

THE PENNSYLVANIA RAILROAD

SPECIFICATIONS FOR SIGNAL
and
INTERLOCKING SYSTEMS

C. E. 234-(b)





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THE PENNSYLVANIA RAILROAD

Specifications for Signal and Interlocking Systems

CONTENTS

	Section Numbers
SPECIFICATIONS	
Air Supply and Distribution Systems	36
Arresters, Lightning	25
Automatic Train-Stop, Train-Control, and Cab-Signal Systems	40
Batteries	24
Battery Shelters	27
Bell (See Highway Grade Crossing Protection)	44(l)
Bolts, Screws and Washers	34
Boards, Model	33
Bonding	16
Bonds, Impedance	17
Boxes, Stuffing (See Interlockings)	38(b)7
Bridges, Movable	43
Bridges, Signal	2
Cab-Signal, Automatic Train-Stop, and Train-Control Systems	40
Cables, and Wires	30
Cantilever Supports (See Highway Grade Crossing Protection)	44(d)
Carriers, Pipe (See Interlockings)	38(b)6
Centralized Traffic Control (See Traffic-Control Systems)	39
Circuits, Signals-Control and Associated Circuits.	5
Circuits, Standard Plans	5(g)
Circuits, Switch Mechanism (See Switches)	8
Circuits, Track	14
Circuits, Typical Plans	5(f)
Clearances, Minimum Roadway	46
Code Change Points, and Other Similar Protective Devices, etc.	42
Compensators (See Interlockings)	38(b)4
Concrete	13
Conduits	29
Cover Glass (See Lamps)	7(b)
Cranks	35
Crossing Protection, Highway Grade	44
Deflecting Bars (See Interlockings)	38(b)3
Derails	10
Detectors, Dragging Equipment	41
Detectors, Point (See Switches)	8(b)
Distribution System, Air	36
Distribution, A.C. Power Supply and	23
Electro-Mechanical Machine (See Machines, Interlocking)	37

Eyelets, Wire (See Wire Terminals)	31
Fences, Slide Protection	42
Flashing Light Signals (See Highway Grade Crossing Protection)	44
Foundations	12
Gates, Short Arm (See Highway Grade Crossing Protection)	44
Grade Crossing Protection, Highway	44
Grounds and Grounding	26
Heaters, Frost Prevention	45
Heaters, Switch	9
Highway Grade Crossing Protection	44
Impedance Bonds	17
Index to Electrical Wire and Cable	45
Instrument and Battery Shelters	27
Insulating Rail Joints	15
Interlocking Machines	37
Interlockings	38
Jaws and Lugs (See Interlockings)	38(b)8
Joints, Insulating Rail	15
Lamps	7
Leadout and Ground Work	38(b)1
Lightning Arresters	25
Locking, Mechanical, electro-mechanical interlocking machine	37(g)
Locking, Mechanical, power interlocking machine	37(c)
Lugs, and Jaws (See Interlockings)	38(b)8
Machines, Interlocking	37
Machines, Torpedo Placing	42
Markers—Type	1
Masts, Ground	2
Mechanical Locking, electro-mechanical interlocking machine	37(g)
Mechanical Locking, power interlocking machine	37(c)
Mechanism, Switch, electric (See Switches)	8(e)
Mechanism, Switch, electro-pneumatic (See Switches)	8(f)
Mechanism, Switch, electro-pneumatic (See Switches)	8(e)
Model Boards	33
Movable Bridges	43
“No Turn” Signs (See Highway Grade Crossing Protection)	44(e)
Numbering Signals (See Signal Numbering)	6
Oil Siding	47
Painting	28
Pipe and Pipe Lines (See Interlockings)	38(b)5
Pipe Carriers (See Interlockings)	38(b)6
Plans, Standard	5(g)
Plans, Typical	5(f)
Pneumatic Power Supply	36
Point Detectors (See Switches)	8(b)
Power Supply, A.C., and Distribution	23
Protective Devices, Other Similar Systems, etc.	42
Quick Switch (See Switches)	8
Rail Joints, Insulating	16
Reactors and Resistors	18

Rectifiers and Transformers	19
Relays, A.C.	20
Relays, D. C.	21
Releases, Time, and Timing Relays	22
Resistors, and Reactors	18
Rocking Shafts (See Interlockings)	38(b)2
Route Interlocking (See Interlockings)	38
Screws, Bolts, and Washers	34
Shafts, Rocking (See Interlockings)	38(b)2
Shelters, Instrument and Battery	27
Short Arm Gates (See Highway Grade Crossing Protection)	44
Sidewalk Gate Arms (See Highway Grade Crossing Protection)	44
Signal Bridges, Bridge Signal Supports and Ground Masts	2
Signal Numbering	6
Signals, Control and Associated Circuits	5
Signals, Flashing Light (See Highway Grade Crossing Protection)	44
Signals, Location of	3
Signals, Markers and Signs—Type	1
Signals, Spacing of	4
Signs, “No Turn” (See Highway Grade Crossing Protection)	44(e)
Signs, Signals, and Markers—Type	1
Slide Protection Fences, and other Similar Protective Devices, etc.	42
Smashboards (See Movable Bridges)	43
Standard Plans (Circuits)	5(g)
Straps, Tie	11
Stuffing Boxes (See Interlockings)	38(b)7
Supports, Bridge Signal	2
Supports, Cantilever (See Highway Grade Crossing Protection)	44(d)
Switch Heaters	9
Switches—including Switch Mechanisms and Circuits	8
Tagging of Wires	32
Terminals, Wire	31
Tie Straps	11
Time Releases and Timing Relays	22
Torpedo Placing Machines, and Other Similar Protective Devices	42
Track Circuits	14
Traffic-Control Systems	39
Train-Control, Automatic Train-Stop, and Cab-Signal Systems	40
Transformers and Rectifiers	19
Typical Plans	5(f)
Washers, Bolts, and Screws	34
Wire Eyelets (See Wire Terminals)	31(d)
Wire and Cable-Index	45
Wires and Cables	30
Wires, Tagging of	32
Wire Terminals	31

SPECIFICATIONS

These specifications cover new work and extensive changes in existing apparatus.

References to plans and specifications show the original or basic number. The latest or current issue shall be followed.

1. Signals, Markers, Indicators and Signs, Type.

(a) Signals shall be of the position light type in accordance with the following plans:

1. High Signals S-400 and S-401
2. Dwarf and Pedestal Type S-410

(b) Pedestal type may be used where maximum speed does not exceed 30 M.P.H. in locations approved by Chief Engineer. Color light type, and markers other than (c) may be used in locations approved by Chief Engineer.

(c) Markers for Semaphore Signals, in accordance with Plan S-468, may be used in locations approved by the Chief Engineer.

(d) Other signals, signs, indicators and markers shall be in accordance with the following plans:

1. Smashboards S-380
2. Flag Station Signal S-470
3. Block Limit Signal and Approach
Block Limit Signal S-464
4. Markers (Reflector Type and Triangle) S-468
5. Distant Switch Signal S-470
6. Scale Signal S-470
7. Grade Signal and Spring Switch Marker S-545
8. Light Hump Signal S-470
9. Signs ("E", "O", "No Left Turn", etc.) S-469
10. Train Order Signals S-454
11. End of Block and Fouling Point Signs S-472
12. Take Siding Indicator S-452

2. Signal Bridges, Bridge Signal Supports and Ground Masts.

(a) Signal bridges, signal supports and ground signals, shall be in accordance with the following plans:

1. Standard Signal Bridge 17100
2. Signal Beam Bridge, 4 Tracks 25963 (Sh. E1)
3. Signal Beam Bridge, 6 Tracks 25964 (Sh. E2)
4. Signal Supports for Bridge #17100 S-400
5. Signal Supports for Beam
Bridges 26253 (Sh. E3, E3D & E3E)
6. Signal Supports for Catenary
Poles ET-1141 and ET-1142
7. Pedestal and dwarf signal S-410
8. Ladders, Platforms and Ground Masts
for P.L. signals S-400 & S-401
9. Decking, Railings and Cable
Supports S-432 & SK-432

3. Location of Signals.

(a) Signals shall be located over or to the right of and adjacent to the track governed.

(b) Signal masts on bridges shall be located over center of the intertrack space but not exceeding four (4) feet six (6) inches from gauge of rail and for the outside track they shall be the same distance from the center of the track to which they refer as those located between tracks.

(c) Ground signals, dwarf signals, pedestal signals, bridge legs, etc., shall be so located as to provide proper clearance as indicated on the standard plan 70050. Intertrack space for structures located between tracks shall be as prescribed by Parag. 939, C.E. 78—“[Specifications for Standard Track.](#)”

(d) Signal mast shall be vertical; securely fastened on suitable support, and signal alined to give the best possible indications for approaching trains. Signals shall be installed to avoid so far as possible, liability of mistaking the indication of one signal for the indication of another signal, or confusion between signal and other lights.

(e) Home signals shall be so located that insulating joints shall be not less than three feet from the nearest switch protected. Signals located with respect to fouling point shall have insulating joints located in accordance with Note 10, Plan [S-803](#), Sheet No. 1.

(f) Smashboards shall be generally located on or immediately adjacent to high signals governing movements over movable bridges, railroad crossings at grade, or on approach to draw span, as local conditions may require. Smashboard signals with lamp in lieu of signals and smashboards may be installed where traffic conditions are such that the installation of other signals is not deemed necessary. Smashboards may be installed where other than high signals are in service where traffic or local conditions require. Smashboards for protection at railroad grade crossing may be installed only by approval of the Chief Engineer.

4. Spacing of Signals.

(a) The distance between signals shall be not less than the stopping distance required for a speed of 100 miles per hour for passenger trains where conditions permit, except where otherwise authorized by the Chief Engineer, the spacing being adjusted for grades and alinement in accordance with C.E. 205.

(b) Where three-block indication is required blocks shall be of sufficient length for a passenger train to reduce from authorized to medium speed, grades and alinement being considered.

(c) Freight trains must be operated at a speed from which it will be possible for them to stop within the established signal spacing.

5. Signals-Control and Associated Circuits.

(a) Interlocking and manual block signals shall be semi-automatic stick, except where the route is seldom changed, the stick feature may be omitted on approval of the Chief Engineer.

(b) Where the top arm of an interlocking signal is used as a manual block signal, the bottom arm shall not be used to admit trains to the route governed by the top arm.

(c) In manual block signal system territory, separate block signals shall be used only where the necessary block indications cannot be given by the top arm of home interlocking signal, or where operating conditions make it advisable to sub-divide the block.

(d) Manual block signal aspects shall preferably be given by the top arm. Where speed restrictions appear in the time-table for movements over turnouts, a one arm signal may be provided to give block indication for such movements where only one speed and one route is involved.

(e) Successive approach or successive approach medium indications shall not be provided except when authorized by Chief Engineer.

(f) Typical Plans:

1. Circuits for Remote Control of
Outlying Switches S-826
2. Circuits for Remote Control of
Manual Block Signals S-827
3. Circuits for Automatic Gauntlet Signals S-835
4. Drawbridge Circuits S-840
5. Circuits for Torpedo Placing Machines S-841
6. Circuits for Automatic Interlocking
at R.R. Grade Crossings S-844
7. Circuits for Absolute Permissive
Block Signal System S-845
8. Home Signal Control Circuits S-851
9. Circuits for "SS" Protection S-852
10. Circuits for Clear Control of
Distant Signals S-853
11. Control Circuits for Block Signals S-854
12. Circuits for Interlocking Operated
Part Time S-859
13. Control Circuits for Track
Indicating Relays S-861
14. Control Circuits for Home Signals S-862
15. Lighting Circuits for Lamps on
Highway Crossing Signals S-866
16. Control Circuits for Position Light
Dwarf Signals S-867
17. Circuits for Indication and
Approach Locking S-870
18. Control Circuits for Traffic Locking S-871

19. Circuits for Electric Switch Locks on Non-interlocked Switches	S-872
20. Circuits for Check Locking	S-873
21. Coded Track Circuits for Interlockings.....	S-881
22. Coded Track Circuits Approaching Home Interlocking Signals	S-887
23. Coded Circuits Superimposed on D.C. Track Circuits	S-888
24. Control Circuits for Flashing Light Train Order Signal	S-830
25. Circuits for Detectors for Dragging Equipment	S-879
26. Circuits for Code Change Points Approach- ing Home Interlocking Signals	S-889
27. Circuits for Flashing Light Highway Crossing Signals	S-860
28. Circuits for Route Locking	S-825

(g) Standard Plans:

1. Lighting Circuits for Position Light Home Interlocking and Block Signals	S-855
2. Lighting Circuits for Position Light Distant Signals	S-856
3. Circuits for Position Light Automatic Signals	S-857
4. Arrangement of Terminals in Terminal Box of Position Light Signals	S-858
5. Distant Switch Signal	S-470
6. Scale Signal	S-470
7. Approach Lighting Circuits	S-865
8. Coded Track Circuits Approaching Distant Interlocking Signal	S-883
9. Coded Track Circuits in Automatic Territory	S-884
10. Track Circuits Approaching Distant Interlocking Signals—Universal Code.....	S-893
11. Track Circuits in Automatic Territory— Universal Code	S-894
12. Track Circuits Approaching Home Interlocking Signals—Universal Code.	S-897
13. Circuits for Spring Switches	S-828

6. Signal Numbering.

(a) Each position light signal whose most restrictive indication is more favorable than Stop shall be numbered, the number to be placed on the face of the pole or structure, or in a location adjacent thereto, so as to be seen from trains approaching in the normal direction.

(b) The decimal system of numbering from the preceding mile-post, taking the mile-post distance as the first part of the number and tenths of a mile there from as the second part, selecting the nearest even numeral for the second part for eastward or northward movements, and the nearest odd numeral for westward or southward movements, shall be used for signals.

(c) By authority of the Chief Engineer, when necessary for clearness of location, and to avoid confusion between numbers on main and branch lines, the initial letter of the branch, or other significant letter if clearer, shall be prefixed to the number.

(d) Numerals and letters shall be applied in accordance with Plans [S-489](#) and [S-490](#).

7. Lamps

(a) Incandescent Lamps shall be in accordance with Plan [S-483](#).

(b) Cover glasses, roundels and lenses shall be in accordance with Plans [S-486](#) and [S-487](#).

8. Switches—Including Switch Mechanisms and Circuits.

(a) Route locking, in accordance with Plan [S-825](#), shall be provided throughout interlocking limits.

(b) Point Detectors.

1. Point detector shall be applied to each switch protected by signal, unless otherwise authorized by the Chief Engineer.

2. Point detector protection on switches in mechanical and electro-mechanical interlocking shall be provided in applying switch circuit controller connected to front rod foot.

3. Where Style “CP” valves, type “F” controllers or DP-25 relays are used, equipped with indication circuit contacts, the quick switch on the switch operating lever shall be omitted if the switch mechanisms are provided with point detectors.

The quick switch shall be provided if any of the above protection is omitted except in slow speed territory, if the point detector only is not used, the quick switch may be omitted when authorized by the Chief Engineer.

(c) Non-interlocked switches shall be arranged in accordance with Plans [S-228](#), [S-232](#), [73930](#), or other approved arrangement.

(d) Switches having switch rails forty-five (45) feet in length, switches having rail section heavier than 131 pounds, or switches located in excess of 800 feet from the interlocking station, shall be power operated.

1. Ties for mounting switch mechanism S-195
2. Switch circuit controller
installation S-220 and S-222

(e) Power-operated Switch Mechanisms.

1. Pneumatic switch operating mechanisms shall be the low pressure type A-5 with separately mounted Style CP valves. They shall be installed in accordance with Plans S-207, S-213, S-214 and S-222.

2. Electric switch operating mechanisms shall be low or high voltage type, not equipped for dual operation, with Type F controllers or Style DP-25 relay control. They shall be installed in accordance with Plan S-216 and S-222.

3. Mechanisms shall be placed, where possible, so that the operating rod will be in tension for the highest speed train movement over the switch in the facing direction, applied in accordance with Plan S-195.

4. Control and indication circuits shall be in accordance with Plan S-822 for electro-pneumatic and Plan S-823 for electric switch mechanisms.

(f) Electro-Mechanical Switch Mechanisms.

1. Switch mechanisms shall be in accordance with Plan S-258, except as indicated in Sect. 8(d).

2. Switch operating mechanisms for facing point switches in main tracks shall be so placed that the operating rod is in tension for the highest speed movement over the switch in the facing direction. At other points they shall be located on the same side of the track as the main pipe line in accordance with Plans S-200, S-201, S-202, S-203, and S-206.

3. Each mechanism operating a facing-point switch, a facing-point derail or a movable point frog, over which train movements are made at medium speed or greater, shall be equipped with an approved electric lock which, when the switch is being operated, shall be energized by positive energy from battery over a contact on the controlling electric lever, contact closed when that lever is in the center position, thence through the magnets of the locks controlled and thence to the negative (return) wire.

4. Switch indication circuits shall be in accordance with Plan S-821.

9. Switch Heaters.

(a) Electrical switch heaters shall be of the following types:

1. Ballast Pad (radiation) type.
2. Rail Pad (radiation and contact) type.
3. Tubular or Strip (contact) type.

NOTE: A working test shall be made each fall before these devices are placed in service to insure that all connections are functioning properly.

(b) The radiation type heater is placed in ballast between the ties and under the base of rail.

(c) The number of radiation type heaters normally required are:

1. Twenty-four (24) heaters per 45-ft. switch.
2. Sixteen (16) heaters per 30-ft. switch.
3. Twelve (12) heaters per 18 and 20-ft. switches.

NOTE: These numbers include two (2) heaters in crib ahead of switch points.

(d) The radiation and contact type heater must contact the under side of base of stock rail and extend under the base of the switch point, heating stock rail by conduction and switch point by radiation.

(e) Contact type switch heaters shall be installed in accordance with Spec. CE-252, Plan S-250 and L.G.P. 148.

(f) Contact heaters may be bent to shape once if found necessary to do so, but should not be re-bent as there is danger of cracking the sheath.

(g) No bends are to be made within 6 inches of the male and female screw connection on each end of the tubing. A solid monel terminal extends 6 inches into the tubing at which point heating element is attached.

(h) Under no circumstances are contact heaters to be installed on the outside of the rail without specific permission from Supervisor C. & S.

(i) Care should always be exercised to prevent damage to contact heaters from insufficient clearance between stock rail and switch point.

(j) When stock rails are changed by track forces, a close follow-up must be made by Foreman to see that contact heaters are promptly and properly re-installed.

(k) When switch points are changed by track forces, possible difference in switch point reinforcement may reduce clearance between stock rail and point; careful check must be made to prevent damage to contact heater.

(l) Where contact heaters have been installed an extra supply of bolts, clips and fuses should be maintained for emergencies.

(m) To insure information being available concerning life of electric heaters, a metal tag indicating date of installation should be attached to each, or other means of identification be provided.

(n) Electrical switch heaters are to be used primarily in electrified territory, unless power requirements outside such territory may be provided on an economical basis.

(o) Where contact heaters are used, track relays shall be provided with fuse protection.

10. Derails.

(a) Derails shall be installed in accordance with Parag. 1401-1411, [Specifications for Standard Track, C. E. 78](#).

11. Tie Straps.

(a) Tie straps shall be used at all switches, derails and movable point frogs and fastened to each tie with one three-fourths by four and one-half ($\frac{3}{4} \times 4\frac{1}{2}$) inch lag screw. They shall be applied as indicated on layout plans showing the application of the operating mechanisms.

(b) Tie straps shall be in accordance with Plan [S-200](#).

12. Foundations.

(a) Foundations shall be in accordance with Plans as follows:

1. Instrument Case [S-109, S-110 & S-111](#)
2. Air Line [S-114](#)
3. Pipe Carrier [S-115](#)
4. Crank and Compensator [S-116](#)
5. Style "CP" Switch Valves [S-210](#)
6. Rocking Shaft Leadout [S-167](#)
7. Position Light Signals [S-498](#)
8. Anchor and Boxes for Air Line [S-550](#)
9. Sectionalizing Case [S-537](#)
10. Highway Crossing Signs, Signals
and Gates [S-498](#)

(b) Foundations shall be rigid, level and in proper alinement.

(c) Concrete foundations poured in the field shall stand until properly set before any apparatus is connected thereto or placed thereon.

(d) Pipe carrier foundations shall be provided with metal tops of a design approved by the Chief Engineer.

13. Concrete.

(a) Cement shall be in accordance with the Pennsylvania Railroad Specifications for Portland Cement C. E. 36.

(b) Concrete shall be in accordance with the Pennsylvania Railroad Specifications for Plain and Reinforced Concrete Structures, C.E. 77.

14. Track Circuits and Track Circuit Connections.

(a) Track circuits through interlockings, automatic block-signal systems and traffic-control territory shall be continuous where practicable. Where not practicable and the dead section exceeds thirty-five (35) feet

or the shortest outer wheel base of an engine, trap circuits in accordance with Plan S-819 shall be installed. In manual block-signal system territory, where a block signal on the leaving side of the block station is remotely controlled, track circuits shall be installed from the block station to the signal in accordance, with Plan S-827.

(b)

1. In A.C. electric traction territory, except through interlockings, where automatic cab signals are in service or contemplated, A.C. universal code shall be used for track circuits in accordance with Plans S-893, S-894 and S-897.

2. In steam territory direct current track circuits in accordance with Plans S-857 or S-894 shall be used.

(c) Bonding and insulation of switches shall be in accordance with Plan S-803.

(d) Track circuit polarities shall be arranged in accordance with Plan S-809.

(e) At highway grade crossings, where crossing protection is provided, track circuit shall be arranged in accordance with Instructions on Plan S-860.

(f) Where alternating current track circuits are used, a separate transformer secondary shall be provided for each track circuit. Where A.C. coded track circuits are used, a separate transformer shall be used for each track circuit located as close as practicable to the point of application to the track circuit involved.

(g) Where coded track circuits are used with track wires in steel taped cables or in steel or iron conduits, both wires of each track circuit must be in the same cable or conduit to avoid improper energization by induction.

(h) Both track wires for an A.C. track circuit must be in the same cable or conduit when steel taped cable or steel or iron conduit is used, to avoid excessive voltage drop.

(i) Where direct current track circuits are used, a separate battery shall be provided for each track circuit, located as near as practicable to the point of application to the track section to be supplied.

(j) The length of any track circuit, except trap circuit or special circuit not used for control of signaling facilities, shall be greater than maximum inner wheel base of any engine or car, except as otherwise authorized by the Chief Engineer.

(k) Track circuit connections and outlets shall be in accordance with Plans S-182 and S-184.

15. Insulating Rail Joints.

(a) Insulating rail joints shall be applied in accordance with Parag. 504-513, [Specifications for Standard Track, C. E. 78.](#)

(b) Insulating rail joints shall be located in accordance with Parag. 503, [Specifications for Standard Track, C.E. 78](#).

16. Bonding.

(a) Rail bonding including bonds and connectors shall be in accordance with Plans [S-179](#) and [S-180](#).

(b) Frogs and switch rails shall be bonded in accordance with Plan [S-182](#).

(c) Switches shall be bonded in accordance with Plan [S-803](#).

(d) In electric traction territory, interlocking station and equipment shall be bonded in accordance with Plan [ET-142-E](#).

(e) Rail bond clips shall be in accordance with Plan [S-178](#).

17. Impedance Bonds.

(a) Impedance bonds shall be in accordance with A.A.R. Specification 74 and Plans [S-176](#) and [S-177](#).

18. Reactors and Resistors.

(a) Reactors shall be in accordance with A.A.R. Specification 104.

(b) Resistors shall be in accordance with A.A.R. Specification 106.

(c) A reactor or resistor, or both, depending upon the requirements of each installation, shall be used for each A.C. track circuit, as indicated on the detailed circuit plan for the installation and Plan [S-816](#).

(d) Resistors, as indicated on C. E. 232, Instructions for Adjustment of Track Circuits, shall be used in all D.C. track circuits.

(e) Resistors shall be used in light circuits where necessary.

19. Transformers and Rectifiers.

(a) Line transformers shall be in accordance with current issue of specifications entitled "Specifications for Power Transformers and Reactors," C.E. 510, and shall be installed in accordance with approved plan. Dry type self cooled transformers shall be in accordance with C.E. 510.

(b) Transformer shall be of sufficient capacity for the service required and shall be suitable for the frequency and the voltage supply with which it is used.

(c) Proper size fuses or automatic overload switches shall be provided to protect secondary windings of signal power transformers. To determine the proper size fuses or automatic over-load switches, divide the volt-ampere capacity by the secondary voltage. Where fuse or automatic switch of exact capacity is not obtainable, next higher rating shall be provided.

(d) Rectifier shall be of sufficient capacity for the service required and shall be used only with the voltage and frequency for which it is suitable.

(e) Separate rectifier shall be provided for each track battery.

(f) When rectifiers without combined transformer are used to charge track batteries, each rectifier must be connected to a separate and individual transformer secondary to insulate the A.C. supply from all other circuits.

(g) Fuses of capacity prescribed by Engineer C. & S. for the location involved shall be provided in each transformer primary connection to the power line.

20. A.C. Relays.

(a) The type of alternating current relays for the various services involved shall be specified by the Chief Engineer.

(b) Contact arrangements for various types of alternating current relays are indicated on Plan S-806.

(c) The application of centrifugal relays is indicated on Plan S-816.

(d) Code transmitting relays having other than a frequency of 100 cycles and other than a cam arrangement for codes of 80, 120 and 180, shall have painted completely across two opposite glass side faces of the relay a horizontal red stripe $\frac{3}{8}$ inch wide. Relays bearing this stripe must be examined closely to assure that the code transmitting relay, with proper frequency and cam arrangement, is selected for the service required.

21. D.C. Relays.

(a) Direct current relays shall be in accordance with the requisites for Direct Current Relays, C.S.E. 41 (when reissued C.E. 241).

(b) Resistance of relays shall be as specified by the Chief Engineer.

22. Time Releases and Timing Relays.

(a) Time releases shall be of the hand-operated clock-work type, except in slow-speed territory they may be of the automatic clock-work type. Timing relays shall be of a type approved by the Chief Engineer.

(b) Time interval in each case shall be in accordance with Form C.E. 209.

(c) Time interval shall be shown on drawings and marked on or near the time releases and timing relays.

23. A.C. Power Supply and Distribution.

(a) Equipment for generating signal power shall be in accordance with plans and specifications furnished by the Chief of Motive Power, or the Manufacturer, for each installation.

(b) All A.C. power supply wires shall terminate on a positive and negative bus respectively, a separate pair of buses being provided for each source of energy. The terminations for power circuits for more than 110 volts shall be insulated or enclosed.

(c) Connections to commercial power sources shall be installed to meet the requirements of the power company and in a manner approved by the Chief Engineer. A transformer shall be provided to avoid the possibility of ground on the commercial line affecting the signal system.

(d) Signal power system shall not be grounded.

(e) Where the signal power is used for other than signal purposes a transformer shall be interposed in the circuit to avoid possibility of a ground affecting the signal system.

(f) Power line shall be of the aerial type wherever practicable, and shall be constructed in a manner approved by the Chief Engineer.

(g) Power lines consisting of a two-wire circuit, with voltage not exceeding 550 volts between conductors, with transmitted power not exceeding 3200 watts, may be located below the communication circuits, as follows:

1. Wires shall be hard drawn copper or equivalent in strength, size No. 8 A. W. G. or larger with good grade of commercial weatherproof covering. Construction otherwise shall conform to requirements for supply circuits of the same class.

2. Power circuits shall be placed on the end and adjacent pins of the lowest through signal crossarm, with 30 inch climbing space from the ground to at least two feet above the circuits, and shall be on insulators of different form or color from others, or the voltage shall be designated on each side of the crossarm by stencilling or metal characters. Other pins on the crossarm may be occupied by circuits used in the operation or control of the signal system.

3. Arresters and fuses shall be provided at the supply end of each circuit and installed on the secondary side of the supply transformer when circuit is alternating current. Arresters shall break down at approximately twice the circuit voltage but not less than 1000 volts. Fuses shall have a rating of at least 600 volts and not more than twice the maximum operating current of the circuit but not less than 10 amperes. Where a step down transformer is used for supply, the fuses shall be capable of opening the circuit if transformer primary voltage is impressed on them.

4. Where signal supply wires are located on a pole below communication conductors, transformers and other associated apparatus shall be attached only to the sides of the crossarm between and no higher than the supply wires.

5. Lateral runs carried on a pole below the communication space shall be protected through the climbing space by wood molding or equivalent covering, or be carried in cable with suitable substantial insulating covering. Such runs shall be placed on the under side of the crossarm.

(h) Open-wire transmission line operating in excess of 550 volts shall be placed not less than 4 feet above the nearest crossarm carrying signal or communication circuits.

(i) Power line in underground ducts, voltage not exceeding 660, may be installed where desirable and shall be constructed in a manner approved by the Chief Engineer.

(j) Power supply for interlocking shall be in accordance with Plan S-811.

(k) Wire and cable of the following types shall be used. for signal power lines:

1. Aerial lines of 660 volts or less shall be of single conductor or braided cable except where conditions are such as to cause rapid deterioration of braided cable lead sheath or parkway may be used with the approval of the Engineer C. & S. Aerial lines for voltages above 660, lead sheathed cables or parkway cables with lead sheath shall be used.

2. Underground lines of 660 volts or less shall be lead sheathed cables for use in duct line, or parkway with lead sheath where duct line is not provided. Underground lines of voltages above 660, lead sheathed rubber covered or varnished cambric in duct line, or lead sheathed parkway cables, rubber covered or varnished cambric, where duct line is not provided, shall be used.

3. Lines under water of any voltage shall be submarine cable, wire armor, with or without lead sheath.

NOTE: When special conditions make it necessary to depart from the above, the approval of the Chief Engineer shall be obtained.

24. Batteries.

(a) Except in electric traction territory, where power line is established, local battery of sufficient capacity shall be provided to supply energy to signal lights and other control apparatus during power outages.

(b) Batteries may be either approved nickel or lead type storage or primary type and housed in battery boxes in accordance with Drawing S-510 and S-512, or approved substitute.

(c) The system of wiring from each battery shall be kept separate from that of any other battery or source of energy as far as possible.

(d) Positive and negative wires for each instrument shall terminate on a positive and a negative bus provided for the battery or source of energy involved. One wire, connected to each end of bus, shall be run from bus to corresponding pole of battery or source of energy.

(e) Each set of batteries shall be placed so as to be free from chance of grounding.

(f) One rectifier may be used for charging control batteries at interlockings.

(g) Equipment for charging batteries shall be approved by the Chief Engineer.

(h) Energy shall be applied to the circuit at the nearest practicable point to the controlling device.

(i) Batteries shall supply current as follows:

1. Interlocking station or instrument house-to all circuits originating in or confined to the building or house and, where required, for E. P. or electric switches.

2. Home signal-to all circuits originating at or confined to the location, and between the location and interlocking building or instrument house except where supplied from building or instrument house battery; also for signal lighting during failure of normal power supply.

3. Distant or other signal-to all circuits originating at or confined to the location, and for signal lighting during failure of normal power supply.

(j) Batteries shall be provided:

1. One at each home signal location.

2. One or more in interlocking building or instrument house.

3. Where the above number of batteries is unnecessary for the amount of apparatus involved, one battery may be provided in the interlocking building, or at each home signal location, or in any combination as required.

4. At highway grade crossing protection in accordance with Sect. 44, Para. (n) and Para. (o).

(k) Batteries shall be designated in accordance with Plan S-802.

(l) A separate battery shall be provided for:

1. Each D.C. track circuit.

2. Each traffic control system line and local control.

3. Train starting or train announcing system.

(m) Ground detectors shall be installed in accordance with Plan S-810.

25. Lightning Arresters.

(a) Arresters of a type approved by the Chief Engineer shall be installed as follows:

1. Across filaments of lamps of crossing signals and gates, Plan S-860.

2. Between open construction aerial lines and ground.

3. Across the magnet leads of aerial line-controlled relays.

4. Across the magnet leads of track relays (Refer to Plan S-813).

5. Across the leads of copper-oxide track rectifiers.

6. Across the track leads of feed end of track circuit where circuit feed is taken over relay contacts, except where, in the judgment of the Chief Engineer, their use is not justified.

(b) Lightning protection for signal circuits in steam territory shall be in accordance with Plan S-813.

(c) Arresters shall be connected to ground with resistance to ground preferably not more than 15 ohms.

(d) Pin point arresters, when used, are for shunt application only.

26. Grounds and Grounding.

(a) Grounds shall be provided to protect the following apparatus:

1. Lightning arresters, high and low voltage.

2. Transformer cases, where primary voltage is above 150 volts.

3. Sectionalizing and other metal housings for transformers and associated apparatus where primary voltage is above 150 volts.

4. Steel instrument cases and houses.

5. Mechanism cases for crossing gates at locations where gate arm may accidentally contact overhead high voltage circuits.

(b) Grounds shall be installed as follows:

1. The ground element shall be a Copperweld rod at least $\frac{3}{4}$ inch by 9 feet, driven to a depth of at least 8 feet in a location as close as practicable to the apparatus protected, except where rock bottom prevents use of a driven ground a buried plate, or wire attached to a wooden pole before setting, shall be used.

2. The buried plate shall be of at least 0.06 inch copper or $\frac{1}{4}$ inch ferrous plate, with not less than 2 square feet of surface, and imbedded below permanent moisture level.

3. The wire element shall be bare copper wire not smaller than No. 6 A. W. G., having a continuous length below ground level of not less than 12 feet and shall extend to the bottom of the pole.

(c) Within buildings cold water pipes, where available, may be used as the grounding element.

(d) The maximum allowable -resistance of the ground shall, where practicable, not exceed 15 ohms.

(e) The ground lead between the apparatus or housing to be protected and the ground element, shall be copper wire not smaller than No. 6 A. W. G., and shall be connected to the ground element with approved bronze clamp designed for such purpose. The ground lead shall be installed as direct to the ground element as practicable, avoiding acute angles.

(f) Where the primary voltage exceeds 600 volts, two ground attachments are required for transformers and transformer housings except, when all parts of the equipment are above the reach of a man standing on the ground level, only one attachment will be required.

(g) In electrified territory signal masts, signal bridges, steel instrument cases and houses, and inter locking buildings shall be bonded and grounded in accordance with rail bonding and structure bonding plans and plan ET-142-E.

27. Instrument and Battery Shelters.

(a) Instrument and battery shelters shall be in accordance with the following plans:

1. Instrument Cases and Bases for
Signal Masts S-408
2. Instrument Case S-470
3. Battery Boxes S-510 & S-512
4. Instrument Cases and Platforms..... S-530 & S-108
5. Instrument Houses S-538
6. Sectionalizing Case and Foundation S-537
7. Instrument Racks S-540

(b) Primary batteries shall be located in battery boxes or similar suitable housing.

(c) Storage batteries shall be housed in battery boxes.

28. Painting.

(a) All corrodible exposed metal parts and all wooden parts exposed to the weather shall be painted.

(b) Large steel instrument houses and the metal and wooden part of concrete houses requiring paint, shall be painted in accordance with the following: Roof, black; side walls, light standard; trim, dark standard.

(c) Small steel instrument houses, instrument cases, battery housings, unit compressors and air lines, telephone boxes and supporting post or pipe shall be painted aluminum, or in electrified territory the same as used on catenary poles and transmission line supporting structures in the area.

Dwarf signals impedance bonds, switch valves, switch and lock 'movements, mechanical pipe line,

Parkway outlets (where painted), shall be painted black.

Note: Refer also to 28(e).

(d) In other than electrified territory, instrument cases and small instrument houses, battery housings, unit compressor cases and air line, telephone boxes and supporting post or pipe, shall be painted aluminum, except black shall be used at locations where aluminum would become soiled and discolored from steam and Diesel locomotive exhausts.

Dwarf signals, switch valves, switch and lock movements, mechanical pipe line, Parkway outlets (where painted), signal supporting structures such as bridges, masts, etc., shall be painted black. Note: Refer also to 28(e).

(e) The backs of position light dwarf signals, valve cases, and similar objects between or adjacent to tracks, may be painted with aluminum paint if contact with such objects may endanger employes whose duties require them to be on or about these tracks, or where greater visibility at night is desired.

(f) Position light high signals including both faces of backgrounds, units, pipes., combined terminal box and lamp support shall be painted with dark oxide primer and finished with dull black. Mast and ladders shall be painted in accordance with plan S-400.

(g) Position light dwarf signals shall be painted dull black on the inside, front face and hoods.

(h) Instrument cases shall be painted with aluminum paint inside.

(i) Highway crossing signs, signals and gates shall be painted in accordance with Plans S-462 and S-463. Masts shall be painted aluminum except where local or state law requires otherwise.

(j) No-Ox-Id or other approved compound shall be applied as follows:

1. To metal parts that cannot be painted before assembling.

2. To bottom of metal cases, housings, signals, etc.

3. All foundation bolt holes to be filled with a liberal amount and covered with large flat washer.

(k) Cases of interlocking machines shall be painted olive green.

(l) Unfinished parts of levers of interlocking machines shall be painted black, except where lever manipulation will be facilitated, in which case the signal and smashboard levers shall be painted yellow, facing point lock levers blue, switch levers black, traffic and master levers red, spare levers white.

(m) The derailing block of sliding derails shall be painted yellow where non-interlocked and black where interlocked; other parts shall be painted black.

(n) Paint and application to iron and steel shall be in accordance with Specification C.E. 31.

29. Conduits.

(a) Metallic conduit shall be in accordance with Spec. A53 of the A.S.T.M. for steel pipe and Spec. A72 of the A.S.T.M. for W. I. pipe. Coating, if required, shall be in accordance with A.A.R., Signal Section, Spec. Manual Part 63.

(b) Fibre conduit shall be in accordance with Specifications for Fibre Conduit, GST-602.

(c) Vitrified clay duct shall be in accordance with Specifications for Vitrified Clay Conduit, GST-601.

(d) Fibre, vitrified clay and other ducts of approved fire resisting material shall be installed in accordance with C.E. 502 and Specifications for joint Underground Conduit Construction, for communication and signal service, GST-2008, and Underground Conduit Construction, A.A.R. T. & T. Section, Spec. 1C1.

(e) Before installing wire or cable in a duct, a mandrel of proper cross-section should be drawn through the duct to insure clearance and free interior of duct from obstruction.

30. Wires and Cables.

(a) Wire and cable of the following types shall be used in signals and interlocking plants.

1. Line wire shall be bare or weatherproof copper or copperweld of a size not smaller than No. 10 A.W.G.

2. Aerial switch, signal and all other circuits, except power line, may be in braided cable. Single conductor should only be used where impracticable to use cable.

Where conditions are such as to cause rapid deterioration of braided cable, lead sheath or Parkway should be used with the approval of the Engineer C. & S.

3. Underground switch, signal and all other circuits, except power line, shall be cable with lead sheath, or Spec. C.E. 210 asbestos braid, placed in duct line, or parkway cable with lead sheath or equivalent where duct fine is not provided.

4. Underwater switch, signal and all other circuits, except power line, shall be in submarine cable, wire armor, with or without lead sheath.

Where special conditions make it necessary to depart from the above, the approval of the Chief Engineer shall be obtained.

(b) Wires for various purposes shall be in accordance with Specification for Electric Wire and Cable 112, Spec. CE-210, or approved A.A.R. Specifications.

(c) Wire or cable not meeting the specification, for class of service intended, must not be installed.

(d) Aerial signal wires shall be arranged on pole lines in accordance with the following:

1. Wires and cables of less than 150 volts shall preferably be placed below communications circuits and on crossarms used exclusively for signal circuits except, where this is impracticable, they may be placed on the lowest communication crossarm.

2. Line wires may be located adjacent to any other wire except:

The circuits specified below, not having separate return wires, shall not be located adjacent to any wire which, due to a cross, might falsely energize apparatus controlled by such circuits, but may be located adjacent to the common return wire—

- (a) Approach relay wires (P, Q or AR)
- (b) Signal and electric switch lock indication wires (K, L or M)
- (c) Dragging equipment detector wires (DTM or DEDPR)

(e) Bare line wire may be used for signal circuits which have been arranged for individual returns, other wise wires must have weatherproof insulation.

(f) Wire for use under tension must not be heated or soldered.

(g) Line wire must be properly secured to insulator (one wire on each insulator) and tied in so as not to injure the wire or the insulation.

(h) Line wires must be kept free from contact with guy wires, trees or structures.

(i) Wire and cable shall be tested for continuity and megger tested to ground and between conductors before being placed in service. Tests on Parkway cables should be made after they are placed in the trench before and after back-filling.

(j) Wires outside home signal limits shall be open wire construction on pole lines in aerial cable, in park way cable underground, or in conduit underground. Parkway cables include cables with Neoprene or equivalent sheath, or cable approved by the Chief Engineer for underground construction.

(k) Where pole line construction is available the main wire run shall preferably be in aerial cable: other wise it shall be lead covered cable in underground duct line, or parkway cable, or in a manner approved by the Chief Engineer.

(l) Wires shall be without splices as far as practicable.

(m) Splices may be made in manholes, junction boxes or in aerial cable, in accordance with C.E. 525.

(n) Splices underground are prohibited where avoidable. Where unavoidable, as in Parkway cable, a protector or splice box in accordance with C.E. 525, or other approved type, shall be used and filled with an approved insulating compound.

(o) Half-splices are prohibited at any point for permanent construction. Branch wire connections shall be made in terminal boxes on terminal posts.

(p) Wires or cables entering interlocking buildings, instrument houses or instrument cases shall be connected to terminals or terminal rack. Cables shall be terminated in conductor order with conductor No. 1 (core wire) at top or left end of cable termination.

(q) Parkway cables, and other cables constructed for underground service without conduit, may be used and, except for track connections to rails, should be imbedded in loam, sand or clay and protected by cover board when buried less than 2 feet 6 inches except when otherwise specified by the Chief Engineer.

(r) Track circuit wires, also fouling and shunt wires where insulation is required, shall be single conductor, non-metallic parkway.

(s) Underground wire line construction across tracks and parallel to tracks within ballast border limits shall be located not less than 2 feet 6 inches below the bottom of ties, vertical clearance. Outside ballast border limits underground wire line shall, where practicable, be located 2 feet 6 inches below surface of ground.

(t) Underground wire line construction, other than duct line, shall be indicated by cable markers, Plan S-546.

(u) Wire runs through tunnels should be avoided where possible. Where unavoidable they shall be in lead covered cable attached to the side wall in underground duct line or in Parkway cable.

(v) Cables attached to side structures must be supported by messenger or installed in conduit.

(w) Before installing wire or cable in a duct a mandrel of proper cross-section should be drawn through the duct to insure clearance and free the interior of duct from obstruction.

(x) Separate wires or cables that are to go into the same duct space should be pulled in at the same time. For small-gauge single-conductor wires it is preferable to hitch to the copper conductors and arrange the hitch so that the pulling strain will equalize on all the wires in the pull. The "basket weave" hitch, which grips the outside of a cable, should be used when pulling in a multiple-conductor cable. Lubrication, where required, shall preferably be suds made with mild soap. Oil or grease may be used for lead-covered, and pumice for braid-covered, cables.

(y) Braided cables, or a number of single-conductor wires, shall be pulled into conduit by hand in order to avoid straining conductors in the event they become "caught."

(z) Due to extreme deterioration caused in cable coverings in steam territory, protective casings of tran-

site or equal should be clamped over aerial cables where engine exhaust strikes the cables.

(aa) Wires entering interlocking buildings and instrument houses shall be in parkway, lead or asbestos taped cables or in fireproof conduits, to a point as close as practicable to point of termination. Parkway cables exposed inside the building or house shall be uncovered to the lead sheath or metal tape, cleaned, and metal tape painted. In electrified territory, Parkway and lead sheathed cables entering a building or instrument case shall be insulated to prevent outside currents from reaching metal parts of the building or case. The metal sheaths inside the building shall be bonded together and to the building ground wire; outside the building or instrument case shall be bonded together.

(ab) The following minimum radii for cable shall be used:

(1) Without metallic covering—8 cable diameters

(2) With metallic covering—12 cable diameters.

(ac) Exposed ends of metal covered cable must be sealed when not in service or in storage.

(ad) Insulated wires or cables used aerially must be properly supported by, and fastened to, a messenger or insulator. They should enter housings and poles through bushings or specially-formed entrances.

(ae) Aerial wires or cables entering housing should be formed with a weather drip to prevent water follow in- the wire or cable into the housing and shall be secured to prevent movement of drip.

(af) At the point where cable leaves the messenger or termination on the pole, or for re-running as a drop, for carrying the circuits to instrument housing, it shall be adequately secured and protected by cable clamps or serving with marline to prevent abrasion due to creepage or wind sway.

(ag) Where it is impracticable to bring the cable into the instrument housing the aerial cable shall be terminated at the pole and the connecting conductor run in Parkway cable from termination to housing. Parkway cable down the pole shall be secured by proper side cable cleats and the cable so run as not to interfere with the climbing of the pole.

(ah) In forming eyes or applying terminals to ends of wires the wire must not be nicked or twisted.

(ai) In removing insulation from wire, do not cut with knife at a right-angle to the wire because a very slight nick may cause the wire to break at that point when subject to strains and vibrations. Approved wire strippers may be used.

(aj) Wires on signal bridges shall be in parkway cable, and if metal covered cable is used, the jute shall

be removed and metal covering painted. Cable shall be installed on signal bridges in accordance with approved plans.

(ak) As individual feed wire and an individual return wire shall be installed as required from the nearest terminal location to each unit controlled, to avoid making connections for branch circuits on terminal posts of relays, switch or signal mechanisms, or in circuit controllers.

(al) When A.C. circuits, or circuits carrying coded current, are placed in cables with steel tape, or in steel or iron conduit, both the outgoing and return wires of the circuits must be in the same cable or conduit to avoid inductive effects and excessive voltage drop.

(am) Wires leading to devices mounted on ties, or other points where excessive vibration is prevalent, shall be flexible. The flexible wires shall be terminated with and connected to solid wire in approved terminal box located outside ties, or at a point free from vibration, adjacent to the device. Where terminals are not provided, soldered or compression sleeve shall be used. The terminals provided with CP type valves may be used to meet above requirements. The flexible wire shall be enclosed in an approved flexible conduit with fittings suitable for attaching conduit to device and terminal box.

(an) Wiring inside of interlocking building between terminal boards, instrument rack and interlocking machine, and between spring combination, push buttons and indication lights shall be No. 16 copper wire having approved fire resisting insulation. Wires from terminal blocks on machine to latch contacts and to and between magnets shall be No. 16 flexible copper wire having approved fire resisting insulation.

(ao) An individual battery and common wire, of sufficient capacity, shall be run from the source of battery to each end of the battery and common bits on the interlocking machine. On miniature lever (C.T.C.) machines an individual battery wire shall be run to each end of the battery loop for the starting buttons.

(ap) Wire or cable should be stored under cover where it will not become mildewed or liable to be damaged by other materials, and must be kept away from excessive heat. Coils of braided wire or cable must not be stored on edge.

(aq) Wire or cable showing any evidence of injury must not be used without proper authority.

(ar) Care must be exercised in shipping, handling, laying or pulling in, splicing and housing of wire and cable.

(as) Wire or cable in coils should be shipped properly bound and wrapped with a protective covering of burlap or other suitable wrapping material. Tags giving a description of contents should be firmly attached to the coils, both inside and outside of wrapping.

(at) Wire or cable on reels should be shipped with all lagging or other protective covering properly in-place. Care must be taken in nailing lagging on the reels so as not to puncture the insulation. Nails must not be used in securing tags to reels.

(au) Wire or cable must not be removed from reels or coils until ready to install. All nails must be removed from the edges of reels.

(av) Reels must be set up so they will revolve easily and the wire or cable will pay off from the top.

(aw) When wire is used from a coil, a pay-out reel should be used. The reel should be attended to prevent excessive slack from running out. If necessary to pay out by hand, the reversing of the coil every four or five turns will tend to prevent twisting.

(ax) Precaution must be taken to prevent the kinking or twisting of wire. Should any kink or twist unavoidably occur do not attempt to pull or throw out the kink or twist but carefully remove it by hand.
Rev. 5-13-54

(ay) Insulation must not be injured or bruised by dropping, or stepping, throwing tools or material on wire.

(az) Insulation must be kept free from oils, grease, acids and alkalis.

(ba) Wire or cable must not be pulled over rough surfaces or through hot cinders.

31. Wire Terminals.

(a) Terminal blocks shall be in accordance with Plan [S-513](#).

(b) Eyelets shall be in accordance with Plan [S-528](#).

(c) Terminal blocks shall be neatly arranged in an accessible position in housings and located so that relays or apparatus supported by shelving or bottom of housing and free to move on a horizontal plane cannot move to point of contact with any part of terminal block.

(d) Eyelets shall be used on all flexible wire where connected to terminals.

(e) Approved terminal connectors shall be used on all flexible wire where connected to other wires.

32. Tagging of Wires.

(a) Each wire shall be identified by a tag securely fastened and located at or near the point of wire termination.

(b) Nomenclature of tag or wire identification shall correspond to that of the circuit plan.

(c) Tags or other marks of identification shall be made of insulating material.

(d) Wire and tag shall be so placed that they will not interfere with moving parts of apparatus.

(e) Tags shall be in accordance with Plan [S-528](#).

33. Model Boards.

(a) Track diagram shall be in white lines on a black background, each line representing a track, siding or other connection, and its width shall be determined by the size of the layout and by the distance to the point

from which the Model Board must be observed. In electrified territory, electrified tracks shall be shown continuous and non-electrified tracks shall be indicated by broken lines.

(b) The limits of track circuits shall be indicated by short breaks in the white line representing the track.

(c) Lever number shall be shown for each switch, signal or other function controlled.

(d) Indication lights, normally out, shall be arranged as follows:

1. Green shall indicate signals in a proceed position. Amber shall indicate track circuits occupied. Two lights for each signal or track circuit is recommended for terminals and for dense traffic territory. At other locations one is sufficient.

2. Blue where directional traffic control is used. Traffic direction shall be indicated by arrows with light to indicate direction traffic is in effect.

3. Red in electric traction territory shall be used to indicate de-energized trolley.

4. White shall indicate other functions such as low air pressure, power off, and dragging equipment detector actuated, etc.

34. Bolts, Screws and Washers.

(a) Bolts, tap bolts, set screws and machine screws shall have American standard screw threads.

(b) Nuts, bolt heads and tap bolt heads, etc., used in connection with interlocking machines shall be hexagonal; others may be square.

(c) Lag screws shall be galvanized, with gimlet points and square heads.

(d) Lag screws shall be turned (not driven) their entire length into holes previously filled with oil. These holes shall be bored small enough to provide full thread.

(e) Washers shall be used under bolt heads, nuts and heads of lag screws where they come in contact with wood. Where bolt heads are underneath ties, washers of the type shown on Plan S-216 shall be used.

(f) Where bolt heads are to be underneath ties or in other similar inaccessible places, a stud bolt with a square nut on the inaccessible end may be used.

(g) Lock washers shall be used under bolt heads and nuts, where contact is made with metal.

(h) Holes drilled in ties for bolts should be one sixteenth (1/16) inch larger than diameter of bolt.

35. Cranks.

(a) Horizontal cranks shall be in accordance with Plans S-100 and S-101.

(b) Vertical cranks shall be in accordance with Plan S-107.

(c) Crank arms for main pipe runs shall be drilled eleven and three-fourths by eleven and three-fourths ($11\frac{3}{4} \times 11\frac{3}{4}$) inch centers.

(d) Compensators shall be in accordance with Plan S-112.

36. Air Supply and Distribution Systems.

(a) Compressed air may be obtained from an available, continuous air supply system which supplies air for other railroad services. Where such supply is not available, automatically controlled motor driven compressor units of sufficient capacity shall be installed.

(b) Compressor units shall be located preferably at the end or ends of the single main air line. Where double main air lines are provided, they shall be located at the most convenient point.

(c) The normal air pressure, when air is supplied by compressor units, shall be maintained between fifty five (55) pounds per square inch minimum and seventy five (75) pounds per square inch maximum, unless otherwise authorized by the Engineer C. & S.

(d) Where the normal air pressure exceeds seventy five (75) pounds per square inch, provision shall be made to reduce the pressure of the air delivered to the switches, as follows:

1. By using a reducing valve in the air supply line.
2. Where reducing valve is not practicable:
 - (a) Where Style "CP" valves are used, by using a restricting washer in the union between valves and cylinder.
 - (b) Where Style "C" valves are used, by restricting the valve exhaust port with a one half inch pipe plug having a one-eighth inch hole through it.

(e) Air gauge shall be provided in a location where it can readily be observed by operator.

(f) A recording air gauge may be provided.

(g) Low air alarm and signal circuit arrangement in accordance with Plan S-862 shall be provided unless otherwise authorized by the Engineer C. & S.

(h) Atmospheric after-coolers, in accordance with Plan S-555, shall be provided where individual compressor capacity greater than 10 C.F.M. (piston displacement) is installed.

(i) Storage reservoir of sufficient capacity, mounted on a suitable foundation, and so connected to circulate the air before use, shall be installed. Facilities shall be provided for draining or blowing off condensation. Installation shall be made in accordance with Plan S-554.

(j) Suitable by-passes shall be provided around the reservoir and after-cooler.

(k) A two-inch main air line shall be installed above ground on one side of the tracks. At terminals and large interlockings in dense-traffic territory a main air line may be provided on each side of the tracks when authorized by the Chief Engineer, the two lines to be connected by two-inch cross-connecting pipes at intervals of not more than four hundred feet.

(l) Pipe larger than two-inch, for main air line, may be used when authorized by the Chief Engineer.

(m) Cross connections shall be not less than two feet six inches below the bottom of the ties.

(n) Branch connections to switches shall be either two-inch or three-quarter inch pipe, connected at the top of the main air line with a street ell and a horizontal nipple not less than six inches long, to compensate the movement of the main line due to temperature changes.

(o) Not more than two cylinders shall be supplied by one three-quarter ($\frac{3}{4}$) inch connection.

(p) Pipe shall be standard black copper-bearing steel where located above ground on pipe foundations. Where underground, pipe shall be extra strong galvanized wrought iron with approved protective coating applied.

(q) Main air line shall be supported on foundations in accordance with Plan S-114 or other approved type. Foundations shall be spaced not more than ten feet apart.

(r) Expansion joints, in accordance with Plan S-130, shall be installed in main air line at intervals of not more than five hundred feet.

(s) Pipe anchors in accordance with Plan S-550, shall be installed midway between each pair of expansion joints, at end of line, and where main pipe line goes underground.

(t) An auxiliary reservoir, provided with a blow off cock, shall be located at each low point in the main air line.

(u) Where necessary, a drip feed for alcohol, in accordance with Plan S-555, shall be provided.

(v) Gate valves shall be screw type with double brass seat. A gate valve shall be placed in main air line each side of auxiliary reservoir, in the branch or cross connection at the same location, and at other locations where necessary.

(w) Gate valve and stop cock handles, unless secured, shall be removed and kept available in a convenient place for use only by authorized persons.

(x) Stop cocks, unions, and combination cocks and unions, shall have brass seats, ground joints.

(y) Elbows, tees, and other fittings shall be of extra heavy malleable iron.

(z) A flange union, in accordance with Plan S-130, shall be placed between each gate valve and reservoir in the main, branch or cross-connecting air lines at each auxiliary reservoir, and at other points as may be necessary.

(aa) Connections for emergency air supply shall be provided at suitable locations. Construction shall be made to meet local conditions.

(ab) Check valve shall be provided in each air supply connection to the main air line.

(ac) Leakage in air distribution system shall not exceed one pound in one minute, from normal pressure with all apparatus connected and at rest.

(ad) An insulated union shall be installed in the air line as it enters the switch valve pipe assembly; also provide insulation at the valve end of the flexible duct similar to the bushing and connection, (US&S Ref. 49,

Pl. C-3871.) Make sure that armored switch hose, from cylinder to valve, cannot be grounded on both the valve and switch movement frames. Where concrete or other types of valve foundations are used, the flexible duct should be insulated from all parts of the valve frame.

37. Machines, Interlocking-

(a) Route, Miniature Lever (C.T.C.) or other similar type interlocking machines shall be of a type approved by the Chief Engineer. Insofar as applicable, the method of installation shall adhere to Standards, Requisites, and Specifications prescribed herein.

NOTE: The above includes machines for controlling all-relay interlockings.

(b) Power interlocking machines shall be of an approved type and shall be in accordance with A.A.R. Signal Section Specification 76 unless otherwise specified. Levers, mechanical locking and spring combination shall be arranged as required by layout plan and circuit plan furnished by the Chief Engineer, which plans will indicate the data required for the blanks in the A.A.R. Specification above mentioned.

(c) Mechanical locking for power interlocking machines to be as follows:

1. Longitudinal locking bars shall be limited to 12-foot lengths., maximum, splicing two or more lengths if necessary. Splices must be straight with bolts, nuts and cotter pins in place. Where no locking is required in brackets, sufficient blank crossbars shall be provided to insure longitudinal bars retaining proper position.

2. Driving pieces, dogs, stops and trunnions shall be rigidly secured to locking bars with rivets.

(Temporarily, where conditions require, the dogs, stops and trunnions may be secured with machine screws which must be replaced with rivets as promptly as circumstances permit).

3. Swing dogs shall have full and free movement. They shall be secured on the trunnion by slight riveting on top edge of trunnion by center punching.

4. Top plates shall be maintained securely in place.

5. The various parts of locking bed, locking bed supports, and tappet stop rail shall be rigidly secured in place and alined to permit free operation of locking.

6. Locking faces shall fit squarely against each other with a minimum engagement when locked of at least one-half the designed locking face.

(d) Lever requirements for power interlocking machines:

1. Where manual block signals are controlled by levers in the machine, one signal lever shall be used for each signal and shall be equipped with a three position device. Where the top arm of a home interlocking signal is a manual block signal, one lever shall be used for its control and a second lever shall be used for the

control of all other signals that otherwise would be controlled by that one lever.

2. One switch lever shall be used for operating a single twitch, derail, switch and derail, crossover or slip crossover with or without movable point frogs.

3. Spare levers, where specified, shall be furnished in place complete ready for operation and control of interlocking units.

4. Levers shall be equipped with normally lighted lever lights, with green cover glass, two for each signal lever and one for each switch lever, unless- otherwise specified.

Levers of traffic. control type machines should be equipped with normally lighted lever lights, colors to be as follows:

Switch normal	Green
Switch reverse	Amber
Switch locked-direct wire installations.	Red
Signal normal	Red
Electric lock locked	Green
Electric lock unlocked	Amber

5. A mechanical stick push button with two contacts shall be provided on each signal lever as required on the detailed circuit plan. These contacts shall be restored by the lever after it has passed the indicating point going normal.

(e) Electro-Mechanical interlocking machines shall be in accordance with A.A.R. Signal Section Specification 134. Levers, mechanical locking and spring, combination shall be arranged as required by layout plan and circuit plan furnished by the Chief Engineer, which plans will indicate the data required for the blanks in the A.A.R. Specification above mentioned. .Circuit controllers, lock magnets and other vital parts shall be enclosed in a metal case which shall be arranged for standard locks.

Unit electric levers may be added to an existing mechanical machine for the operation of additional functions where sufficient mechanical levers are not available. Levers for operation of switches may be obtained by substituting power operated signals operated by a unit electric lever for existing mechanical signals.

Machine shall be ser with lever side toward the front (track side) of the building and shall be supported on I beams built into the ends of -the building.

(f) Lever requirements for electro-mechanical interlocking machines.

1. One mechanical lever shall be used for a single switch. Not less than two adjacent mechanical levers shall be used for operating a cross-over or a switch and derail, the four points of double slip switch being considered as one switch. Two adjacent mechanical levers may be used for operating a movable point frog. All adjacent mechanical levers operating a crossover, a

single switch and derail or a movable point frog shall be controlled by one electric lever.

2. One electric signal lever may be used for one or more signals.

3. Where a manual block signal is controlled by a lever in the interlocking machine, an electric lever equipped with a three-position device shall be used for such signal. Where the top arm of a home interlocking signal is a manual block signal, one electric lever shall be used for its control and a second electric lever used for the control of all other signals that otherwise would be controlled by the first lever.

4. Electric levers shall be equipped with normally lighted lever lights, with green cover glass, two for each signal and one for each switch, unless otherwise specified.

(g) Mechanical locking for electro-mechanical interlocking machines to be as follows:

1. Driving pieces, dogs, stops and trunnions shall be rigidly secured to locking bars with rivets. (Temporarily, where conditions require, the dogs, stops and trunnions may be secured with machine screws and doweled. Screws must be replaced with rivets as promptly as circumstances permit).

2. Swing dogs shall have full and free movement. They shall be secured on the trunnion by cotter pin through top of trunnion. Where two swing dogs are applied to the same trunnion and it is impractical to secure the swing dogs by a cotter pin, trunnion must be slightly riveted on the top edge of trunnion by center punching.

3. Top plates shall be maintained securely in place.

4. The various parts of locking bed, locking bed supports, and tappet stop rail shall be rigidly secured in place and alined to permit free operation of locking.

5. Locking faces shall fit squarely against each other with a minimum engagement when locked of at least one-half the designed locking face.

(h) Segments for electric locks shall be in accordance with Plan [S-824](#).

38. Interlockings-Method of Installation.

(a) Power, Route and All-Relay interlockings shall adhere, insofar as applicable, to the Standards, Requisites and Specifications prescribed herein.

(b) Electro-Mechanical interlockings insofar as extensive changes and additions are concerned:

1. Leadout and Ground Work.

(a) Leadout foundation shall be in accordance with Plan [S-167](#).

(b) Leadout shall be rocking shaft wherever pipe line is on the same side of the track as the building, provided cross-section of roadbed, etc., will permit. Where impossible to use rocking-shaft leadout, vertical cranks and horizontal deflecting bars or horizontal cranks shall be used.

(c) Down rods shall be in accordance with Plan S-150.

(d) Down rods shall be vertical with screw jaw at top.

2. Rocking Shafts.

(a) Rocking shafts and fittings shall be in accordance with Plans S-153 and S-154.

(b) Rocking shafts shall be supported by a bearing at each end and not more than six (6) feet of shaft shall be unsupported, intermediate bearings being used where necessary.

(c) Rocking shaft bearings shall be securely bolted to foundations with four three-fourth ($\frac{3}{4}$) inch bolts.

3. Deflecting Bars.

(a) Horizontal deflecting bars shall be in accordance with Plan S-160.

4. Compensators.

(a) Compensators shall be in accordance with Plan S-112.

(b) Compensation shall be installed in pipe lines in accordance with C.S.E. 30.

5. Pipe and Pipe Lines.

(a) One inch copper bearing steel pipe with couplings, plugs and rivets shall conform to A.A.R. Spec. 122.

(b) One inch copper bearing pipe shall be used for connections to switches, derails, movable point frogs, locks and bridge couplers.

(c) Where solid connections are required one and eleven thirty-seconds ($1\frac{11}{32}$) inch round iron shall be used, unless otherwise specified.

(d) Main pipe lines shall be in alinement and, where practicable, with nearest pipe not less than four (4) feet six (6) inches ($4'6''$) from gauge.

(e) Where practicable, pipes in main pipe line shall be installed so that they will lead off on track side in regular order.

(f) Top of pipe carrier foundations in main pipe line shall be level with the base of rail where conditions will permit.

(g) Cranks and compensators in main line shall be so located as to leave field side clear for additional pipe lines.

(h) Pipe lines shall be laid two and three fourths ($2\frac{3}{4}$) inch centers and shall be supported on pipe carriers placed not more than eight (6) feet centers on tangents and on curves 4 less than two (2) degrees. On curves of two (2) degrees or more, they shall be placed seven (7) feet centers.

(i) With the lever in the center -position of stroke, the couplings in pipe shall be located not less than twelve (12) inches from pipe carriers.

(j) Main pipe line shall leave the building parallel to the tracks where practicable and, where necessary to carry pipe lines across the tracks, not more than two (2) pipes shall occupy one inter-tie space so

arranged as to permit standard spacing and proper tamping of ties. If not practicable to avoid crossing tracks at the cabin with the main pipe line, special construction approved by the Chief Engineer shall be used.

(k) Turns in pipe lines shall be made with cranks or radial arms in preference to deflecting bars.

(l) Offsets in pipe lines shall be made in body of jaws or in an iron rod one and eleven thirty seconds (1-11/32) inch in diameter. The total offset between any two supports shall not exceed three and one-half (3½) inches; minimum distance between ends of offset shall not be less than twice the amount of the offset. Offsets in cranks and radial arms should be avoided as far as practicable.

(m) Main pipe lines of more than ten (10) pipes shall be supported on two (2) pipe carrier foundations.

(n) In electric traction territory pipe line insulation located as closely as practicable to the main pipe line shall be used in each connection crossing the tracks. Pipe line insulations shall be in accordance with Plan S-124.

(o) Pipe lines shall be compensated in accordance with C.S.E. 30.

6. Pipe Carriers.

(a) Pipe carriers shall be in accordance with Plans S-138, S-139 and S-140.

(b) Pipes leading under track rails shall be supported by transverse pipe carriers in accordance with Plan S-140.

(c) Pipe carriers shall be fastened to foundation tops with two (2) one-half (½) inch bolts.

(d) Transverse pipe carrier supports shall be fastened to ties with two (2) three-quarters by four (¾ x 4) inch lag screws.

(e) Pipe carrier foundations shall be in accordance with Plan S-115 with tops of an approved type.

7. Stuffing Boxes.

(a) Stuffing boxes for one inch pipe line shall be in accordance with Plan S-125.

(b) Pipes installed underground shall either be made up of eight (8) foot lengths, with standard sleeves, or roller guides, or carriers, located at about eight (8) foot intervals, and, encased in two (2) inch galvanized iron pipe, filled with an approved non-freezing, oil and provided at each end with a stuffing box.

8. Jaws and Lugs.

(a) Jaws and lugs shall be in accordance with Plans S-118 and S-121.

(b) One screw jaw shall be placed in each operating connection of each bridge lock and coupler and one on each side of each coupler for all through connections, located in each case at the unit to be adjusted. Pipe adjusting screw shall be in accordance with Plan S-122. A screw jar should be placed in F.P.L. line at the point where plunger enters lock, in order to adjust.

39. Traffic Control Systems—Method of Installation.

(a) Standards, Requisites and Specifications prescribed herein, shall be adhered to so far as applicable.

40. Automatic Train-Stop, Train-Control, and Cab Signal Systems—Method of Installation.

(a) Standards, Requisites and Specifications prescribed herein, shall be adhered to so far as applicable.

41. Dragging Equipment Detectors.

(a) Dragging equipment detectors shall be installed in accordance with Plans [S-241](#) and [S-879](#).

(b) Location of detectors in the vicinity of switches, station platforms and road or other crossings in the track shall be avoided where possible. Detectors shall not be installed on curves.

(c) Audible and visual indicators in cabin shall be located as nearly in front of operator as practicable. Where conditions require, visual indicators may be located in telephone box near signals involved.

(d) Snow and ice deflectors to be installed where required.

42. Slide Protection Fences, Code Change Points, Torpedo Placing Machines, and Other Similar Protective Devices and Systems—Method of Installation.

(a) Standards, Requisites and Specifications prescribed herein shall be adhered to so far as applicable.

43. Movable Bridges—Method of Installation.

(a) Where movable bridge is not part of an interlocking, Standards, Requisites and Specifications otherwise applicable to interlocking shall be adhered to.

(b) Interlocking machine shall be used for controlling signals, derails, smashboards, rail locks, couplers, or other devices, with necessary indications to indicate that all movements have properly been completed.

(c) Smashboards, as shown on Plan [S-380](#), shall be used in conjunction with high signals except where derails are required by governmental or other authorities.

(d) Signal devices shall be interlocked with bridge devices so that no bridge device can be operated unless all signal devices have properly functioned to release the bridge. The following sequence shall be followed to unlock the bridge:

1. Home signals in stop position.
2. Open trolley couplers.
3. Smashboards at stop or derails in derailing position.
4. Rail and bridge locks in unlocked position; electric or pipe couplers open.
5. Bridge operating mechanism released.

NOTE: Above sequence of operation shall be reversed to lock the bridge.

(e) Locking for movable bridges shall be in accordance with the following plans:

1. Center pivot bridges (rail 130# or less) S-371
2. Center pivot bridges (rail 131# or heavier) S-372
3. Lift bridges S-375

(f) Mechanical locking, to insure predetermined order of lever movements, or circuits to insure proper correlation of the units of the movable bridge shall be provided.

(g) Electric or mechanical control shall be provided to lock the wedge and bridge engine clutches, or the electric power application for wedge and bridge operation, in proper sequence.

(h) Rail locks, electric couplers and pipe couplers shall be operated by electric, pneumatic or mechanical mechanisms.

(i) A circuit controller connected to and operated by each bridge surfacing wedge or bridge lock, lift rail, rail lock, latch, electric bridge coupler, trolley carrier, and dead-weight roller when provided, shall indicate each position of the device to which controller is connected.

(j) Insulation shall be provided in pipe lines and connections, where necessary, to prevent grounding or shunting of track circuits.

44. Highway Grade Crossing Protection.

(a) Automatic Highway Grade Crossing Protection shall be signals of the flashing light type or Automatic Gates with flashing light signals.

(b) Installations shall comply with regulations or other authorities.

(c) Signals shall be installed to the right of the highway on the approach to the tracks, one signal on each side of the tracks, unless otherwise required by proper State or other authorities.

(d) Cantilever supports shall only be used where required.

(e) “No-Turn” signs, illuminated only when crossing protection indicates the approach of a train, may be used on highways adjacent to, and approximately paralleling the tracks, which intersect or join another highway that crosses the railroad, to supplement the highway grade crossing protection which is located at the crossing. Each sign shall be supplemented by a flashing yellow marker light located above the sign displaying “No Right Turn” or “No Left Turn”, and operating in synchronism with the grade crossing signals.

(f) Automatic Gates shall be located in accordance with Plan S-462. Where local conditions require they may be mounted on separate posts adjacent to the crossing signals.

(g) Time of operation of signals or gates and controlling circuits shall be as specified on Plan S-860.

(h) Each highway gate arm shall be equipped with not less than three red lamps arranged to shine in both

directions along the highway. Lights shall operate at all times when the gate is in position to obstruct highway traffic. The light nearest the tip end of the arm shall burn steadily and the other lights shall flash alternately and in unison with the lights on the signals.

(i) The bottom of highway arms, when in the horizontal position, shall be as indicated on Plan S-462.

(j) Gate arms for sidewalk protection shall be provided, when required, on either the highway gate arm post or a separate post adjacent to sidewalk, and each arm shall be equipped with one red lamp arranged to shine in both directions along the side walk.

(k) Gate arms shall be painted on both sides with alternate diagonal stripes of white and black, in accordance with A.A.R.-Signal Section-Dwgs. 1491 and 1492.

(l) Bell, where required, shall be mounted on the top of the mast supporting the crossing, signal, with the face of the gong parallel to the highway, and shall sound a warning from the time the signal lights start to operate and shall continue at least until the gate arm has descended to within ten degrees of the horizontal position. Bells shall be inoperative when gates are raising.

(m) Highway Grade Crossing Protection shall be in accordance with the following plans:

- 1 Automatic Highway
Crossing Gates-Layout S-462, Sh. 1
2. Automatic Crossing Gate &
Signal Assemblage S-462, Sh. 2
3. Signal—Highway Crossing S-463
4. Signs—“No Right Turn” &
”No Left Turn” S-469
5. Foundations—Precast Concrete S-498
6. Circuits for Auto. Highway Crossing
Signals & Gates S-860
7. Manual Gates—Circuits for
Lighting Lamps S-866
8. Lamps, Incandescent Electric S-483
9. Cantilever Supports
A.A.R.—Sig. Sect.—Dwgs. 1686 and 1688

(n) Storage batteries, where provided, shall have capacity as follows where batteries are housed so that the temperature within the housing does not fall below 20 degrees Fahr.:

1. Where Automatic Gates are provided—240 Amp. Hours.
2. Where Flashing Light Signals only are provided:
 - (a) Where lamp 4832, 25E-4211, is used:
 - 8 lights or less 120 Amp. Hours
 - 9 to 12 lights 160 Amp. Hours
 - 13 to 18 lights 240 Amp. Hours

(b) Where 10 volt, 18 watt precision lamp 25E-12293 is used:

8 lights or less 160 Amp. Hours

9 to 12 lights 240 Amp. Hours

Where more than 12 lights are required, or for other reasons the 240 Amp. Hour battery is not of sufficient capacity, the matter shall be referred to the Chief Engineer.

(o) Primary Batteries, where provided, shall be as follows:

Where lamp 4832, 25E-4211 is used:

8 lights or less20 cells HA-1000

Over 8 lights22 cells HA-1302

45. Heaters for frost prevention in switch mechanism circuit controllers, battery boxes, electric locks, etc., shall be installed where required.

46. Clearances, Minimum Roadway — shall conform with Plan 70050.

47. Oil Sidings-Protection from Electric Sparks.

(a) Facilities for loading and unloading inflammable liquids shall be electrically connected between track, piping and apparatus, and grounded, in accordance with Plan S-807 and L.G.P. 140.

(b) Fuel oil facilities for locomotives shall be electrically connected between track, pipe and apparatus, and grounded in accordance with Plan SKI-807 and L.G.P. 140.

(c) In A.C. electrified territory, approval of the individual case, by Chief Engineer and Chief of Motive Power, shall be obtained prior to placing the facilities in service.

C. R. HENRY,
Chief Engineer.

W. G. SALMONSON,
Assistant Chief Engineer—Signals

5-3-57

