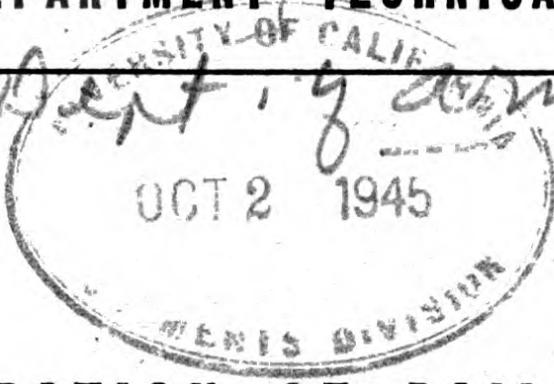


U13
2
TM
1945

TM 55-277

WAR DEPARTMENT TECHNICAL MANUAL



OPERATION OF RAILROADS

MAINTENANCE OF SIGNALS

WAR DEPARTMENT . JUNE 1945

WAR DEPARTMENT

WASHINGTON 25, D. C., 14 June 1945

TM 55-277, Operation of Railroads: Maintenance of Signals, is published for the information and guidance of all concerned.

[AG 300.7 (23 May 45)]

BY ORDER OF THE SECRETARY OF WAR:

OFFICIAL:

G. C. MARSHALL

J. A. ULIO

Chief of Staff

Major General

The Adjutant General

DISTRIBUTION:

AAF (5); AGF (10); ASF (2); T of Opns (5);
Dept (2); Base Comd (2); Arm & Sv Bd (1);
S Div ASF (1); Tech Sv (2); SvC (2); PE (5);
H&R (2); Dist O 55 (1); TZ (2); Consolidating
Sta (1); Gen & Sp Sv Sch (2); USMA (2);
TCRRS (5); A (2); T/O & E 55-202 (5);
55-225 (5); 55-227 (30); 55-302 (5); 55-500,
BA BE (3), BM BF (3).

Refer to FM 21-6 for explanation of distribution formula.

WAR DEPARTMENT TECHNICAL MANUAL

TM 55-277

OPERATION OF RAILROADS

MAINTENANCE
OF SIGNALS



WAR DEPARTMENT

•

JUNE 1945

United States Government Printing Office

Washington: 1945

CONTENTS

	<i>Paragraph</i>	<i>Page</i>
CHAPTER 1. GENERAL.		
<i>Section I.</i> Purpose and scope.		
Purpose	1	1
Scope	2	1
<i>II.</i> Railroad signaling.		
General	3	1
Power supply for signaling systems	4	3
Pole lines for signal circuits.....	5	4
Theaters of operations.....	6	4
<i>III.</i> Definitions.		
Signal terms	7	5
<i>IV.</i> Duties of personnel.		
Signals and communications engi- neer	8	11
Railway signal maintenance super- intendent	9	12
Signal maintenance supervisor.....	10	12
Signal mechanics, railway.....	11	12
 CHAPTER 2. SIGNAL MAINTENANCE RULES.		
<i>Section I.</i> General rules		14
<i>II.</i> Automatic block signals		16
<i>III.</i> Interlocking		21
<i>IV.</i> Track circuits		29
<i>V.</i> Pole lines and power supply		32
<i>VI.</i> Inspections and tests, all signaling systems.....		33
<i>VII.</i> Interlocking tests		36
<i>VIII.</i> Inspections and tests, signal transmission lines		38
 INDEX TO RULES		42

U 113
.2

TM 55:077

1945



CHAPTER 1 GENERAL

Section I. PURPOSE AND SCOPE

1. PURPOSE. This manual is a guide for signal maintenance sections of railway operating battalions and for other signal maintenance personnel of War Department railroads. War Department railroads include all military railroads, all railroad companies being operated by the War Department, and all utility railroads serving War Department installations.

2. SCOPE. This manual describes basic types of railroad signaling devices, explains their operation and their function, and sets forth rules for proper maintenance. It lists terms and definitions common to railroad signaling, and defines the duties and responsibilities of signal maintenance personnel.

Section II. RAILROAD SIGNALING

3. GENERAL. a. Railroad signaling is the operation of railroad switches to establish routes, and the control of signals to direct and authorize train movements. The purpose of railroad signaling systems is to transmit information to personnel operating trains, to insure safety, to prevent collisions, and to avoid derailments due to open switches, broken rails, or other hazards.

b. Signals increase operating efficiency by permitting higher speeds with attendant safety and by reducing the number of train stops and delays. These factors shorten schedule time between stations, increase track capacity, and allow maximum utilization of motive power.

c. The types of signaling equipment by which the above objectives are accomplished include interlocking, block signaling, centralized traffic control, cab signaling, and automatic train control. Signal devices such as highway crossing bells, lights, gates, and various types of barriers are used at grade crossings for warning pedestrians and vehicle drivers of the approach of trains at such crossings.

d. Signal equipment may be controlled also through special devices which protect trains from other hazards such as equipment dragging under trains, rocks falling on track, mud or snow sliding on track, water rising to a dangerous level under bridges or adjacent to embankments, girders or spans shifting with reference to piers or abutments, bridge piers settling out of alignment, and fires on bridges, trestles, or in timber-lined tunnels. When any of these devices are actuated by a hazardous condition, the controls of automatic block or interlocking signals are so affected as to cause restrictive aspects of the signals to be displayed. Special markers on the signals or instructions in the timetable inform operating personnel of the type of hazard existing.

e. Semaphore and light signals are used almost exclusively in the various systems of train signaling. The day-time indications of semaphore signals are given by positions of the semaphore blade; night indications are transmitted by colored lights. A fixed lamp on the semaphore mast shines through colored glass roundels which form a part

of the movable semaphore unit. In general practice, a red light is displayed when the blade is in a horizontal position, a yellow light at the 45° position, and a green light when the blade is vertical. Light signal indications, both day and night, are given by colored lights.

f. The "aspect" of a signal is what an engineman sees when he views the position of the semaphore blades, colored lights, and their relative arrangement. Each aspect is named and given a rule number. The indication tells an engineman what he is to do to control the movement of his train in accordance with the aspect displayed.

4. POWER SUPPLY FOR SIGNALING SYSTEMS.

The operating equipment and control arrangements in modern signaling systems are energized by electrical power with the exception that pneumatic pressure is used for operating electro-pneumatic signals and switches, and hand power is used for operating mechanical interlocking. Air pressure for operating the electro-pneumatic type is provided by air compressors driven by electric motors.

a. A basic principle of all railroad signaling is that a failure of the power supply will result in the most restrictive aspect of the signals being displayed.

b. When electrical power is secured from an outside source, batteries are used for stand-by power to insure continuous operation in case of a power line failure; if the power fails the batteries automatically take up the load.

c. Signaling systems are operated either by alternating or direct current.

(1) When alternating-current signaling equipment is used and power is secured from utility companies, the current is passed through line transformers to secure the volt-

ages required for the signaling apparatus. The voltage required varies widely depending on the type of apparatus used.

(2) When direct-current signaling equipment is used and power is secured from alternating-current sources, the current is passed through rectifiers transforming it into direct current. Direct-current track circuits cannot be used on tracks equipped for electrically-operated trains.

(3) Primary batteries are also used as a source of power for the operation of some signals. A primary battery is one in which electrical energy is produced by chemical action between dissimilar metals. When in operation the elements are gradually consumed and when exhausted must be replaced.

5. POLE LINES FOR SIGNAL CIRCUITS. The majority of signaling systems include transmission lines along the railroad right-of-way for the distribution of electrical power. In systems requiring comparatively few line circuits, the wires are sometimes run on an additional cross-arm placed on the poles of an existing line that is used primarily for communication circuits. There are two serious objections to using existing communication lines for signal wires.

a. The amount of power which can be transmitted is limited because of interference with the communication circuits.

b. Communication wires may fall on the signal line causing signal circuit interruptions resulting in false clear signal indications.

6. THEATERS OF OPERATIONS. Normally, few, if any, of the signaling devices mentioned are available on

newly constructed or reconditioned military railroads in theaters of operations. Signaling equipment may be installed at a subsequent time but this is seldom justified either by the safety factor or by more expeditious operation. Existing signals should be utilized when available.

Section III. DEFINITIONS

7. SIGNAL TERMS. Knowledge of the following terms and definitions is essential in maintaining signals so that they will display the proper aspects in accordance with track plan, signal circuit arrangement, and controlling devices:

Automatic block signaling. Signal system in which the signals are operated by an electric, pneumatic, or other agency upon actuation by a train or by certain conditions restricting the use of a block, such as a broken rail, an open switch, or a car standing on the turnout foul of the main track.

Automatic brake application. The application of train brakes through the operation of an automatic train control device.

Automatic interlocking. Signal devices at railroad grade crossings which operate automatically upon the approach of a train.

Automatic train control. Device which will, under certain conditions, automatically make a brake application until the train has been brought to a stop, make a brake application until the speed of the train is reduced to a predetermined rate when this rate is exceeded, or slow the train and stop it.

Automatic train stop. Device which will, under certain conditions, automatically make a brake application until a train has been brought to a stop.

Block. Length of track of defined limits. Its use by trains is governed by block signals.

Block, absolute. Block based on the principle that no train will be permitted to enter the block while it is occupied by another train.

Block, absolute permissive. Term used for an automatic block signal system on single track in which stop signals are used for opposing movements between fixed points, and stop and proceed signals are used for following movements.

Block, permissive. Block in manual or controlled manual territory, based on the principle that no train will be admitted to the block when it is occupied by an opposing train or by a passenger train.

Block section. Section of track of defined length, the use of which is regulated by a fixed signal at the entering end of a double track and at each end on a single track.

Block signaling, absolute. System of block signaling based on the principle that no train will receive a signal for a block while it is occupied by another train.

Block signaling, permissive. System of block signaling permitting one or more trains moving in the same direction to enter the block before the last preceding train has passed out of the block.

Block system. A series of consecutive blocks.

Block system, automatic. Series of consecutive blocks governed by block signals, cab signals, or both, activated by a train or engine or by certain conditions affecting the use of a block.

Block system, manual. Series of consecutive blocks, governed by block signals operated manually upon information by telegraph, telephone, or other means of communication.

Centralized traffic control. Term applied to a system of railroad operations by means of which the movements of trains over routes and through blocks on a designated section of track or tracks are authorized and directed by signals controlled from a designated point without requiring the use of train orders and without the superiority of trains.

Circuit breaker. Device constructed primarily for the interruption of a circuit under infrequent abnormal conditions.

Circuit, closed. Whole or complete electric circuit.

Circuit, common return. Circuit of which a common return wire forms a part.

Circuit, electric. Path for an electric current.

Circuit, line. Term applied to a signal circuit on an overhead or underground wire.

Circuit, open. Incomplete electric circuit.

Circuit, polyphase. Circuit of more than a single phase.

Circuit, series. Circuit in which the separate sources or separate electro-receptive devices, or both, are so placed that the current produced in it or going through it passes successively through the entire circuit.

Circuit, short. Shunt circuit abnormally applied.

Circuit, shunt. Low-resistance connection across the source of supply between it and the operated unit.

Circuit, single phase. Circuit energized by a single electromotive force.

Circuit, three phase. Combination of circuits energized by alternating electromotive forces which differ in phase by one-third of a cycle.

Circuit, track. Electric circuit of which the rails of the track form a part.

Circuit, trap. Term applied to a circuit used at locations where it is desirable to protect a section of track and where it is impractical to maintain a continuous track circuit.

Interlocking. Arrangement of switch, lock, and signal appliances so interconnected that their movements succeed each other in a predetermined order. It may be operated manually or automatically.

Interlocking, electric. Interlocking in which the units are operated and controlled by electricity.

Interlocking, electro-mechanical. Interlocking in which a portion of the units is operated manually and the remaining portion is operated electrically.

Interlocking, electro-pneumatic. Interlocking in which the units are operated by compressed air but controlled by electricity.

Interlocking limits. Track between the home signals of an interlocking.

Interlocking machine. Assembly of levers and locking in a frame, with connections arranged so that the levers can be moved or unlocked only in a certain predetermined order and so that a movement of a lever or its unlocking preparatory to its movement may be made to lock any or all other levers in the frame. Interlocking machines are designated to operate the various kinds of interlocking.

Lightning arrester. Device for protecting circuits and apparatus against lightning or other abnormal potential rises of short duration.

Lock and block. A term commonly used for the controlled manual block system.

Lock, drawbridge, electric. Electric lock used in connection with a drawbridge to prevent its operation until released.

Lock, facing point. Mechanical lock for a switch, derail, or movable point frog, comprising a plunger which engages a lock rod attached to the switch points to lock the switch or other operated unit in its normal or reversed position.

Lock, rail drawbridge. Mechanical device used to insure the drawbridge rails being in proper position for the movement of trains.

Locking. Mechanical arrangement of locking bars, dogs, tappets, cross-locking, and other apparatus by means of which the interlocking is effected between the levers of an interlocking machine and so interconnected that their movement must succeed each other in a predetermined order.

Locking, approach. Electric locking effective while a train is approaching a signal that has been displayed for it, and adapted to prevent manipulation of levers or units that might create unsafe conditions in the route lined up.

Locking, indication. Electric locking adapted to prevent manipulation of levers that would bring about an unsafe condition in event a signal, switch, or other operated unit fails to make a movement corresponding with that of the operating lever; or adapted directly to prevent the operation of one unit in event another unit to be operated first, fails to make the required movement.

Locking, traffic, electric. Electric locking adapted to prevent the manipulation of levers or units for changing the direction of traffic on a section of track while that section is occupied or while a signal is displayed for a train to proceed into that section.

Rectifier. Device for transforming alternating current into direct current; used for charging storage batteries at low rates of charge.

Relay. Device that is operated by a variation in the conditions of one electric circuit to affect the operation of other devices in the same or another electric circuit.

Signal. Means of conveying information to personnel in charge of operation of trains.

Signal, approach. Fixed signal used in connection with one or more signals to govern the approach thereto.

Signal, automatic. Signal controlled automatically.

Signal, block. Fixed signal at the entrance to a block to govern trains entering and using that block.

Signal bridge. Structure which spans one or more tracks for the purpose of supporting signals.

Signal, color light. Fixed signal in which the indications are given by the color of a light only.

Signal, color position light. Fixed signal in which the indications are given by the color and position of two or more distinctive color lights for each indication.

Signal, distant block. Fixed signal used in connection with a home block signal to govern the approach thereto.

Signal, distant switch. Signal used to indicate the position of the points of one or more switches.

Signal, false clear. Improper operation of a signal, giving an erroneous indication and not in accordance with the purpose intended.

Signal, flashing light. Highway crossing signal, the indication of which is given by two horizontal red lights flashing alternately at predetermined intervals.

Signal, four position. Signal arranged to give four different indications.

Signal, highway crossing. Electrically- or mechanically-operated signal used for protection of highway traffic at railroad highway grade crossing.

Signal, home. Fixed signal at the entrance of a block or route to govern trains or engines entering and using that block or route.

Signal, interlocking. Fixed signal of an interlocking.

Signal, marker light. Light used to distinguish certain fixed signals.

Signal, semaphore. Signal in which the day indications are given by the position of an arm.

Signal, three position. Signal arm arranged to give three different indications.

Signal, train order. Signal used to indicate to a train whether or not it will receive orders.

Signal, two position. Signal arranged to give two different indications.

Signal, wigwag. Highway crossing signal, the indication of which is given by a horizontally swinging disk with or without a red light attached.

Section IV. DUTIES OF PERSONNEL

8. SIGNALS AND COMMUNICATIONS ENGINEER.

Directs and supervises operation, installation, and maintenance of signals and communications for a military railway service. (See T/O & E 55-302.)

9. RAILWAY SIGNAL MAINTENANCE SUPERINTENDENT. Supervises installation and maintenance of signal, telephone, and telegraph facilities for a railway grand division. (See T/O & E 55-202.)

10. SIGNAL MAINTENANCE SUPERVISOR. Directs and supervises signal mechanics of signal maintenance section, railway operating battalion, (T/O & E 55-227) in the installation and maintenance of railway signals. He will—

a. Be responsible for the safe condition and maintenance of signals and interlocking on his assigned territory and for supervision of personnel engaged thereon.

b. Make inspections of facilities and apparatus for which he is responsible.

c. Investigate and report accidents and unusual conditions which may affect signals or interfere with efficient and safe operation of trains.

d. Confer with the train dispatcher, arranging for proper time to perform any work affecting train operation

e. Keep on file complete plans for signal and interlocking facilities maintained by his forces and will provide signal mechanics with all necessary plans and instructions.

f. Examine and instruct signalmen on the operation of interlocking.

11. SIGNAL MECHANICS, RAILWAY. Under direction of the signal maintenance supervisor, signal mechanics will—

a. Be responsible for the inspection, adjustment, and proper maintenance of all apparatus assigned them and will do no work that will affect the operation of trains unless trains are properly protected.

b. Make, or permit to be made, any alterations or additions to signal apparatus or any circuits pertaining thereto, only when authorized.

c. Call the train dispatcher at frequent intervals throughout the day to ascertain conditions on their territories.

d. Be responsible for the care and use of tools, material, and equipment necessary for the efficient performance of their work.

e. Make thorough inspections when directed and make such repairs of apparatus under their charge as will insure proper operation.

f. Inspect signals and switch lamps at regularly designated intervals.

g. Keep in close communication with the train dispatcher during severe storms, and cover their entire territory as soon as practicable after the storm is over to make sure that all signal equipment is in safe operating condition.

h. In case of accident or damage to signal apparatus, proceed immediately to that point, request such assistance and material as may be required, and make repairs promptly.

i. Make a thorough investigation of every reported failure, determine the trouble, and eliminate the cause.

j. Reach an understanding with the signalman on duty to insure safe operation when any work is to be done on an interlocking which may affect the safe operation of trains; leave the work only when the apparatus has been operated and is known to be in safe working condition.

k. Report to proper authority all defects or dangerous conditions observed.

CHAPTER 2

SIGNAL MAINTENANCE RULES

Section I. GENERAL RULES

Rule 1. The commanding officer of personnel whose duties are prescribed herein will provide each with a copy of this manual and also a copy of TM 55-281 (when published). Personnel whose specific duties require it will also be provided with copy of TM 55-280 (when published).

Rule 2. Signal apparatus will be so installed and maintained as to insure safe operation of trains.

Rule 3. Correct track lay-out plan, circuit plan, locking sheets, and dog chart will be maintained in good condition at each interlocking station and at each place where their use is required.

Rule 4. Maintenance and repair work which will interfere with safe movement of trains will not be started until train movements have been fully protected. Temporary repairs or adjustments when required will be made in such manner that safety of operation will not be impaired.

Rule 5. Defective apparatus or defective parts will be replaced promptly and proper record made of such replacement.

Rule 6. Circuit will not be opened, shunted, or other action taken which will cause operation of signal or other apparatus at a time when such action will affect the safety of train operation.

Rule 7. In event of a severe storm, an inspection of track circuits will be made as soon as practicable and any trouble will be corrected.

Rule 8. In event of an accident in which signal apparatus or other controlling device is concerned, a thorough examination will be made immediately of all parts involved and the results of such examination recorded.

Rule 9. In event of failure or damage to apparatus which cannot be repaired immediately and which may affect safety of train operation, signals or other controlling devices will be arranged to provide protection until the condition is corrected.

Rule 10. When broken rail, wide gauge, or any other condition is discovered which may affect safety of train operation, action will be taken immediately to protect trains by flag, signals, or other controlling devices. Record will be made of the defect and repairs made as quickly as possible.

Rule 11. Signals or other controlling devices will be arranged to provide protection when rail is being laid or other track changes are being made which render the track unsafe for passage of trains. The signals or other controlling devices will not be restored to normal operation until proper tests have been made and it is known that the

equipment is functioning as intended and that the track is safe for the passage of trains.

Rule 12. Circuits will be kept free of grounds which may interfere with proper operation.

Rule 13. Outside signal and instrument cases will be locked unless otherwise ordered. Power interlocking machine cabinets, time releases, and electric locks will be locked or sealed.

Rule 14. When repair, adjustment, change, or replacement is made in any part of the system that may affect the operation of the system, tests will be made immediately to determine that proper operation is assured.

Rule 15. Normal functioning of any electrical device will not be interrupted by mechanical means, or by means of any other form of energy, without proper precautions to insure safe operation of trains.

Rule 16. All signal apparatus will be so installed and maintained that it will not constitute a source of danger to trainmen, signalmen, or other personnel.

Section II. AUTOMATIC BLOCK SIGNALS

Rule 17. Signal masts will be installed in a vertical position, securely fastened on suitable support, with signal aligned to give the best possible indications for approaching trains. Signals will be located to avoid, as far as possible, liability of mistaking the indication of one signal for the indication of another, or confusion between signal and other lights.

Rule 18. Signal blade, lens, roundels, glass, and lamps will be cleaned as often as necessary to insure good indications.

Rule 19. Lamp brackets will be securely fastened and all parts of lamp will clear spectacle not less than $\frac{1}{2}$ inch.

Rule 20. Ladder, hand railing, and platform will be securely fastened and maintained in good condition.

Rule 21. Movable parts of signal will operate freely under all weather conditions.

Rule 22. Semaphore spectacle casting will rest against the stop provided for that purpose, allowing slot-arms and vertical connections to be free from downward pressure when in the most restrictive position.

Rule 23. Semaphore signal will not be placed in service until bearings have been cleaned; oil, dirt and grease removed from the armature and poles of slot magnets and gears; and all parts lubricated, preferably after electrical torque tests have been made.

Rule 24. Bearings will be lubricated periodically and kept free from grit and dirt.

Rule 25. Mechanism will be kept in proper adjustment; excessively worn or defective parts will be replaced.

Rule 26. Slot or equivalent device will release when voltage is reduced to less than the release voltage for which such apparatus is designed.

Rule 27. Air gap between movable and fixed members of slot or retaining device will be not less than the minimum

for which the apparatus is designed. Movable and fixed members of slot or retaining device will be kept free from grease, oil, and dirt.

Rule 28. Electrical contacts will be kept clean and in proper adjustment.

Rule 29. Wires will be arranged so they will not interfere with operating parts of mechanism.

Rule 30. Signals will be buffed or snubbed to eliminate undue strain on mechanism. Buffers will be cleaned and lubricated once each year and repacked or refilled as often as necessary to maintain proper buffing.

Rule 31. Armature of signal motor will not have excessive lost motion in bearings. Clearance between rotating and stationary parts will be adequate to insure proper operation.

Rule 32. The slot toggle adjustment will not be changed from its original setting on signals employing a toggle arrangement. Toggle or slot-arm will be replaced if adjustment changes due to wear.

Rule 33. Slot magnet armature will have sufficient end-play to allow armature to seat firmly against pole face core pins under all conditions.

Rule 34. Slot armature side-play, measured at lower end of armature, will not exceed $\frac{1}{8}$ inch.

Rule 35. Tooth disk on motor armature or pawl in retaining mechanism will be replaced when worn or burred.

Rule 36. In signals of the searchlight type, relay mechanism will be maintained in accordance with rules 118 to 120 inclusive, so far as those rules apply.

Rule 37. In light signals other than searchlight type, no changes will be made from original settings in the internal parts, including the lamp receptacle, except where provision has been made for focusing.

Rule 38. Action will be taken to prevent phantom indications from reflected sources.

Rule 39. Deflecting prisms will be assembled and maintained to spread the light in the proper direction.

Rule 40. The apparatus will be so installed and circuits so arranged that failure of any part of the system affecting the safety of train operation will cause all signals affected to give the most restrictive indications required by conditions.

Rule 41. Signals will be located preferably to the right of and adjoining the track to which they refer.

Rule 42. Signal indications will be given by positions of semaphore, by colored light, or by both. A single white light will not be used for a proceed indication.

Rule 43. Signals will be spaced at least stopping distance apart, or where not so spaced, an equivalent stopping distance will be provided by two or more signals arranged to display restrictive indications approaching signal where such indications are required.

Rule 44. Signals will be automatically controlled by continuous track circuits on main track and on other track where medium speed is permitted.

Rule 45. Signals governing movement over a switch will be so controlled that proper restrictive indications are displayed when such switch is not in proper position.

Rule 46. On track signaled for movements in both directions, signals will be so arranged and controlled that proper restrictive indications are provided to protect both following and opposing movements.

Rule 47. Circuits will be so installed that—

a. The failure of any part of a circuit affecting the control of a signal will not result in the signal displaying a more favorable indication than intended.

b. Each signal governing a train movement into the block will display its proper restrictive indication when—

(1) A train, engine, or car is in a block.

(2) A switch is misplaced or its points not in proper position.

(3) An independently-operated fouling point derail, equipped with switch circuit controller, is misplaced or not in derailing position.

(4) A track circuit or signal control relay is in de-energized position.

c. Each signal governing a train movement into the block will display its proper indication for approaching train to proceed when—

(1) There is no train, engine, or car in a block.

(2) All switches and independently-operated fouling point derails, equipped with switch circuit controllers, are in normal position.

(3) All track and signal control relays are in energized position.

Rule 48. Signal control relay circuit will not be broken through the contacts of switch, station, tower indicator, or annunciator in which the indicating element is attached to the armature.

Rule 49. Battery or other power supply for signal control relay circuit will be installed at the end of the circuit farthest from the relay.

Rule 50. Signal control relay will be controlled by track circuits extending through the entire block.

Section III. INTERLOCKING

Rule 51. The apparatus will be so installed and circuits so arranged that failure of any part of the system affecting the safety of train operation will cause all signals affected to give the most restrictive indications which conditions require.

Rule 52. Signals will be located preferably to the right of and adjoining the track to which they refer.

Rule 53. Signal indications will be given by position, by colored lights, or by both. A single white light will not be used for a proceed indication.

Rule 54. Approach and home signals will be spaced at least stopping distance apart, or where not so spaced, an equivalent stopping distance will be provided by two or more signals arranged to display restrictive indications

approaching home signals, the indications of which require such restrictive indications.

Rule 55. Track circuits will be provided throughout interlocking limits, except when otherwise authorized.

Rule 56. Signals governing movements over switches, movable point frogs, and derails will be so controlled that indications to proceed can be displayed only when such units are in proper position.

Rule 57. Mechanical locking to insure predetermined order of lever movement, or circuits to insure proper correlation of the units of the interlocking, will be provided.

Rule 58. Signals which form a part of an automatic block signal system will be controlled semiautomatically, except at automatic interlockings.

Rule 59. Approach or time locking will be provided in connection with signals governing movements at high or medium speed.

Rule 60. Electric switch locking will be provided except when otherwise authorized.

Rule 61. Facing-point lock or switch-and-lock movement will be provided for mechanically-operated switches, movable point frogs, or split-point derails.

Rule 62. Power switch operating and locking mechanism at manually-operated interlocking will be provided with means to indicate on interlocking machine or to the operators when movement is completed and unit is locked. Cir-

uits will be provided to insure proper correlation of the units of automatic interlockings.

Rule 63. Indication locking or equivalent will be provided for approach signals of the semaphore type and for power-operated home signals at manually-operated interlocking.

Rule 64. At automatic interlocking, circuits will be arranged so that when trains enter approach circuits simultaneously, proceed indications of home signals on conflicting routes cannot be displayed at the same time.

Rule 65. Approach signals will be installed at automatic interlocking. Operative approach signals will be provided when authorized train speed between home signals exceeds 20 miles per hour.

Rule 66. Automatic interlocking will be so arranged that when home signal has been cleared and route has not been used, if there is a train on approaching sections of such route, home signal for conflicting route can be cleared only after the expiration of a predetermined time interval.

Rule 67. The proceed control circuits at automatic interlockings for home signals will be broken through relays for all track circuits between home signals on the same and intersecting tracks; through signal mechanism contacts or relay contacts repeating stop signal indications for conflicting routes; and through normal contacts of time releases for conflicting routes.

Rule 68. The controlling apparatus at automatic interlocking, except manually-operated time release, will be located at a distance from the tracks to avoid damage.

Manually-operated time release will be located adjacent to tracks at a point where personnel have an unobstructed view of each route.

Rule 69. When movable bridge is protected by interlocking, provision will be made to insure that movements of the bridge devices succeed each other in a predetermined order, and that the movable span, tracks, and switches within interlocking limits are locked in proper positions.

Rule 70. Movable bridge will be equipped with mechanism to surface and align bridge and track accurately and fasten them securely in position.

Rule 71. One-inch pipe or larger, or equivalent will be used for connection to switch, derail, movable point frog, lock, bridge operating and locking devices, and mechanically-operated signal. Pipes will be screwed into coupling until the ends abut, and then riveted securely. Pipe line will be in alignment, properly compensated and supported on carriers spaced not more than 8 feet apart on tangent and curve of 2° and less, and not more than 7 feet apart on curve of 2° or more. Couplings in pipe line will not foul carriers with lever in any position.

Rule 72. Lever locks of the forced drop type or equivalent will be used in new installations and in making replacements on interlocking machines.

Rule 73. Interlocking or control machine, switch movements, and other appurtenances will be kept in good condition, free from excessive lost motion, rust, grease, and dirt. Levers and locking will be kept clean. All bearings will be kept lubricated but excessive lubrication will be

avoided. Bolts and dowel pins will be kept tight, cotter pins properly spread, and sufficient tension maintained in latch springs. Contacts will be clean and properly adjusted.

Rule 74. Proper measures will be taken to protect train movements until plant is restored to normal operation when mechanical locking of interlocking machine is to be changed or removed from machine, or locking becomes disarranged or broken.

Rule 75. Switches will be so maintained that they cannot be locked when a $\frac{1}{4}$ -inch rod is placed between stock rail and switch point 6 inches from point of switch. Locking edges will be kept square.

Rule 76. Cranks, compensators, and other mechanical connections will work freely with no excessive lost motion in moving parts. They will be kept clean, lubricated, properly centered, and in alignment.

Rule 77. Holes in lock rod will have square edges, the holes not more than $\frac{1}{8}$ inch larger than plunger.

Rule 78. Plunger of facing point lock will have at least an 8-inch stroke and when lever is in normal position the end of plunger will clear lock rod by 1 inch. The end of the plunger will have square edges.

Rule 79. Bolt lock will be so maintained that signals governing movements over switch or derail cannot be cleared when derail is in derailing position, or when switch point is open $\frac{1}{4}$ inch or more when bolt lock is used in lieu of facing point lock, and $\frac{1}{2}$ inch or more when switch or derail is otherwise protected. Signal bar will be against

the stop when signal lever is normal. Notches will have square edges.

Rule 80. Driving bar of switch and lock movement will travel, both normal and reverse, so that locking dog will pass through lock rod $\frac{1}{2}$ inch or more.

Rule 81. Disconnecting will be done at the crank nearest the unit when necessary to disconnect switch, derail, or other unit.

Rule 82. Air distribution will be maintained so that leakage in any section of the plant will not exceed 1 pound in 1 minute from normal pressure with all apparatus connected and at rest.

Rule 83. Air strainer used between air distribution system and air apparatus will be cleaned frequently enough to avoid air pressure reduction.

Rule 84. Valves and cylinders will be inspected and tested in service by application of air pressure with apparatus at rest. These will be done frequently enough to insure that parts are clean, packing tight, air supply unrestricted, and apparatus functioning efficiently.

Rule 85. Switch and signal valves and cylinders will be removed from service and repaired in a shop.

Rule 86. Condensers, tanks, reservoirs, and air distribution lines will be drained frequently enough to avoid overflow of condensation into branch line and apparatus. Means of draining condensation out of distribution system will be provided and maintained at low points.

Rule 87. Overload relay and magnet brake on electric switch-and-lock movements will be checked frequently enough to insure proper operation.

Rule 88. Lock and point detector rod connections will be maintained with a minimum of lost motion, inspected and tested frequently, and maintained in proper adjustment.

Rule 89. Corner edges of locking dogs and rods of switch-and-lock movement or facing point lock will be maintained with not more than $\frac{1}{16}$ -inch wear.

Rule 90. Pole changer on electric switch operating mechanism will be maintained to insure that mechanism follows movement of lever.

Rule 91. Point detector will be maintained so that when switch mechanism is locked in normal or reverse position contacts cannot be opened by manually applying force at the switch points in either direction. Contacts will remain open when $\frac{1}{4}$ -inch obstruction is between switch point and stock rail approximately 6 inches from point where latch-out device is *not* used and $\frac{3}{8}$ -inch obstruction where latch-out device *is* used.

Rule 92. Mechanical locking will be maintained so that it is effective and that levers cannot be operated except in proper sequence.

Rule 93. Driving pieces, dogs, stops, and trunnions will be properly secured to locking bars. Swing dogs will have full and free movement. Top plate will be kept in place.

Rule 94. Various parts of the locking beds, locking bed supports, and tapped stop rail will be secured rigidly and aligned properly to insure free and effective operation.

Rule 95. Locking dogs and notches will be examined for wear. Locking faces will fit squarely against each other with a minimum engagement of at least one-half the designed locking face when locked.

Rule 96. Locking will be in accordance with locking sheet and dog chart currently in effect.

Rule 97. Excessive lost motion will be removed when lever or latch that is locked can be moved more than shown below:

a. Mechanical machine. (1) *Latch-operated locking.* When lever latch block can be raised to within $\frac{3}{8}$ inch of top of quadrant.

(2) *Lever-operated locking.* When lever latch block can be moved more than $\frac{3}{8}$ inch on top of quadrant.

b. Electro-mechanical machine. (1) *Lever moving in horizontal plane.* When lever can be moved more than $\frac{3}{16}$ inch when in normal position or $\frac{7}{16}$ inch when in reverse position.

(2) *Lever moving in arc.* When lever can be moved more than 5° .

c. Power machine. (1) *Latch-operated locking.* When lever latch block can be raised to within $\frac{3}{16}$ inch of top of quadrant.

(2) *Lever moving in horizontal plane.* When lever can be moved more than $\frac{5}{16}$ inch when in normal position or $\frac{9}{16}$ inch when in reverse position.

(3) *Lever moving in an arc.* When lever can be moved more than 5° .

Rule 98. In electro-mechanical interlocking machine locking between electric and mechanical levers will be maintained to insure that mechanical lever cannot be operated except when properly released by electric lever.

Rule 99. Latch shoes, rocker links, and quadrants of mechanical and electro-mechanical interlocking machines will be maintained so that locking will not release if the foot is used on the rocker while lever is in mid-stroke position.

Rule 100. Rail lock on movable bridge will be maintained so that it cannot be locked with the rail displaced $\frac{1}{4}$ inch or more from its proper position.

Rule 101. Bridge lock on movable bridge will be maintained so that it cannot be locked unless the movable members are within 1 inch of their proper positions.

Rule 102. Circuit controllers operated by surfacing devices on movable bridge will be so maintained that the circuits will not be completed unless the locking bars are within 1 inch of their proper positions.

Section IV. TRACK CIRCUITS

Rule 103. Track circuits will be installed and maintained so that the track relay is in a de-energized position, and the track circuit of an automatic train stop, train control, or cab signal system will be de-energized in the rear of the point where any of the following conditions exist:

- a. A rail is broken or a rail or frog is removed.
- b. A train, engine, or car occupies any part of a track section including fouling section of turnout or crossover.

c. Where switch shunting circuit is used and—

(1) A switch is misplaced or its points are not in proper position.

(2) A switch is not properly locked where facing point lock with circuit controller is used.

(3) An independently-operated fouling point derail equipped with switch circuit controller is misplaced or not in derailing position.

Rule 104. The track relay at cut section will, when in de-energized position, open the track energy supply for the adjacent track circuit and, in noncoded direct current territory, shunt the adjacent track circuit.

Rule 105. At grade crossing with an electric railroad where tests indicate presence of foreign current, electric energy for noncoded direct current track circuit will be connected to feed away from the crossing.

Rule 106. The length of any track circuit, except trap circuit, will be greater than maximum inner wheel base of any engine or car.

Rule 107. Special circuit will be installed where dead section exceeds 35 feet, or the shortest wheel base of an engine.

Rule 108. Track circuit will be maintained so that it is properly energized during wet weather or during minimum ballast resistance conditions, and during dry weather or maximum ballast resistance conditions. Track circuit will not be overenergized to such an extent that shunting sensitivity will be decreased below a safe value.

Rule 109. Bonding will be maintained in a condition that insures low resistance.

Rule 110. Shunt wires, preferably in duplicate, will provide adequate conductivity to insure effective shunting and will be maintained in good condition.

Rule 111. Track connections and fouling circuits will be installed and maintained so as to avoid breaks or undue resistance.

Rule 112. Switch circuit controller connected at the point of switch located in main track, or other track equipped with track circuit and not equipped with facing point lock, will be maintained so that when point is opened $\frac{1}{4}$ inch or more on facing point switch and $\frac{3}{8}$ inch or more on trailing switch, track or control circuits will be shunted, opened, or both. Switch circuit controller will be securely fastened and contacts kept clean, with minimum resistance and with contact opening of not less than $\frac{1}{16}$ inch when open.

Rule 113. Circuit controller operated by switch and lock movement will be maintained so that the contacts remain closed or open or both until the locking dog has passed through the lock rod.

Rule 114. Insulated rail joints will be maintained in good condition, drainage provided, insulation in place, bolts tight, and ties properly spaced and tamped.

Rule 115. Circuits will be arranged so as to provide protection against defective insulation in insulated rail joints.

Rule 116. Insulation in pipe line, switch rod, tie rod, and gauge plate will be maintained in good condition.

Rule 117. Pipe line under rail will clear base of rail at least $\frac{1}{2}$ inch.

Rule 118. Pick-up and drop-away values will be maintained within limits which insure reliable and safe operation.

Rule 119. Relays will not be tilted or turned over to close contacts. Contacts of relay or other controlling device will not be bridged without taking proper measures to insure safe operation of trains.

Rule 120. Voltage at the local terminals of a two-element alternating-current relay will be as nearly as possible the normal voltage at which the relay is designed to operate.

Section V. POLE LINES AND POWER SUPPLY

Rule 121. Pole lines carrying signal circuits will be properly installed and maintained. Wires will be securely tied in on the insulators; broken insulators will be replaced.

Rule 122. The clear space between the lowest overhead signal line conductor and the tops of track rails at points where freight cars are handled and on top of which men are permitted to stand will be not less than 27 feet at 60° Fahrenheit when there is no wind.

Rule 123. Open wire transmission line operating at voltage of 750 volts or more will not be placed closer than 4 feet above the nearest crossarm carrying signal or communication circuits.

Rule 124. Battery of sufficient capacity for the service required will be installed in suitable housing and kept

sufficiently charged or renewed as often as necessary to insure safe and reliable operation. Connections will be kept clean and cracked or broken jars will be replaced.

Rule 125. A transformer will be installed of sufficient capacity for the service required and suitable for the frequency and voltage supply with which it is used.

Rule 126. Lightning arrestors will be properly connected and ground maintained with resistance to ground of not more than 25 ohms.

Rule 127. Insulated wire will be protected from mechanical injury to avoid interference with proper operation of apparatus. Insulation will not be punctured for test purposes. Insulated underground wire will not be spliced when it can be avoided.

Rule 128. Insulated wire and cable used aerially will be supported on insulators or suspended from messenger wire.

Rule 129. Wires will be identified properly. Tags in instrument mechanism and terminal cases will be made of insulating material and so placed that they will not interfere with moving parts of apparatus.

Section VI. INSPECTIONS AND TESTS, ALL SIGNALING SYSTEMS

Rule 130. Periodic inspections and tests will be made to insure that apparatus is in proper condition for service. The frequency of tests named in the following rules represent the maximum intervals between tests.

Rule 131. Proper instruments will be used when making tests of apparatus and determination made that no unsafe conditions are set up by the application of testing equipment.

Rule 132. A general inspection will be made once every 4 years to insure good physical condition and operation.

Rule 133. Signal mechanism will be inspected at stated intervals to insure that the apparatus is maintained in safe and suitable condition for service. The operating characteristics of all parts of the signal mechanism will be tested at specified periods, but not less than once each 2 years.

Rule 134. Switch circuit controllers will be inspected frequently and tests will be made quarterly to insure that they are in good condition and in proper adjustment.

Rule 135. Fouling circuits on switches will be inspected frequently and test made quarterly to insure that fouling wires are intact and that fouling circuit shunts properly.

Rule 136. Insulated rail joints will be inspected monthly to insure that they are in good condition.

Rule 137. Relays will be tested in service every 2 years in accordance with tests specified by the officer in charge. Relays which fail to meet requirements of specified tests will be removed from service, subjected to thorough tests, and replaced in service only after their operating characteristics are in accordance with the limits within which relays are designed to operate.

Rule 138. Lightning arrestors will be inspected frequently during the seasons of the year when lightning occurs. Gas

and vacuum types will be tested annually and date of tests recorded.

Rule 139. Insulation resistance tests will be made when wires, cables, and insulation are dry. Wires and cables, except those connected directly to track rails, will be tested in accordance with the following schedule; wires will be given special attention and, if necessary, removed from service when the insulation test is found to be below that shown in the following schedule:

a. Low voltage wires and cables with braided rubber insulation, any part of which is underground or in trunking—test period 5 years; minimum allowable resistance, 1 megohm.

b. Low voltage aerial wires and cables with braided rubber insulation, no part of which is underground or in trunking—test period 8 years; minimum allowable resistance, 1 megohm.

c. Lead sheathed wires and cables, parkway cables with lead sheath, trench lay and cables with metal sheath, carrying low voltage circuits—test period 8 years; minimum allowable resistance, 1 megohm.

d. Local signal wiring—test period 8 years; minimum allowable resistance, 1 megohm.

e. Lead covered signal power cables—test period 8 years; minimum allowable resistance, 100 megohms between sectionalizing switches.

f. Underground signal power lines not lead sheathed—test period 5 years; minimum allowable resistance, 40 megohms for voltage up to and including 500 volts for section tested, and 100 megohms between sectionalizing switches for voltages exceeding 500 volts.

Section VII. INTERLOCKING TESTS

Rule 140. Complete tests will be made at specified periods but not less frequently than once every 4 years to determine that locking is in condition to insure proper functioning and is in accordance with plans currently in effect.

Rule 141. Approach locking will be tested annually to insure that after a signal has been cleared the position of any switch, derail, or movable point frog in the route governed by that signal cannot be changed with the approach circuit open until after the expiration of a predetermined time interval.

Rule 142. Time locking will be tested annually to insure that after a signal has been cleared, the position of any switch, derail, or movable point frog in the route governed by that signal cannot be changed until after the expiration of a predetermined time interval.

Rule 143. Switch locking, section, route, or other type of switch locking will be tested quarterly to insure that a switch, derail, movable point frog, or facing-point lock cannot be operated with a train occupying any portion of protecting track circuit.

Rule 144. Indication locking will be tested annually on semaphore signals, annually on switch or lock levers, and each 2 years on light signals, as follows:

a. Lock on signal lever—to insure that lever or latch cannot be placed in normal position until the corresponding home signal indicates “stop” and the approach signal indicates “approach.”

b. Lock on switch or lock levers—

(1) When movement is operated, locked, and indicated by the same lever, to insure that lever and switch or switches, or other operated units, are in corresponding positions and locked before lever stroke can be completed and mechanical locking released.

(2) When locked and indicated by lock lever, to insure that operating lever and switch or switches, or other operated units, are in corresponding positions before lock lever can be operated and mechanical locking released.

Rule 145. Traffic locking will be tested annually to insure that levers or units for changing the direction of traffic on a section of track cannot be manipulated while a signal is displayed for a train to proceed into that section or with any part of the section occupied.

Rule 146. Switch obstruction tests will be made quarterly to insure proper maintenance and adjustment of switches.

Rule 147. In electro-pneumatic interlocking, valve locks on valves of the noncut-off type, valves, and magnets will be tested quarterly to insure that apparatus and circuits are in proper condition.

Rule 148. Cross protection will be tested quarterly to insure that protective devices operate properly to prevent movement of switches, signals, and other units when current is improperly applied to the circuits.

Rule 149. Time releases and timing relays will be tested quarterly and timing will be maintained within 10 percent of the predetermined time interval.

Rule 150. Restoring features on power switches will be tested quarterly to insure that power will be applied and

that power will restore switch movements to full normal or full reverse position.

Rule 151. Movable bridge locking will be tested at specified periods, but not less frequently than once each year, to insure that rail locks, bridge locks, bolt locks, circuit controllers, and electric locks are in good condition and are functioning properly.

Section VIII. INSPECTIONS AND TESTS, SIGNAL TRANSMISSION LINES

Rule 152. Pole lines will be inspected at stated intervals to insure that they are in good condition.

Rule 153. All signal transmission lines will be inspected at regular intervals and will be maintained in good physical and operating condition.

Rule 154. At least one general inspection will be made of the entire line each year. The fall of the year is recommended for the general inspection as the winter months are the hardest on the lines. When two general inspections are made each year the second inspection will be made in the spring.

Rule 155. In addition to the general inspections, periodic inspections of all lines will be made by patrolmen. These inspections will be made at stated intervals as required by the officer in charge. All lines will be patrolled immediately after a lightning or wind storm for the purpose of determining if any damage was done by the storm.

Rule 156. Inspectors will inspect all transmission lines and transformer substations, reporting location and full details of all defects found. If the lines are not in need of repairs, the report will so state. Defects requiring immediate attention will be reported to the proper officer.

Rule 157. During both general and periodic inspections pole lines will be inspected for the following defects:

a. **Crossarms.** (1) Rotting, splitting, or twisting.

(2) Loose, broken, or missing pins.

(3) Loose or missing braces.

b. **Insulators.** (1) Cracked, chipped or broken. (Minute inspection will be made for cracks.)

(2) Unscrewed.

c. **Poles.** (1) Broken off.

(2) Raking. (Leaning out of line 2 feet or more at the top.)

(3) Woodpecker holes that impair the strength of the pole.

(4) Hollow rot. (Sound body of pole for hollow rot.)

(5) Splitting.

(6) Effects of lightning.

(7) Splitting or pulling of guys.

(8) Twisting.

(9) Wash-outs at ground line.

(10) Rotting at ground line. (Remove the earth from around the pole to a depth of 3 or 4 inches and use a short bar or hand spike to determine depth to which rot has penetrated.)

(11) Grass around base of pole. (All grass, weeds, and any inflammable material will be kept cleared away from

the base of the pole for a distance of at least 2 feet to reduce the fire hazard.)

(12) Broken or slack guys or broken guy insulators.

(13) Nuts off or loose on any poles.

d. Wires (1) Broken.

(2) Broken strands in conductors.

(3) Broken ground lines.

(4) Ground lines loose from support.

(5) Tie wires broken or burned

(6) Short circuits.

(7) Twisted spans.

(8) Loose connections

(9) Defective ground wire. (Ground wire will be inspected to insure that it is rigidly supported, that it has not been cut, the cross section reduced by linemen's spurs, or that the connection between ground wire and ground pipe has not been weakened by corrosion or mechanical injury.)

(10) Fouling by trees. (Trees or tree limbs in such position that they may touch or blow into the line wires, trees which would fall into the wires if they broke off at the ground line, and trees clearing the line less than 2 feet underneath or 4 feet to one side, are considered danger timber and will be so reported. Wires will be kept clear of tree twigs, limbs, and other debris. Brush will be cut in August or September unless there is danger of the brush fouling the lines before that time.

Rule 158. Inspection and maintenance procedure for certain pole line fixtures:

a. Lightning arrestors. (1) Pipe framework support of

arrestors will be inspected and painted with graphite if necessary.

(2) Gaps will be checked.

(3) Horns will be checked for loose bolts and for position.

(4) Checks will be made for loose ground connection.

b. Transformers. (1) Oil will be removed from tank and filtered if possible. The walls of the tank and the coils will then be cleaned by flushing with oil before tank is refilled.

(2) Transformers will be painted if necessary.

(3) Water cooling coils will be inspected for leaks; test with 75 pounds air pressure.

(4) Compound and oil-filled bushings will be inspected for cracks and leaking compound. If transformer can be taken out of service bushings will be cleaned.

(5) All oil leaks will be stopped.

(6) Tanks, oil gauges, thermometers, and valves will be cleaned.

c. Ground wires. (1) An inspection will be made of all ground connections to transformer cases, transformer secondary wiring, power and lightning arrestors.

(2) Resistance of all ground wires will be measured and minimum allowable resistance will be maintained. (See rule 139.)

INDEX TO RULES

	<i>Rule</i>
Accidents	8
Air distribution	82-86
Approach locking	59, 141
Approach signals, operative	65
Batteries	49, 124
Bridge lock	101
Buffing and snubbing	30
Cables	139
Circuits:	
Controllers	102, 103, 113
Installation	47
Interruption	6, 15
Plan	3
Condensers	86
Controlling apparatus, automatic interlocking.....	68
Crossarms	157
Cross protection, switches, signals	148
Cut section, track relay	104
Defective apparatus	5, 25
Deflecting prisms	39
Disconnecting switch, derail	81
Distribution of manual	1
Dog chart	3
Dogs	93
Driving pieces	93
Drop away value	118
Electrical contacts	28
Electric switch locking	60
Electro-mechanical machine	97, 98, 99
Electro-pneumatic valves	147

	<i>Rule</i>
Facing point lock	78, 79, 89, 103
Foreign current	105
Fouling circuit	135
General inspections	132, 154
Ground wires	158
Home signals	66
Identifying wires	129
Indication locking	63, 144
Inspectors reports	156
Insulated rail joints	114, 115, 136
Insulated wire	127, 128
Insulation in switches, pipe	116
Insulators	157
Interlocking tests	140
Latch-out device	91
Latch-operated locking	97
Latch shoes	99
Lay-out plan	3
Lead covered cables	139
Lever locks	72, 73, 97
Lever-operated locking	97
Lightning arrestors	126, 138, 158
Locating signals	41, 52
Lock and point connections	88, 91
Lock rod holes and plunger	77, 78
Locking:	
Beds	94
Dogs	89, 95, 113
Faces	95
Notches	95
Rods	89, 113
Rules	96
Sheets	93
Low voltage wires	139
Mechanical:	
Locking	57, 74, 92, 97
Machine	97

	<i>Rule</i>
Movable bridges	69, 70, 100, 101, 102, 151
Open wire transmission lines	123
Periodic inspections	130, 155
Phantom indications	17, 38
Pick-up value	118
Pipe connections	71, 117
Pole:	
Changers	90
Lines	121, 122, 152
Poles	157
Power machine	98
Power supply	47
Power switch operating and locking	62, 150
Proceed control circuits	67
Proceed indications, conflicting routes	64
Protecting trains:	
After signal failure	9, 10
During signal repairs	11
Rail lock	100
Relay mechanism	36, 37, 104, 119, 137
Resistance tests	139, 158
Restrictive indications.....	40, 45, 46, 47, 48, 50, 51, 56
Safety	2, 4, 6, 9, 10, 11, 15, 16, 40, 51, 74
Sealing of equipment	13
Semaphore:	
Blade	18
Cleaning and lubricating	23, 24
Ladder	20
Lamp	18, 19, 22
Mast installation	17
Platform	20
Signal:	
Indications	42, 53
Mechanism	133
Motor	31, 35
Semiautomatic	58
Space between	43, 54

	<i>Rule</i>
Transmission lines	153
Slot magnets	26, 27, 28
Slot toggle adjustment	32, 33, 34
Storms	7
Switch and lock:	
Movement	80, 89, 113
Overloading relay	87
Switches:	
Adjustment of switch points	75
Circuit controller	134
Locking	75, 80, 143
Obstruction test	146
Shunting circuit	103
Temporary repairs	4
Tests after repairs	11, 14
Test instruments	131
Time:	
Locking	59, 142
Relays	149
Track:	
Circuits	44, 55, 103
Relay	103
Traffic locking	145
Transformers	125, 158
Turnout foul	103
Valve locks	147
Voltage at relay	120
Wires	29, 139, 157

