purpose
- Differentiate between single and universal interlockings
- Describe signal control circuits and the basic circuits used in an interlocking when requesting routes

Key Terms

- Approach locking
- Approach-locking relay
- Detector locking
- Indication locking
- Locking
- Route locking
- Route check
- Route check relay (RCR)
- Signal indication locking
- Single switch interlocking
- Switch indication locking
- Time locking
- Traffic locking
- Universal interlocking

3-1 OVERVIEW

A key element to interlocking logic is “locking”. There are different types of **locking** utilized in connection with interlocking plants and other types of signaling systems, each type having a definite purpose. This module will focus on the function of the following types of electric locking circuits listed below. Below are some general descriptions of locking terms.

Indication Locking – Prevents manipulation of levers that would result in an unsafe condition for a train movement if a signal, switch, or other operative unit fails to make a movement corresponding to that of its controlling lever, or which directly prevents the operation of a signal, switch, or other operative unit, in case another unit which should operate first fails to make the required movement.

- **Signal indication locking** – Prevents changing the route (position of the switch points) when a home signal is clear. This is what locks the route before a train enters the interlocking.
- **Switch indication locking** – Prevents a signal from being cleared over a route with turnouts moveable point frogs, derails, etc. that are not in correspondence with requested route.

Traffic Locking – Electric locking which prevents the manipulation of levers or other devices for changing the direction of traffic into a section of track on which a route is lined, occupied, or locked.

Route Locking – Effective when a train passes a signal displaying an aspect for it to proceed, which prevents the movement of any switch, movable point frog, or derail in advance of the train within the route entered. It may be so arranged that as a train clears a track section of the route, the locking affecting that section is released (aka Sectional Route Release).

Detector Locking – Effective when the detector track circuit (OS) is occupied. Detector locking prevents the operation of any power operated switch, movable point frog or derail and the display of any signal indication more favorable than ‘proceed at restricted speed’ within the limits of the detector track circuit.

Time Locking – A method of locking, either mechanical or electrical, which, after a signal has been caused to display an aspect to proceed, prevents, until after the expiration of a predetermined time interval after such signal has been caused to display its most restrictive aspect, the operation of any interlocked or electrically locked switch, movable point frog, or derail in the route governed by that signal, and which prevents an aspect to proceed from being displayed for any conflicting route.

Approach Locking – Effective while a train is approaching, within a specified distance, a signal displaying an aspect to proceed, and which prevents, until after the expiration of a predetermined time interval after such signal has been caused to display its most restrictive aspect, the movement of any interlocked or electrically locked switch, movable point frog, or derail in the route governed by the signal, and which prevents an aspect to proceed from being displayed for any conflicting route.

Signal Indication Locking

Signal indication locking is electric locking that prevents changing the route (position of the switch points) when a home signal is clear. This is what locks the route before a train enters the interlocking. When semaphore and searchlight signals were used it checked the position of all signal mechanisms; if a signal was stuck in the green or yellow position but not requested the interlocking remained locked. The Dispatcher requests a signal and the corresponding RGPR and/or ASR is de-energized.

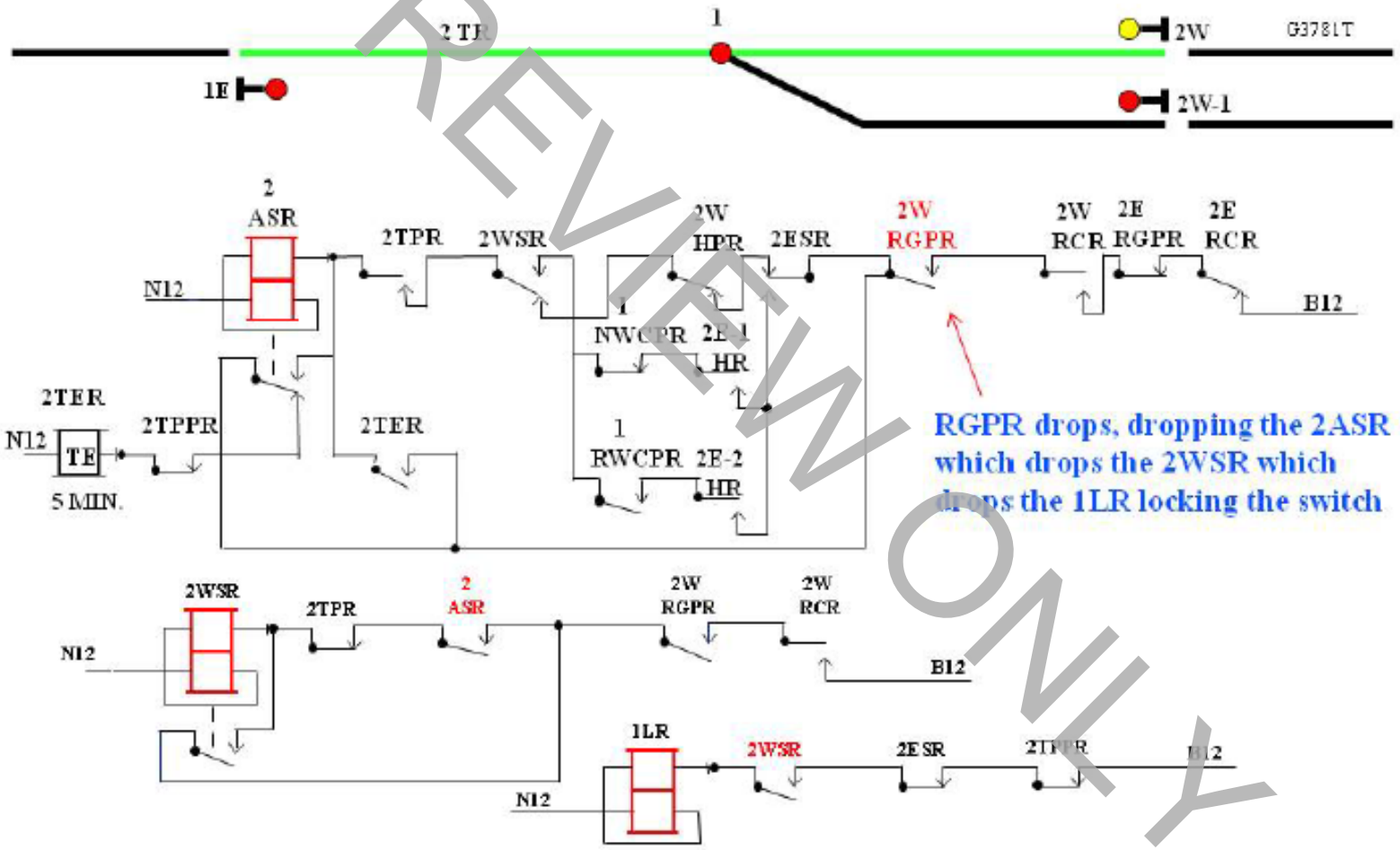

Figure 3.1 (1 of 3) Signal Indication Locking