The Long Beach–Los Angeles Rail Transit Project

TRACKWORK INSTALLATION COURSE

Transit Construction Management

A Joint Venture of:
Parsons Brinckerhoff Quade & Douglas, Inc. ■ Daniel, Mann, Johnson & Mendenhall ■ North Pacific Construction Management

Track Installation Training Program
Course Syllabus

The following is an outline for the instruction of Trackwork Installation and Design

Class I

A. General Course Outline

1) Definition of Terms
2) Brief History of Railroads Basic

B. Basic Track Structure

1) Rail Manufacturing
2) Rail Joints
3) Continuously Welded Rail
4) Tie Plates
5) Ties
   a) Timber
   b) Concrete
6) Anchors
7) Ballast
8) Sub-Ballast
9) Roadway

C. Rail Welding and Grinding

1) Electrostatic
2) Thermite

Course Materials:

1) Definition of Trackwork Terms

2) Rail Cross Sections: 90 RE, 115 RE, 136 RE Rail

* 3) History of Rails

4) Rail Anchor Detail and Plan

5) Design and Performance Criteria - Chapter 6.4 "Standard Types of Construction"

C. Rail Defects

1) Transverse
2) Longitudinal
3) Web
4) Surface

D. Tie Defects

1) Decay
2) Holes
3) Knots
4) Shakes
5) Checks
6) Splits

Course Materials:

1) Surveyor's Textbook, "Circular Curves"

2) Highways - Vertical and Horizontal Curve Formulae.

3) MBTA - Circular and Spiral Curves

4) Back Bay - Single Crossovers, Stationing

5) Track Chart

6) C225 Typical Plan and Profile (3 sheets)

* 7) Comparative Specifications for Crossties

* 8) Track Foreman's Manual

   a) Lesson 5 - Track Alignment and Gage
   b) Lesson 6 - Track Surface
   c) Lesson 9 - Rail Defects

Homework: Track Foreman's Manual
Lesson 5 - Questions 1,4,7,8,18
Lesson 6 - Questions 3,17
Lesson 9 - None

DEFINITION OF TERMS
Relating to Trackwork

Alignment. The horizontal location of a railroad as described by curves and tangents.

Branch Line. The secondary line or lines of a railway.

Closure Rails. The rails between the parts of any special trackwork layout, such as the rails between the switch and the frog in a turnout (sometimes called Lead Rails or Connecting Rails). Also the rails connecting the frogs of a crossing or of adjacent crossings, but not forming parts thereof.

Compromise Rail. A relatively short rail, the two ends of which are of different sections, corresponding with the sections of the rails to which they are to be joined. It provides the transition from one section to a different rail section.

Compromise Joint (Rail). A joint for uniting the abutting ends of contiguous rails of different sections, or of rails of the same section but of different joint drillings.

Connecting Track. Two turnouts with the track between the frogs arranged to form a continuous passage between one track and another intersecting or oblique track or another remote parallel track.

Crossing (Track). A structure used where one track crosses another at grade, and consisting of four connected frogs.

Crossover. Two turnouts with the track between the frogs arranged to form a continuous passage between two nearby and generally parallel tracks.

Curve, Simple. A continuous change in direction of alignment by means of an arc of a single radius.

Curve, Degree of. The angle subtended at the center of a simple curve by a 100 ft chord.

Derail. A track structure for derailing rolling stock in case of an emergency.

Electric Railway (Track). Electric Railway denotes trackwork which accommodates rolling stock: the wheels have smaller flanges and/or narrower treads. The motive power is immaterial.

Elevation (of Curves) (Superelevation). The vertical distance between the outer rail and the inner rail.

Fastenings. Joint bars, bolts and spikes.

Fastenings, Auxiliary. Nutlocks, spring washers, tie plates, rail braces and anti-creeping devices.

Flangeway. The open way through a track structure which provides a passageway for wheel flanges.

Flangeway Depth. The depth of the wheel flange passageway, or the vertical distance from the top of the tread surface to the top of the filler or separator introduced between the tread portion and the guard portion of a track structure.

Flangeway Width. The distance between the gauge line and the guard line of a track structure, which provides a passageway for wheel flanges.

Flare. A tapered widening of the flangeway at the end of the guard line of a track structure, as at the end of a guard rail or at the end of a frog or crossing wing rail.

Flare Opening. The distance between the gauge line and the guard line of a track structure at the wider end of the flare.

Foot Guard. A filler for the space between converging rails to prevent a person's foot from becoming accidentally wedged between the rails.

Frog. A track structure used at the intersection of two running rails to provide support for wheels and passageways for their flanges, thus permitting wheels on either rail to cross the other.

Gauge (Track Tool). A device by which the gauge of a track is established or measured.

Gauge (of Track). The distance between the gauge lines, measured at right angles. (The standard gauge is 4 ft 8½ in.)

Gauge Line. The gauge line can be determined in two ways: (1) A line ⅝ in. below the top of the center of the running rail head, or (2) the corresponding location of tread portion of other trackwork along the side nearer the track center.

Guard Rail. A rail or other structure laid parallel with the running rails of a track. Used to prevent wheels from being derailed or to hold wheels in correct alignment to prevent their flanges from striking either the points of turnout, the crossing frogs or the points of switches.

Insulation. A device or material that prevents the flow of electric current in a track circuit from passing from one rail to the other or through switches and other track structures.

Joint Bar. A steel member embodying beam-strength and stiffness in its structural shape and material. Commonly used in pairs for the purpose of joining rail ends together, and holding them accurately, evenly and firmly in position with reference to surface and gauge-side alignment.

Joint Drilling. The spacing of holes in the ends of rails or other track structures to receive the bolts for the fastening of joint bars.

Joint, Rail. A fastening designed to unite the abutting ends of contiguous rails.

Joint, Insulated. A rail joint designed to arrest the flow of electric current from rail to rail by means of insulations, placed so as to separate the rail ends and other metal parts connecting them.

Main Line. The principal line or lines of a railway.

Main Track. A track extending through yards and between stations, upon which trains are operated by timetable or train order, or both, or the use of which is governed by block signals.

Mate. A track structure having a fixed or immovable point and used on the opposite side of the track from a tongue switch, as its companion piece. (A mate is termed "outside" or "inside" depending upon whether it is placed on the outside or inside of the curve, the "inside mate" being comparatively little used.)

Passing Track. A track which is auxiliary to the main track, for meeting or passing trains. Same as a siding.

Rail, Track. A rolled steel shape, commonly a T-section, designed to be laid end to end in two parallel lines on cross ties or other suitable supports to form a track for railway rolling stock.

Slip Switch, Single. A combination of a crossing with one right-hand and one left-hand switch and curve between them within the limits of the crossing and connecting the two intersecting tracks without the use of separate turnout frogs.

Slip Switch, Double. A combination of a crossing with two right-hand and two left-hand switches and the curved rails between them within the limits of the crossing, and connecting the two intersecting tracks on both sides of the crossing without the use of separate turnout frogs.

Special Trackwork. All rails, track structures and fittings, other than plain unguarded track, which are neither curved nor fabricated before laying.

Spur. A stub track diverging from a main or other track.

Steam Railroad (Track). Steam railroad denotes track for rolling stock which has wheels and treads substantially in agreement with AAR standard wheels. The motive power is immaterial.

Switch. A track structure used to divert rolling stock from one track to another.

Switch, Split. A switch consisting essentially of two movable point rails with the necessary fixtures. (For details see Split Switch Terms.)

Switch, Spring. A switch with automatic spring device incorporated in the operating mechanism. This device returns the points to their original positions after the trailing wheels have passed over the flanges.

DEFINITION OF TERMS (continued)

Heel End of Frog. That end of a frog which is the farther from the switch, or the end which has both point rails or other running surfaces between the gauge lines.

Heel Length. The distance between the heel end and the half-inch point of a frog, measured along the gauge line.

Heel Spread. The distance between the gauge lines at the heel end of the frog.

Throat of Frog. The point at which the converging wings of a frog are closest together.

Toe End of Frog. The end of a frog which is nearer the switch or the end which has both gauge lines between the wing rails or other running surfaces.

Toe Length. The distance between the toe end and the half-inch point of a frog, measured along the gauge line.

Toe Spread. The distance between the gauge lines at the toe end of the frog.

Wing Wheel Risers. Raised portions provided on the top surfaces of the wings of a frog, more particularly when of manganese steel design, directly opposite the point and gradually sloping down to the general level of the running surface, thereby providing additional metal at those parts of the frog which usually wear out first, and also making the transverse contour conform more closely to that of the tread of a tapered wheel.

GUARD RAIL TERMS

Guard Rail (Frog). A rail or other device to guide the wheel flange so that it is kept clear of the point of the frog.

Guard Rail (Switch). A rail or other track structure laid parallel with the running rail ahead of a split switch and forming a flangeway with the running rail, to hold the wheels of rolling stock in correct alignment when approaching the switch.

Adjustable Separator. A metal block of two or more parts acting as a filler between the running rail and the guard rail and so designed as to provide varying widths of flangeway.

Guard Rail Brace. A metal shape designed to fit the contour of the side of the guard rail and extend over the tie. Has provisions for fastening in order to restrain the moving or tilting of the guard rail away from the running rail.

Guard Rail Brace, Adjustable. A guard rail brace which may be adjusted laterally with respect to the rail, to vary the distance between the guard rail and the running rail.

Guard Rail Clamp. A device consisting of a yoke and fastenings designed to engage the running rail and the guard rail and hold them in correct relation to each other.

CROSSING TERMS

Bolted Rail Crossing. A crossing in which all the running surfaces are of rolled rail, the parts being held together with bolts.

Manganese Steel Insert Crossing. A crossing in which a manganese steel casting is inserted at each of the four intersections, being fitted into rolled rails and forming the points and wings of the crossing frogs.

Solid Manganese Steel Crossing. A crossing in which the frogs are of the solid manganese steel type.

Single Rail Crossing. A crossing in which the connections between the end frogs and the center frogs consist of running rails only.

Two-Rail Crossing. A crossing in which the connections between the end frogs and the center frogs consist of running rails and guard rails.

Three-Rail Crossing. A crossing in which the connections between the end frogs and the center frogs consist of running rails, guard rails and easer rails.

Crossing Plates. Plates interposed between a crossing and the ties or other timbers to protect the ties and to better support the crossing by distributing the loads over larger areas.

Center Frogs. The two frogs at the opposite ends of the short diagonal of a crossing.

End Frogs. The two frogs at the opposite ends of the long diagonal of a crossing.

Easer Rail (or Easer). A rail placed with its head along the outside and close up to the head of the running rail and sloped at the ends to provide a bearing for the over-hanging portion of hollowed-out treads of worn wheels.

Guard Rail. A rail placed parallel with the running rail, with the flangeway between them.

Knuckle Rail. A bent rail, or equivalent structure, forming the obtuse point against which the movable center points of a movable point crossing or slip switch rest when set for traffic.

Movable Center Point. One of the movable tapered rails of a movable point crossing or slip switch.

Reinforced Rail. A bent rail placed with its head along the outside of and close up to the head of a knuckle rail to strengthen it and to act as an easer rail; or a piece of rail similarly applied to a movable center point.

Running Rail. The rail or surface on which the tread of the wheel bears.

TURNOUT TERMS

Turnout. An arrangement of a switch and a frog with closure rails, by means on which rolling stock may be diverted from one track to another.

Curved Lead. The distance between the actual point of the switch and the half-inch point of the frog, measured on the outside gauge line of the turnout.

Lead. The distance between the actual point of the switch and the half-inch point of the frog.

Lead (Actual). The length between the actual point of the switch and the half-inch point of the frog measured on the line of the parent track.

Lead (Theoretically). The distance from the theoretical point of a uniform turnout curve to the theoretical point of the frog, measured on the line of the parent track.

Lead Curve. The curve in the turnout interposed between the switch and the frog.

Turnout Number. The number corresponding to the frog number of the frog used in the turnout.

DEFINITION OF TERMS (continued)

Switch, Tongue. A switch piece consisting essentially of a movable tongue with a suitable enclosing and supporting body structure, designed for use on one side of the track, while on the other side there is used either a mate or another tongue switch. (A tongue switch is termed "inside" or "outside" depending on whether it is placed on the inside or on the outside of the curve, the "outside tongue switch" being comparatively little used.)

Switch Point Derail. A derail consisting essentially of a split switch point with the necessary fixtures.

Switch Stand. A device for the manual operation of switches, or of movable center points.

Tangent. Any straight portion of a railway alignment.

Tie Plate. A plate interposed between a rail or other track structure and a tie.

Track. An assembly of rails, ties and fastenings over which cars, locomotives and trains are moved.

Track Bolt. A bolt with a button head and oval or elliptical neck and a threaded nut designed to fasten together rails and joint bars.

Turnout. An arrangement of a switch and a frog with closure rails, by means of which rolling stock may be diverted from one track to another.

Wye. A triangular arrangement of tracks on which locomotives, cars and trains may be turned.

SPLIT SWITCH TERMS

Split Switch with Uniform Risers. A split switch in which the switch rails have a uniform elevation on riser plates for the entire length of the switch. Since there is no heel slope, the point rail rise runs off the back of the switch in the closure rails.

Split Switch with Graduated Risers. A split switch in which the switch rails are gradually elevated by means of graduated riser plates until they reach the required height above the stock rail, and therefore have a heel slope.

Manganese Tipped Switch. A split switch in which the head of one or both of the switch rails is cut away in the point portion and manganese steel pieces fastened to the rail to form the point.

Insulated Switch. A switch in which the fixtures, principally the gauge plates and the switch rods connecting or reaching from one rail to the opposite rail, are provided with insulation so that the electric track circuit will not be shunted.

Heel of Switch. That end of a switch rail which is the farther from its point, and nearer the frog.

Heel Spread. The distance, at the heel, between the gauge line of a switch rail and the gauge line of its stock rail. (This has been standardized at 6¼ in. for straight switches.)

Heel Slope. The inclination produced by graduated risers in that part of the switch which reduces the elevation (as the height of the risers decreases) toward the heel of the switch.

Point of Switch (Actual). That end of the switch rail which is the farther from the frog; the point where the spread between the gauge lines of the stock rail and the switch rail is sufficient for a practicable switch point.

Point of Switch (Theoretical) or Vertex. The point where the gauge line of the switch rail, if produced, would intersect the gauge line of the stock rail.

Point Rail, Switch Rail or Switch Point. The tapered rail of a split switch.

Planing, Bottom. The cut planed at an angle on the bottom of the base of the switch rail from the point and towards the heel to allow the switch rail to rest on the top of the base of the stock rail when the switch rail is closed.

Planing, Side. The cuts made on the sides of the head of the switch rail to form the taper.

Planing, Top. The cut made on the top of the head of the switch rail from the point and approximately to the head separation.

Planing, Chamfer Cut. The vertical beveling of the gauge side of the switch point to produce a sharp edge, so as to prevent wheel flanges from striking the point.

Rail Brace (Switch). A metal shape designed to fit the contour of the side of the stock rail and extend over the switch plate, with provision for fastening through the plate to the tie, to restrain the movement of the stock rail.

Rail Brace, Adjustable (Switch). A rail brace which may be adjusted laterally with respect to the stock rail, to compensate for variation in the dimensions of the rail and to permit adjustment for wear.

Stock Rail. A running rail against which the switch rail operates.

Stock Rail Bend. The bend or set which must be given the stock rail at the vertex of a switch to allow it to follow the gauge line of the turnout.

Switch Angle. The angle included between the gauge lines of the switch rail at its point and the stock rail.

Throw of Switch. The distance through which the points of switch rails are moved sidewise, measured along the center line of the No. 1 switch rod or head rod.

FROG TERMS

Bolted Rigid Frog. A frog built essentially of rolled rails, with fillers between the rails, and held together with bolts.

Spring Rail Frog. A frog having a movable wing rail which is normally held against the point rail by springs, thus making an unbroken running surface for wheels using one track. The flanges of wheels on the other track force the movable wing rail away from the point rail to provide a passageway.

Railbound Manganese Steel Frog. A frog consisting essentially of a manganese steel body casting fitted into and between rolled rails and held together with bolts.

Solid Manganese Steel Frog. A frog consisting essentially of a single manganese steel casting.

Seft-Guarded Frog (Flange Frog). A frog provided with guides or flanges, above its running surface, which contact the tread rims of wheels for the purpose of safely guiding their flanges past the point of the frog.

Frog Angle. The angle formed by the intersecting gauge lines of a frog.

Frog Number. One-half the cotangent of one-half the frog angle, or the number of units of center line length in which the spread is one unit.

Frog Point. That part of a frog lying between the gauge lines extending from their intersection toward the heel end.

(a) Theoretical Point
The point of intersection of the gauge lines of a frog.

(b) Half-Inch Point
A point located at a distance from the theoretical point towards the heel equal in inches to one-half the frog number, and at which the spread between the gauge lines is one-half inch. It is the origin from which measurements are usually made.

SECTION 02450

GENERAL TRACK CONSTRUCTION

PART 1 - GENERAL

1.1 DESCRIPTION

A. The Work specified in this Section consists of track construction procedures and requirements that are common to both standard direct fixation and ballasted track, and to direct fixation and ballasted special trackwork, including laying and fastening continuous welded rail, joining rail, anchoring rail, rail grinding, final alignment, inspection, and cleanliness of the site.

B. All materials required for track construction, unless specified as COMMISSION furnished materials, will be furnished by the Contractor.

C. The Contractor may propose, in writing to the Construction Manager, alternatives for performing the Work specified herein. These alternatives may be used in lieu of the procedures specified herein only if written acceptance of these alternatives has been received from the Construction Manager.

D. Trackwork Definitions - The following abbreviations and terms, with their coinciding definitions, represent the standard glossary of trackwork terms for the COMMISSION and supplement the definitions contained elsewhere in the Specifications and in the AREA Manual for Railway Engineering. In the event of a conflict between the AREA definition and a definition contained herein, the definition contained herein will apply.

1. Adze - To cut into the top surface of a tie to provide proper bearing for a tie plate.

2. Approach Slab - A concrete slab located at interface of ballasted track with embedded or direct fixation track to provide a transition from embedded or direct fixation track to ballasted track.

3. Ballast - An integral part of the ballasted track structure, composed of crushed stone, in which ties are embedded.

4. Bonded Joint - A rail joint that uses high-strength adhesives in addition to bolts to hold rail together. The bonded joint may be insulated or non-insulated. (standard)

5. Bumping Post - A device attached to the rail, designed to stop a rail vehicle at the end of a track. A sliding type of friction arrestor is designed to slide along the track before it brings a rail vehicle to a complete stop.

6. Cant - Inward inclination of the running rails, nominally 1:40.

7. Cross Level - The vertical relationship of the top of one running rail to that of the opposite running rail at any point in the track.

8. Crossover

   a. Double - Two single crossovers which intersect each other between the two adjacent and generally parallel tracks forming a connection between them. Sometimes referred to as a "diamond" crossover.

   b. Crossover, Single - Two turnouts, with track located between the frogs and arranged to form a continuous passage between two adjacent and generally parallel tracks.

   c. Crossing Diamond - A special trackwork assembly consisting of two end frogs and two center frogs that together comprise the central portion of a double crossover.

9. Curve

   a. Circular Curve - A horizontal curve defined by the arc definition and specified by a radius.

   b. Spiral Curve - A transition curve connecting a tangent to a circular curve and defined by the AREA Spiral.

   c. Vertical Curve - A parabolic curve connecting different profile grades.

10. Dap - A recess cut into a switch tie to depress the switch machine.

11. Derail - A device that protects main track by derailing rolling LRT vehicles or maintenance equipment, thereby preventing rolling vehicles or equipment from entering or obstructing the track.

12. Direct Fixation Rail Fastener - A resilient device for securing running rail to a concrete trackbed in direct fixation track.

   a. Rail Clip Assemblies - One or more components of the direct fixation rail fastener used to attach the running rail to the body of the direct fixation rail fastener.

   b. Anchorage Assemblies - One or more components of the direct fixation rail fastener used to attach the body of the direct fixation rail fastener to a concrete trackbed.

   c. Anchorage Insert - A component of the Anchorage Assemblies which is embedded in the concrete and is threaded to hold the anchor assembly bolts.

13. Dutchman - A short piece of running rail temporarily placed between the ends of CWR to reduce the damage which would occur to the rail ends as a result of rail mounted track equipment passing over those ends.

14. Electrical Isolation - The electrical resistance required between the running rail and the ground to prevent harmful levels of stray current from the DC Traction Power circuit.

15. Grade Crossing - The crossing of a railway track and a vehicular roadway at the same elevation. Conventionally constructed of timber, asphalt, rubber, or concrete.

16. Heartwood Face - The side of a timber tie about which the growth rings are concave.

17. OTM - Other track material. Miscellaneous materials required to complete track construction, other than rail, special trackwork, ties, and ballast.

18. Plate

    a. Gauge Plate - A steel plate installed at the switch or the frog to maintain the gauge.

    b. Riser Plate - A steel plate welded to a special switch plate for the purpose of raising the switch rail slightly above the stock rail.

    c. Special Plate - A steel plate for use in special trackwork designed to replace the AREA standard gauge, switch, heel and hook twin tie plates commonly used under switches and frogs.

19. Pocket Track - A track located between the two main tracks on which a train may lay over or reverse direction.

20. Profile Grade Line (PGL) - The datum line which defines the vertical alignment of the track, applied at the top of the low rail.

21. Rail

    a. Continuous Welded Rail (CWR) - A number of standard length rails welded together into a single length.

    b. Jointed Rail - Rails with a nominal length of 78 feet or less joined together by means of joint bars and bolts.

    c. Running Rail - Rail which supports and guides the flanged wheels of the rail vehicle.

d. Special Trackwork Rail - Rails in the special trackwork area to be manufactured in a shop rather than fabricated in the field.

e. Inside Rail - On curved track, the rail closest to the curve center; the rail with the shorter radius. Sometimes referred to as the "low rail."

f. Outside Rail - On curved track, the rail farthest from the curve center; the rail with the longer radius. Sometimes referred to as the "high rail."

22 Rail Anchor - A track device in ballasted track designed to resist longitudinal rail movement due to traffic and temperature variations.

23. Rail Brace - A device which provides lateral support on the field side of stock rails to maintain the track gauge.

24. Rail Field Side - The side of the rail farthest from the center of track.

25. Rail Gauge Side - The side of the rail nearest the center of the track.

26. Rail Stop - A steel plate welded to a special plate to provide lateral restraint to the rail.

27. Roadbed - The earth bed or foundation which supports the ballast, ties and rail of a track structure.

28. Rod

a. Front Rod - A rod connecting the switch rails to the lock or detector rod (whichever rod is furthest away from the turnout frog).

b. Switch Rod - A rod which connects two switch rails together.

c. Operating Rod - A rod connecting the switch rod to the switch operating mechanism.

d. Lock Rod - A rod connecting the front rod to the lock mechanism.

29. Subballast - A material superior in composition to the roadbed material which provides a layer between the track ballast and the roadbed.

30. Superelevation - The design vertical distance that the outer rail is set above the inner rail on a curve.

31. Switch machine - A device for remote-controlled mechanical operation of a switch or derail.

32. Switch Rail (Switch Point) - A tapered rail which diverts the wheel flanges to the desired track.

33. Tie

    a. Cross Tie - The transverse member of the track structure which is centered on the track and holds the rails in position and distributes the rail loads to the roadbed.

    b. Switch Tie - A transverse member of the track structure which functions as a cross tie but is longer and supports a crossover or turnout.

34. Track

    a. Ballasted Track - Track constructed of rail, ties, OTM, and ballast.

    b. Direct Fixation (DF) Track - Track constructed of rail and direct fixation rail fasteners attached to a concrete surface.

    c. Embedded Track - Track similar to DF track but with other materials such as asphalt added to bring the surface grade up close to the top of rail, allowing rubber tired road vehicles to operate easily along or across the track.

35. Zero Thermal Stress Temperature - The temperature at which a string of continuous welded rail will have no stress in it due to thermal expansion or contraction.

1.2 QUALITY ASSURANCE

A. Quality Assurance Program

1. The Contractor shall establish, implement and maintain a quality assurance program to provide verification of compliance with contract requirements and in conformance with Section 01453, Quality Control Requirements, through generation of inspection and test records and related objective evidence. The quality assurance program shall consist of detailed procedures and instructions for monitoring and controlling those activities related to quality during design, fabrication, delivery, handling, storage, assembly, inspection and testing. The areas which the quality assurance program shall address include the following:

    a. Establishment, review and control of quality procedures and instructions.

    b. Calibration/certification of measuring and testing of construction equipment.

ABBREVATIONS

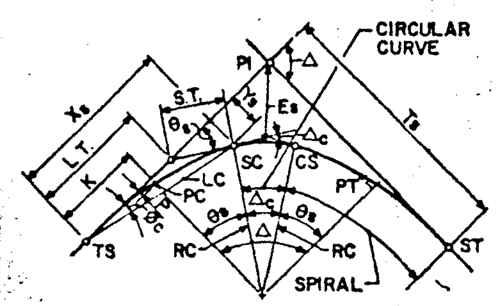
TRACK ALIGNMENT

HORIZONTAL

I	TOTAL INTERSECTION ANGLE
PI	POINT OF INTERSECTION OF TWO TANGENTS
TS	TANGENT TO SPIRAL
SC	SPIRAL TO CIRCULAR CURVE
ST	SPIRAL TO TANGENT
CS	CIRCULAR CURVE TO SPIRAL
E	TOTAL SUPERELEVATION
E_u	UNBALANCED SUPERELEVATION
E_s	EXTERNAL DISTANCE
D_c	DEGREE OF CURVE
R_c	RADIUS OF CIRCULAR CURVE
T_c	TANGENT LENGTH OF CIRCULAR CURVE
T_s	TANGENT OF COMPLETE CURVE
θ_s	CENTRAL ANGLE OF SPIRAL
Δ_c	CENTRAL ANGLE OF CIRCULAR CURVE
E_s	EXTERNAL DISTANCE
PC	POINT OF CIRCULAR CURVE
P	OFFSET DISTANCE FROM TANGENT TO P.C.
PT	POINT OF TANGENCY
L.T.	LONG TANGENT
L_c	TOTAL LENGTH OF CIRCULAR CURVE
L_s	TOTAL LENGTH OF SPIRAL
S.T.	SHORT TANGENT
T_s	TANGENT DISTANCE FROM TS OR ST TO PI
X_s	TANGENT DISTANCE AT SC OR CS
Y_s	TANGENT OFFSET AT SC OR CS
K	DISTANCE FROM TS TO P.C. ALONG TANGENT
E_e	SUPERELEVATION
ϕ_c	DEFLECTION FROM TANGENT AT TS TO SC
N B	NORTHBOUND
S B	SOUTHBOUND

VERTICAL

VC	VERTICAL CURVE
PVC	POINT OF VERTICAL CURVE
PVT	POINT OF VERTICAL TANGENCY
PVI	POINT OF VERTICAL INTERSECTION
LVC	LENGTH OF VERTICAL CURVE
GB	GRADE BREAK



SPIRAL CURVE TERMINOLOGY

AC	ASPHALT CONCRETE
&	AND
@	AT
AHD	AHEAD
AREA	AMERICAN RAILWAY ENGINEERING ASSOCIATION
ASCE	AMERICAN SOCIETY OF CIVIL ENGINEERS
ASTM	AMERICAN SOCIETY FOR TESTING AND MATERIALS
A/R	AS REQUIRED
APPROX	APPROXIMATE
BEG	BEGIN
BK	BACK
℄	CENTERLINE
C TO C	CENTER TO CENTER
CLR	CLEAR, CLEARANCE
CONC	CONCRETE
CONN	CONNECTION
CONST	CONSTRUCTION
CWR	CONTINUOUSLY WELDED RAIL
DF	DIRECT FIXATION
DIA. ∅	DIAMETER
DWG	DRAWING
EA	EACH
ELEV	ELEVATION
EQ	EQUAL, EQUATION
ET	END OF TRACK
EXIST	EXISTING
EOR	END OF ROAD
FL	FLOW LINE
FG	FROG GAUGE PLATE
FIN GR	FINISH GRADE
FT	FOOT OR FEET
FS	FINISHED SURFACE
F	FUTURE
GALV	GALVANIZED
GP	GAUGE PLATE
GR	GUARD RAIL PLATE
HD	HEAD
HL	HEEL LENGTH
HF	HEEL OF FROG
HP	HEEL PLATE
HS	HIGH STRENGTH
HS	HEEL OF SWITCH
ID	INSIDE DIAMETER
IN	INCH OR INCHES
I.J.	INSULATED JOINT
JT	JOINT

LA	LOS ANGELES
LB, #	POUND
LH	LEFT HAND
LG	LONG
MAX	MAXIMUM
MIN	MINIMUM
MPH	MILES PER HOUR
NIC	NOT IN CONTRACT
NO. (S), #	NUMBER, NUMBERS
NTS	NOT TO SCALE
OC	ON CENTER OR ON CENTERS
OD	OUTSIDE DIAMETER
PF	POINT OF FROG
PGL	PROFILE GRADE LINE
PS	POINT OF SWITCH
PVMT	PAVEMENT
PITO	POINT OF INTERSECTION OF TURNOUT
QTY	QUANTITY
R	RADIUS
RBM	RAILBOUND MANGANESE
RD	ROAD
REF	REFERENCE
REINF	REINFORCING
RH	RIGHT HAND
REQ'D	REQUIRED
RR	RAILROAD
R/W	RIGHT OF WAY
SA	SERVICE AISLE
SD	STORM DRAIN
SP	SPACE, SPACING
SPI	SPECIAL PLATE, INSULATED
STA	STATION, SANTA
STD	STANDARD
SW	SWITCH
SQ	SQUARE
TC	TRACK CENTER, TOP OF CURB
TEMP	TEMPORARY
THEO	THEORETICAL
TL	TOE LENGTH
TO	TURNOUT
T/R	TOP OF RAIL ELEVATION
TRK	TRACK
TYP	TYPICAL
TF	TOE OF FROG
W/	WITH
W/O	WITHOUT
X-ING	CROSSING
X-OVER, X	CROSSOVER

TRACK SYMBOLS

- SLIDING ARRESTOR
- GAUGE LINE
- CENTERLINE
- STANDARD RAIL
- HIGH STRENGTH RAIL
- LEFT HAND CURVE
- RIGHT HAND CURVE
- ARROW INDICATES DIRECTION OF INCREASED STATIONING
- POINT OF SWITCH - LOCATION OF SWITCH MACHINE
- TURNOUT
- SINGLE CROSSOVER
- DOUBLE CROSSOVER
- CONTINUOUS WELDED RAIL
- BUMPING POST
- PITO
- PI/PVI
- (000-0) COORDINATE NUMBER
- (0000) CURVE NUMBER
- EXISTING RAILROAD
- EXISTING TRACK, FUTURE TRACKS
- PROFILE GRADE LINE
- STA. 233 + 45.29 BK = STA. 234 + 00 AHD — STATION EQUATION
- BONDED STANDARD JOINT
- BONDED INSULATED JOINT
- BONDED STANDARD JOINT
- BONDED INSULATED JOINT
- BONDED STANDARD JOINT
- BONDED INSULATED JOINT
- BONDED STANDARD JOINT W/ 6" OVERLAP IN CLOSURE RAIL
- BONDED INSULATED JOINT W/ 6" OVERLAP IN CLOSURE RAIL
- BONDED STANDARD JOINT, 4 BOLT

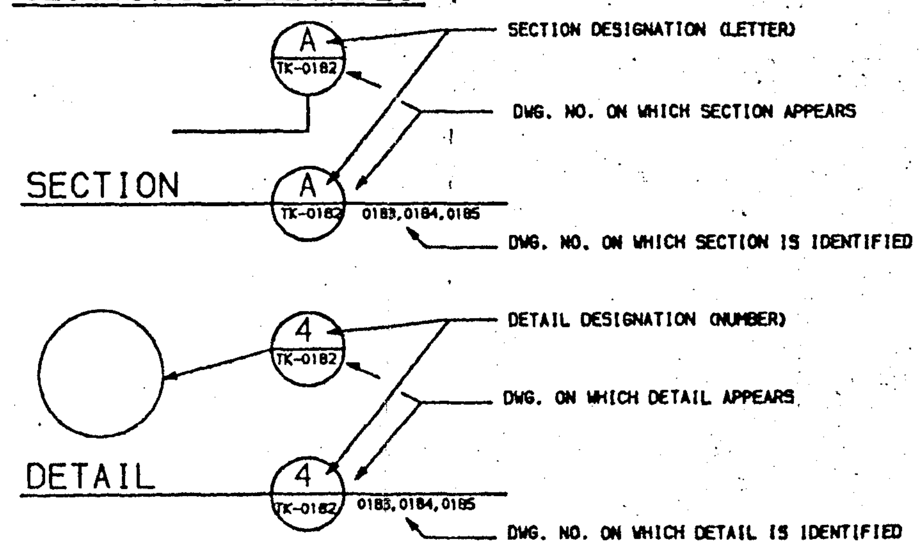
MATERIAL SYMBOLS

- CONCRETE
- ELASTOMER
- INSULATING MATERIAL
- TIMBER
- ASPHALT
- STEEL
- SUBGRADE EARTH
- WELDING
- BASE COURSE
- BALLAST

GENERAL SYMBOLS

- A / B — DOWN GRADE IN DIRECTION OF ARROW A = RUN B = RISE
- DIMENSION LINE CONTINUES
- BREAK IN DRAWING
- BREAK IN DIMENSION
- 1/4" — 1/4" FILLET WELD

SECTIONS & DETAILS



REV.	DATE		BY	APP.
1	9/1/87	ADDENDUM NO. I - REVISE SYMBOLS FOR JOINTS	WKS	
	5/5/87	ISSUED FOR BID		

DESIGNED BY J.L. Patterson
DRAWN BY
CHECKED BY
APPROVED BY
DATE: 04/16/87

REGISTERED PROFESSIONAL ENGINEER — WAYNE K. SAN FILIPPO — No. 19837 — EXP. 9/30/89 — CIVIL — STATE OF CALIFORNIA

LOS ANGELES COUNTY TRANSPORTATION COMMISSION
The Long Beach-Los Angeles Rail Transit Project

DMJM

SUBMITTED:

Southern California Rail Consultants

APPROVED:

LRT TRACKWORK INSTALLATION
ABBREVIATIONS AND SYMBOLS

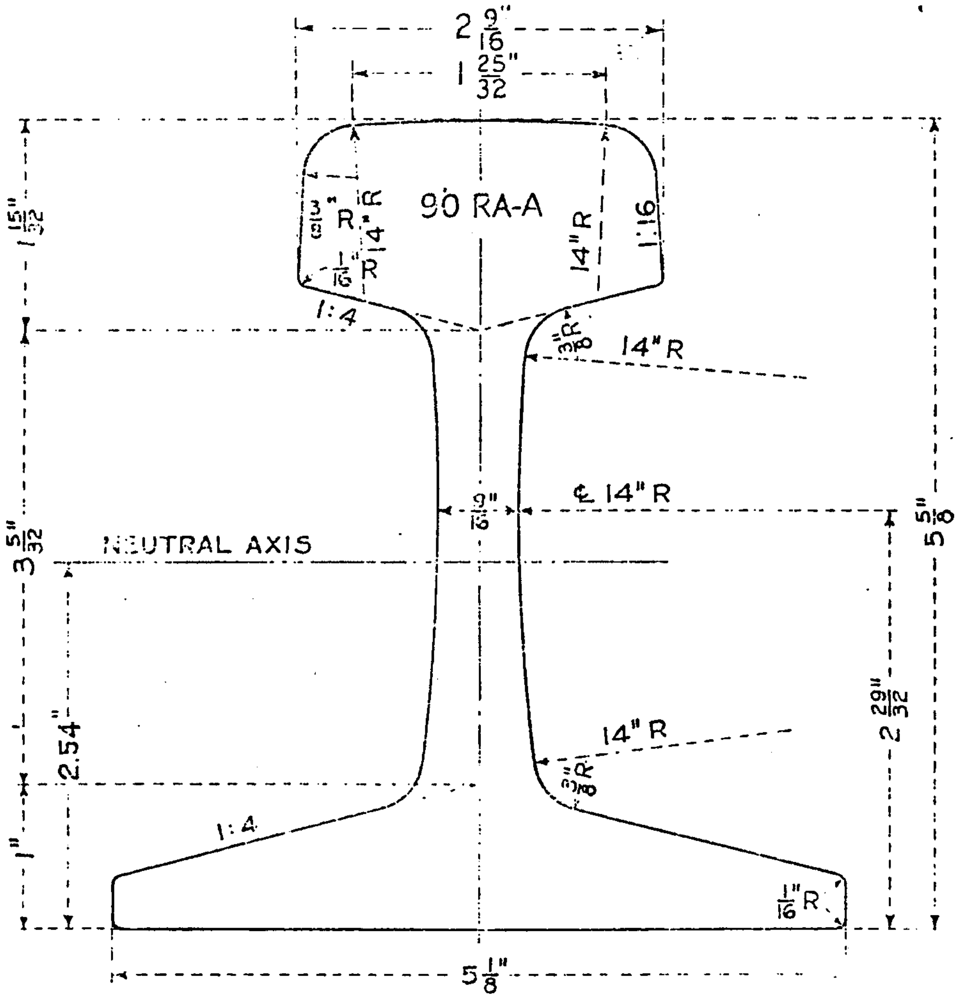
CONTRACT NO. R01-T08-C25I
DRAWING NO. GI-1223
REV. 1
SHEET NO. 13
SCALE NONE

Part 1
Design

RECOMMENDED RAIL SECTIONS

1962

(Reapproved without change 1962)



	Area Sq In	Percent
Head	3.19	36.3
Web	2.12	24.0
Base	3.51	39.7
Total	8.82	100.0

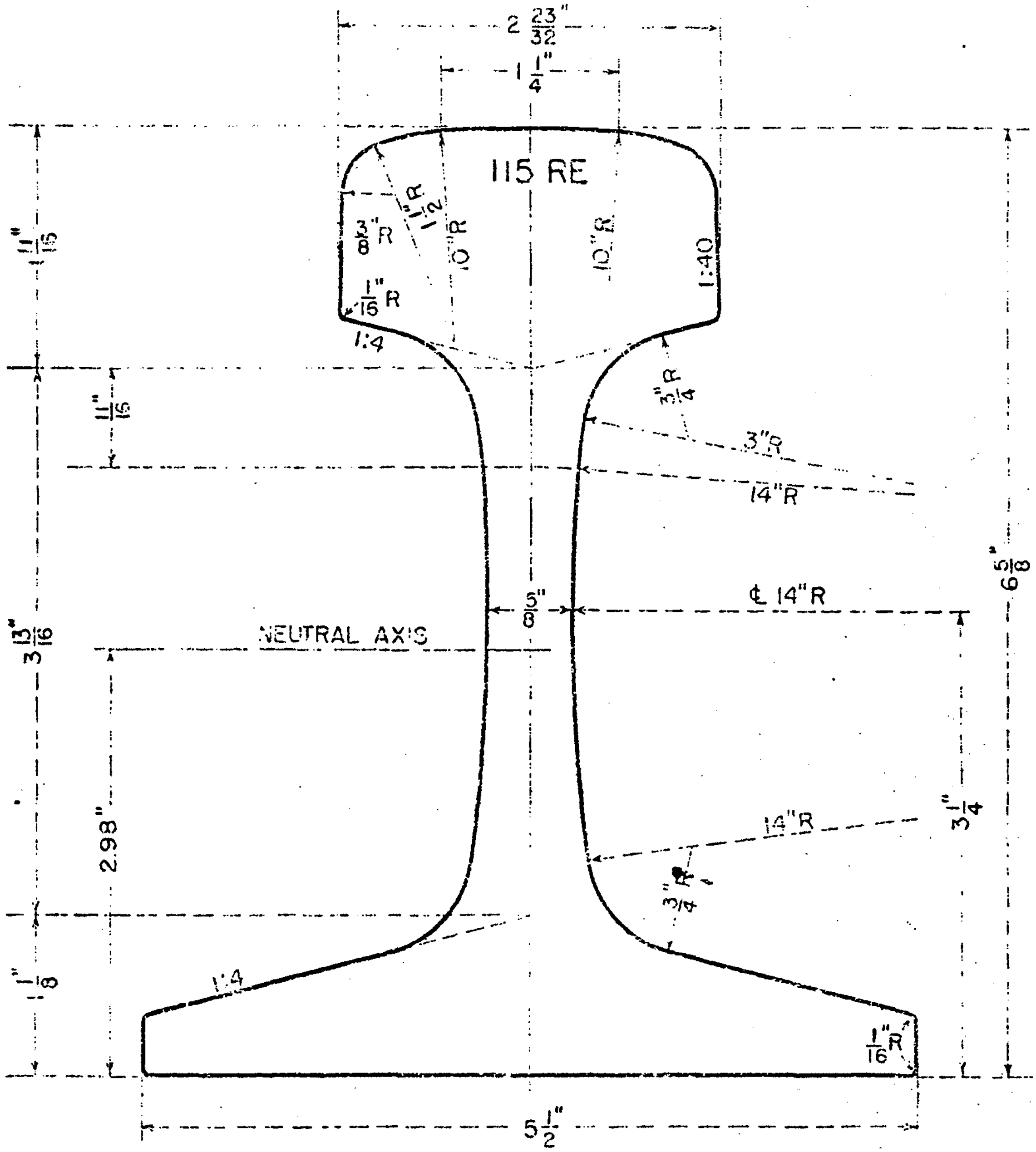
Moment of inertia	38.7
Section modulus, head	12.6
Section modulus, base	15.2
Ratio m.i. to area	4.39
Ratio s.m. head to area	1.43
Ratio height to base	1.10
Calculated weight, lb per yd	90.0

Fig. 1—90 RA–A rail section.

References, Vol. 16, 1915, pp. 397, 1117; Vol. 49, 1948, pp. 375, 614; Vol. 54, 1953, pp. 1177, 1413; Vol. 63, 1962, pp. 498, 768.

1962

(Reapproved without change 1962)



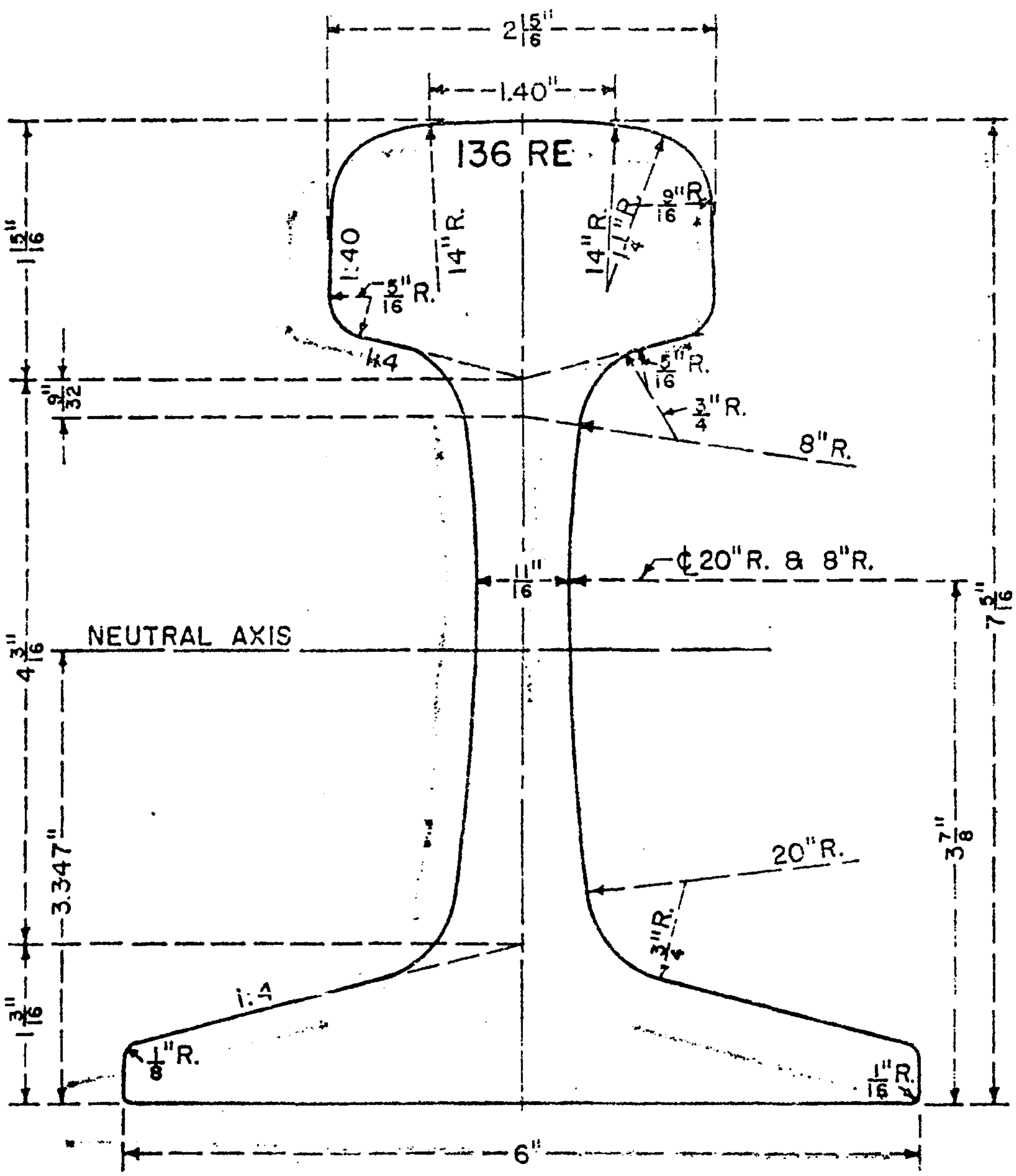
	Area Sq In	*Percent*
Head	3.91	34.8
Web	3.05	27.1
Base	4.29	38.1
Total	11.25	100.0

Moment of inertia	65.6
Section modulus, head	18.0
Section modulus, base	22.0
Ratio m.i. to area	5.83
Ratio s.m. head to area	1.60
Ratio height to base	1.20
Calculated weight, lb per yd	114.7

Fig. 3—115 RE rail section.

1962

(Adopted 1962)



	Area Sq In	Percent
Head	4.86	36.4
Web	3.62	27.1
Base	4.87	36.5
Total	13.35	100.0

Moment of inertia	94.9
Section modulus, head	23.9
Section modulus, base	28.3
Ratio m.i. to area	7.11
Ratio s.m. head to area	1.79
Ratio height to base	1.22
Calculated weight, lb per yd	136.2

Fig. 6—136 RE rail section.

References. Vol. 63, 1962, pp. 498, 768.

FOREWORD

Sperry Rail Service has compiled and published this fifth edition of the Rail Defect Manual as a part of the technical service, in addition to actual rail testing, supplied to Sperry customers. It is designed to benefit railroad men concerned with track safety and maintenance of the right-of-way. Since the publication and enthusiastic reception of the last edition of the Rail Defect Manual in 1957 we have received many valuable and helpful suggestions from interested readers for the improvement of the manual. Each of these suggestions has been given careful consideration and many of them have been incorporated in this new edition.

The Sperry Rail Service staff, working with railroad men throughout the country, has spared no effort to make this manual a complete and accurate handbook of rail defects. The material which it contains represents the findings of over 40 years of experience by Sperry Rail Service in the field of rail testing. We realize that our interpretation of certain defects may not be in absolute accord with your own ideas and experience, and we invite your comments and suggestions.

For easy reference this edition has been arranged according to the location of each defect in the rail. The various types of defects have been listed according to the classification system used by Sperry Rail Service.

We thankfully acknowledge the section titled "Making Steel for Railroad Rail" which was contributed by the Bethlehem Steel Co. and consists of excerpts from their Booklet 1822, "The Railroad Rail".

We take this opportunity to thank all the railroad men who assisted us in the compilation of the defect section of the manual.

We also thank the U. S. National Museum, Smithsonian Institution, for help in obtaining the historical data contained in this book.

RAILS AND RAIL TESTING

History of Rails

The earliest record of the use of track for transportation comes from England, where, in 1604, a railway was constructed from nearby coal mines to the river Tyne. The tracks were made of wooden rails, upon which wooden carts with flanged wheels were pushed by men or pulled by horses.

During the eighteenth century, the growth of railways continued in the mining districts of England and Wales. As yet, the steam locomotive was unthought of. Horses or mules pulled the early trains. The tracks were originally made of pine or other soft wood. To improve the wearing quality, a top strip of hard wood was applied. During the middle period of the century, strips of malleable iron replaced the hard wood topping. These iron strips were used only to provide a more durable wearing surface; the timber carried the weight and guided the wheels.

First Metal Rail

In 1776 the first all-iron rail was manufactured near the city of Sheffield, England. These rails, called *plate rail,* (Fig. 1) were made of cast iron in sections 3 feet long. Since flanged-wheel carts were not common in the south of England nor in Wales, these rails were cast in shape of an L, the long leg of which rested on the roadbed while the short leg projected upward. This construction permitted the use of either flanged or common cart wheels upon the track, the upthrust leg taking the place of the wheel flange in the latter case.

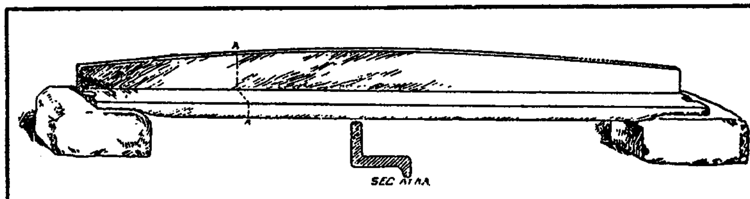


Fig. 1. Plate rail. 3-feet long, made of cast iron, with an upward projecting flange to accommodate either cart or flanged wheels.

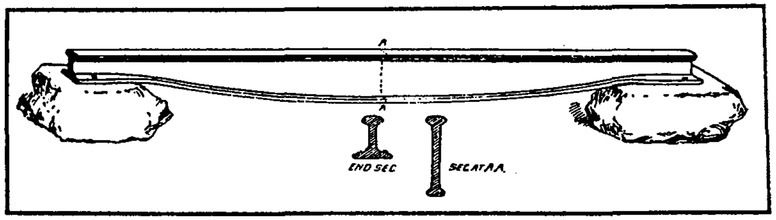


Fig. 2. Edge rail, made of cast iron in 6-foot sections, for use with flanged wheels.

In 1789 William Jessop, who later built the London-Croydon Railway, developed a new type known as *edge rail* (Fig. 2). Due to its vertical section it was many times stronger than either strip or plate rail. In its earliest form, edge rail consisted of a thin web widening out at both head and base while the cross section above the supports closely resembled a modern rail section.

First Public Railway

In 1803 the first railroad intended for public use, the Surrey Iron Railway, was opened for operation between the London docks and Croydon. Intended primarily as a public super-highway, the track was laid with flanged plate rail to accommodate cargo wagons or any other conveyance whose owner was willing to pay for the privilege of a smooth fast ride on a hard road.

The early iron rails were spiked directly to wooden sleepers. As loads on the railroads increased the need for heavier roadbeds became apparent. The most common method of positioning the rails was to set stone blocks along the line to be followed by the track, insert wooden plugs into holes drilled in these blocks and then spike the rail to these plugs. Later, edge rail was supported at each stone block by a cast iron chair (Fig. 3).

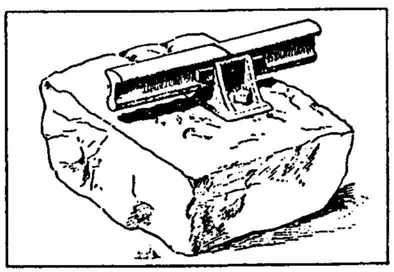


Fig. 3. Cast iron chair, used to support and join early edge rail.

At the beginning of the 19th century the railways, commonly known as tramways, had grown to an impressive size but as yet the carrying capacity and the speed attainable was limited by the strength of the draft animals used for locomotion. With the growth of manufacturing came a corresponding need of better and faster transportation. The natural result was an effort to improve the railroads.

First Steam Locomotive

Road carriages powered by steam had already been successfully demonstrated. The logical step was to apply steam power to the railroad.

On February 1st, 1804, on the plate rail tracks of the Pennsylvania tramroad in South Wales, a steam locomotive successfully hauled a train of cars. The locomotive was designed by Richard Trevithick. The freight hauled in the cars consisted of several tons of ore for the iron works at Merthyr Tydfil.

In 1825 the Stockton and Darlington Railway in England commenced operation using a steam locomotive designed by George Stephenson. This was the beginning of the commercial use of steam locomotives on regularly scheduled common carriers.

It had originally been planned to lay flanged plate rail on the Stockton and Darlington, but upon Stephenson's repeated recommendation cast iron edge rail was used. This instance marked the adoption of flanged wheels in railway construction.

Origin of Standard Gage

The track of the Stockton and Darlington was laid to a gage of 4 feet 8½ inches—the gage in standard use throughout England and the United States today. The story runs that the width of the Killingworth colliery tramline was 4 feet 8 inches. Since Stephenson, who was the colliery millwright, designed his early experimental locomotives to run on that line, he quite naturally built them to that gage. When he was called upon to design the Stockton and Darlington locomotive he did so to the width to which he was accustomed. The extra half-inch was added to the track width to ease the gage. Stephenson's personal prestige helped to bring about the adoption, after considerable controversy, of the 4-foot 8½-inch gage as the English standard.

The influence of Stephenson's work on American locomotive designs, plus the fact that a number of English locomotives were imported to this country, resulted in the use of the 4-foot 8½-inch gage on the Baltimore & Ohio, several of the New England railroads and on the early Pennsylvania line.

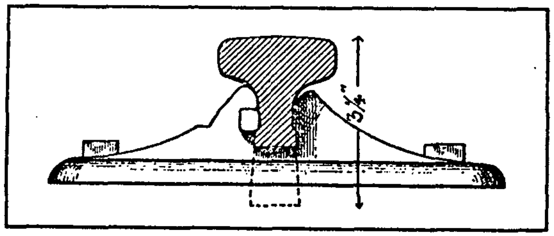


Fig. 4. Rolled iron edge rail, made in 15-foot sections and supported at joint by cast iron chairs.

The South Carolina Railroad, as well as most of the other Southern lines, was built to a gage of 5 feet. The Erie tracks were built to a 6-foot gage, the Missouri Pacific spaced its rails at 5 feet 6 inches, while the early Jersey & Ohio road used a 4-foot 10-inch gage. Not until many years later did the necessities of interchange force the adoption of a standard gage of 4 feet 8½ inches for all American tracks.

First Rolled Rail

A few years prior to the advent of the steam locomotive, John Birkenshaw, owner of the Durham Iron Works, turned out the first *rolled iron rail* (Fig. 4). This rail had a wide rounded head and a thick web designed to be supported by cast iron chairs at the joints. The rail was rolled in sections 13 to 15 feet long as compared to the 3- to 6-foot length of the cast iron plate and edge rail, and weighed 26 lb. per yard.

The first American railway was the Granite Railroad of Massachusetts, built in 1826. This 3-mile stretch of track, from Quincy to Milton, used iron-capped wooden rails, and horses for power.

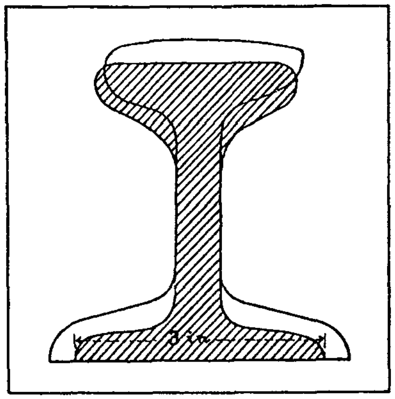
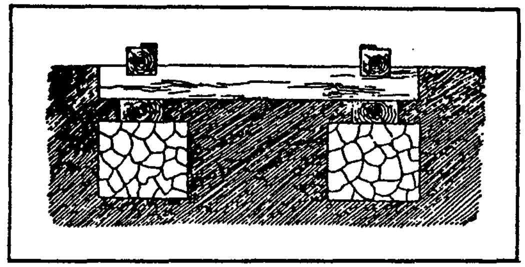


Fig. 5. Stevens T-rail rolled with convex top and base, designed by Robert L. Stevens in 1830. Shaded section shows rail as originally designed. Unshaded section show profile as actually rolled.

First American Locomotive

In 1831 the "Best Friend of Charleston", the first locomotive to successfully pull a train on

Fig. 6. Iron strap rail, spiked to wooden stringers and supported by wooden ties over a gravel and wood sub-foundation.



American tracks, was placed in operation on the South Carolina Railroad. In the spring of the same year construction of the Camden and Amboy Railroad in New Jersey was started, using the rolled *iron T rail* (Fig. 5) designed by Robert Stevens and rolled in England. This rail did away with the need for expensive cast iron chairs since it could be spiked directly to the tie with a hook-headed spike, also designed by Stevens. The roadbed was constructed according to the English idea of securing the rails to stone blocks.

A shortage of stone, however, resulted in the use of wooden ties similar to those in use today. To the surprise of the railroad world it was found that the use of wooden ties made a roadbed that rode better than did track laid on stones.

American Rail Development

Although rolled edge rail rapidly gained favor in English construction, its use in America was necessarily limited by cost. Until the first American rail rolling mill was constructed in Maryland in 1844, the necessity of importing the British product made the use of rolled rail too expensive for widespread use.

As a result, much of the early American track utilized iron strap rail laid on longitudinal wooden stringers (Fig. 6). On the B & O stone stringers were substituted for the wood. Aside from the fact that the the wooden rail had poor wearing qualities, the iron straps that topped it had a pronounced tendency to pull loose from the wooden stringers. This usually happened during the passage of a train, when the iron strip, loosened by vibration, would curl back on itself, causing frequent damage to equipment and injury to passengers. These loose rails were known as "snakeheads" and were a common occurrence.

The first rail rolled at the Maryland mill was a 42-pound *iron U rail*

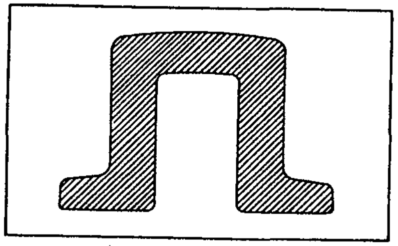


Fig. 7. Iron U-rail. This was the first type of rail rolled in the United States and was used on the Baltimore and Ohio R.R. in Maryland in 1844.

(Fig. 7). A quantity of this rail was used by the Baltimore and Ohio but never achieved much popularity. In 1845, mills in New England and Pennsylvania commenced production of the Stevens T rail. The iron smelted in the United States at this time was inferior to that of England. To provide greater strength the original Stevens rail was modified in such a way that the head was pear shaped in cross section (Fig. 8).

The difficulty of splicing pear shaped rail, led to the development of *compound rails* (Fig. 9). In laying these rails the two sections were staggered so that at no point did a complete gap occur in the rail. At first this type of rail proved highly satisfactory and provided an exceptionally smooth ride. However, the iron wore badly on the inner surfaces and required frequent tightening of the holding nuts or rivets. No new compound rail was laid after 1860.

In 1848 a rolled iron rail weighing 92 pounds per yard, and having

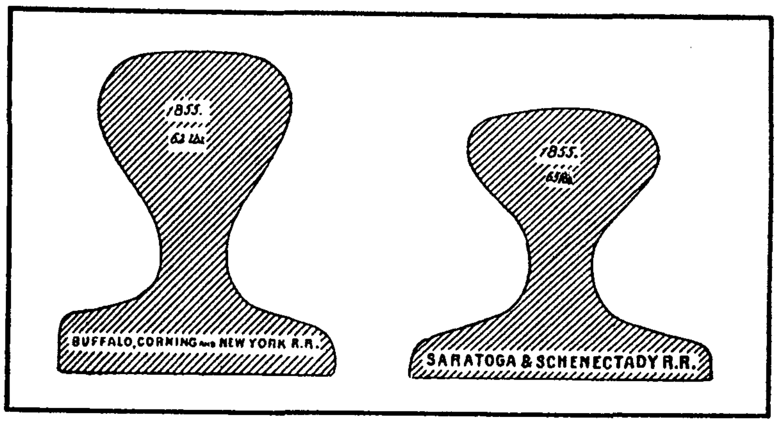


Fig. 8. Pear Shaped rolled iron rail. manufactured in Pennsylvania in 1855.

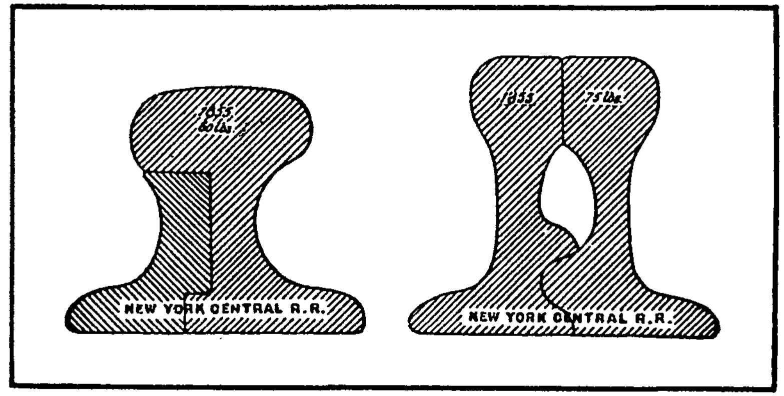


Fig. 9. Compound rail developed in 1855 in an attempt to simplify joint construction. Maintenance difficulties forced its abandonment in 1860.

a cross section very similar to that of modern rail, was tested on the Camden and Amboy Railroad. The iron rail proved to be too rigid to withstand batter by the train and the ends soon hammered out. The rails were removed from the tracks and now form part of the building framework of the U. S. Mint in Philadelphia.

First Steel Rail

The first steel rails are said to have been rolled at the Ebbv-Vale works in Wales in 1855. The difficulty of obtaining good iron on this side of the ocean led the more prosperous American companies to continue to import steel and iron rails from abroad. In 1865 the first Bessemer steel rails made in this country were rolled in the North Chicago Mills. The first steel rails rolled in the United States were produced in Johnston, Pennsylvania in 1867. Between 1870 and 1873 several experiments were made with steel top rail, a type in which web and base were made of iron, and the head of steel. The lessening cost of steel soon made it more practical to make the entire rail of steel.

By 1900, *steel T rail* (Fig. 10) had replaced all other types on the railroads in the United States. From that time until the present, rail development centered about production of heavier rail sections and improved manufacturing processes. Only minor modifications have been made in the shape of the rail. It is interesting to note that the trend toward heavier rail has resulted in the rolling of rail sections of 152 and 155 pounds for use in certain heavy tonnage areas, although the 140 pound section (see Fig. 10) is believed to be the heaviest rail section currently being rolled for general use by any American Railroad.

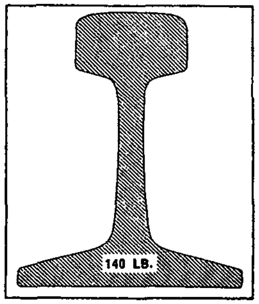


Fig. 10. 140 lb. Cross Section

Rail Manufacturers and Mills

Steel mills equipped for the manufacture of railroad rails have always played an essential part in the development and continual improvement of our railroads. They have developed and tested in cooperation with railroads new manufacturing methods and processes to meet constant needs for better, stronger, longer-lasting rails, rail accessories and other steel products. New sections or types and weights have been made readily available as required and specified. Special treatments (described elsewhere in this booklet) to overcome new problems arising from today's heavy-load, high-speed trains form an increasingly important service which mills render to all railroads seeking the reduced costs and improved performance required for them to stay alive in today's highly competitive transportation market.

Railroads have indeed been fortunate to have their rail needs so ably served by so wide a choice from among the following principal steel manufacturers and their rail mills:

- Algoma Steel Corporation (Canada)—"Algoma" Mill (Sault Ste. Marie, Ont.)
- Bethlehem Steel Company—"Lackawanna" (N.Y.) and "Steelton" (Pa.) Mills
- Colorado Fuel and Iron Corporation—"Colorado" Mill (Pueblo, Colorado)
- Dominion Steel & Coal Corporation (Canada)—"Dominion" Mill (Sidney, N.S.)
- Inland Steel Corporation—"Inland" Mill (Indiana Harbor)
- Tennessee Coal and Iron Company—"Tennessee" Mill (Birmingham, Ala.)
- United States Steel Corporation—"Carnegie" (Pa.) and "Gary" (Ind.) Mills

Special Rail Treatments or Processes

The last few years have seen a decided increase in special treatment of steel rails designed to increase wear resistance and prolong life and thus cut costs for all railroads, but particularly for those with unusual wheel loads, tonnages, terrain (curves) or all of these conditions.

Briefly stated, the most common of these are:

- Controlled cooling of rails (see page 21)
- Heat treating or hardening of rail ends (see page 24)
- Heat treating or hardening the head of the rail. (Railway Track & Structures, Sept. '63—Pages 26-28)
- Heat treating entire rails referred to as "Fully Heat-Treated" Rails (see page 25)
- Changes in manufacturing methods, chemical formulas or content during manufacture to produce tougher steel rails for today's traffic conditions and loads.

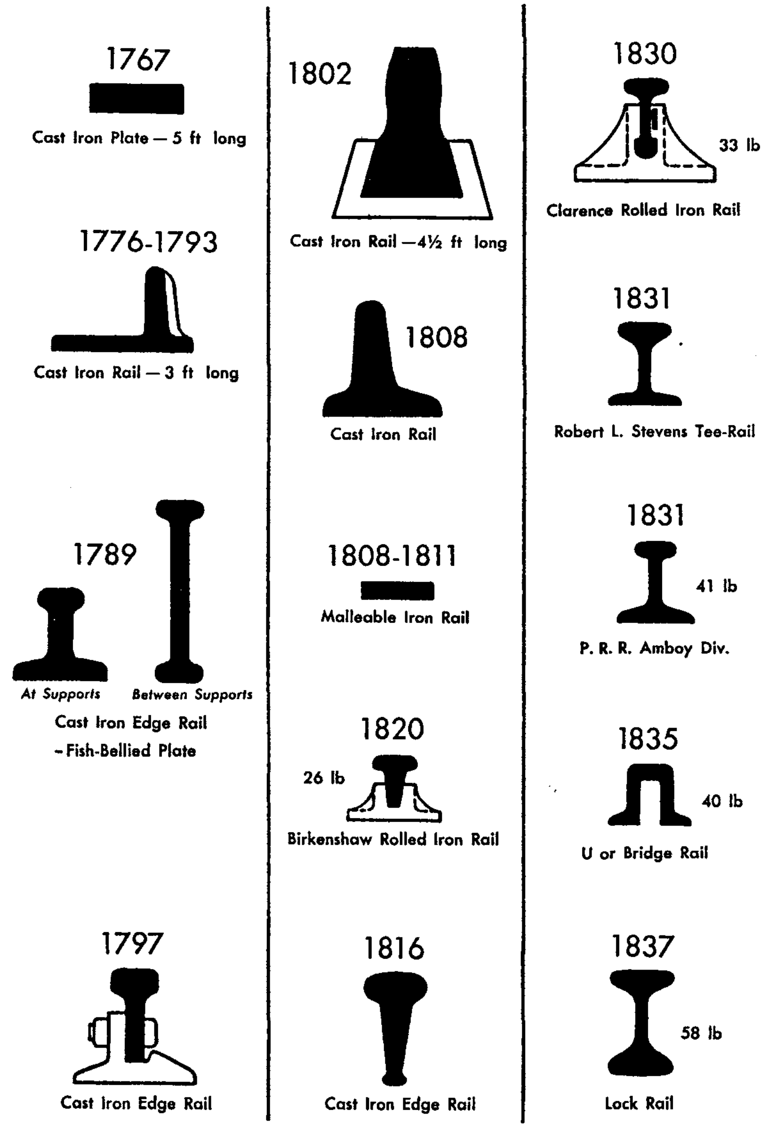
Rail ends are usually hardened at the mill by an electrical induction process, gas burners, or other suitable means though this process is sometimes carried out by railroads on rails already on their property or in track.

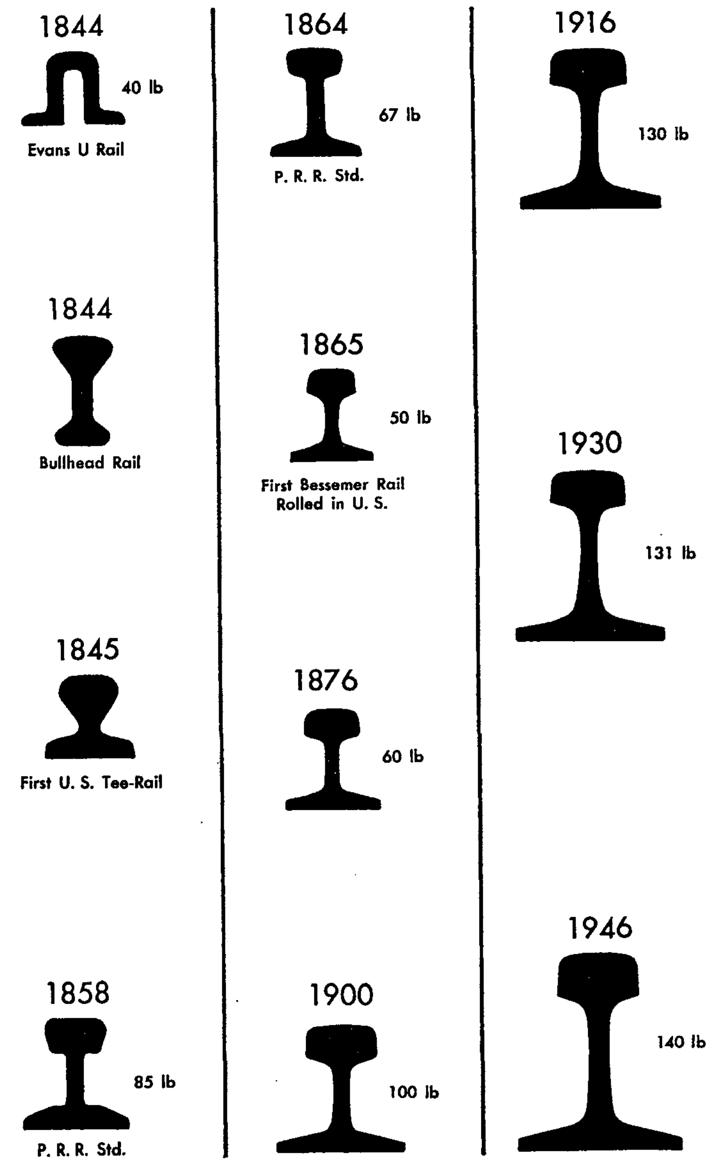
Heat treating the head of rails or the entire rail may be carried out at the mill or on railroad property with automated equipment (see page 25 for Bethlehem Steel's "Fully Heat-Treated" process). At U. S. Steel's Gary, Indiana plant rail heads are heat treated in pairs by an electrical induction system (A.C.) mounted on a movable carriage. As the latter rides over the rails the heads of the two rails are brought to a red hot temperature, then quenched by jets of compressed air followed by a water spray. Rails so treated by either process are said to provide 60% greater yield strength and 27% greater tensile strength than untreated rail, thus reducing normal rail wear on curves and grades and prolonging rail life.

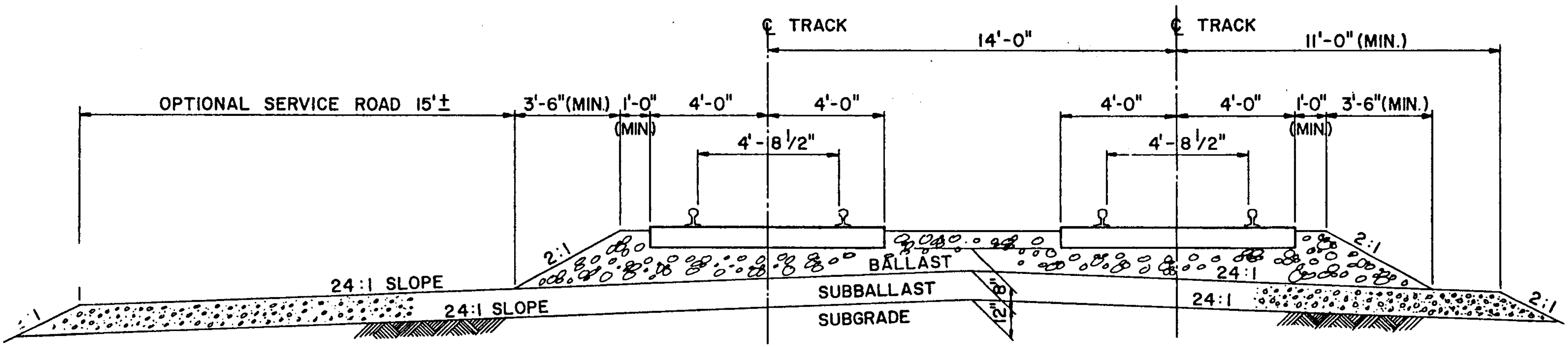
End hardening alone is designed to accomplish the same results in the restricted joint area where rail is normally subjected to unusual wear and batter.

Improved rail wear qualities are also being obtained by changes in specific amounts of certain elements normally specified for the manufacture of steel rail. The element, silicon, has drawn renewed recent attention though the first 17 heats of so-called "High Silicon" rails were made as early as 1930. Increased shelling of rail and detail fractures from shelling by 1950 led to increased investigation and

RAIL CROSS-SECTIONS DOWN THROUGH THE YEARS







DUAL TRACK MAIN LINE - TYPICAL CROSS SECTION

Figure 10-1

Long Beach - Los Angeles RAIL TRANSIT PROJECT
LOS ANGELES COUNTY TRANSPORTATION COMMISSION

Tie and Ballast Section

SECTION 02457

BALLAST

PART 1 - GENERAL

1.1 DESCRIPTION

The Work of this Section consists of quality acceptance testing, production testing, and furnishing crushed rock for use as ballast for ballasted track, ballast pad and walkway construction in the locations indicated.

1.2 INSPECTIONS AND TESTS

A. Inspections and tests shall be performed in accordance with the Quality Control Requirements, Section 01453 of these specifications.

B. General Requirements

1. Deleterious substances present in prepared ballast - not to exceed the following amounts as determined by the specified current method of test.

MATERIAL	PERCENT BY WEIGHT	METHOD OF TEST
Soft Pieces	5.0	AASHTO T189
Fines less than No. 200 sieve	1.0	ASTM C117
Clay lumps and Friable Particles	0.5	ASTM C142

2. Percentage of wear, after testing in a Los Angeles abrasion testing machine - in accordance with ASTM C535, not to exceed 35 percent for granite, 25 percent for traprock or 30% for quartzite.

3. The percentage of flat and elongated particles - not to exceed a weighted average of 5 percent by weight, as determined by the United States Army Corps of Engineers specification CRD-C 119.

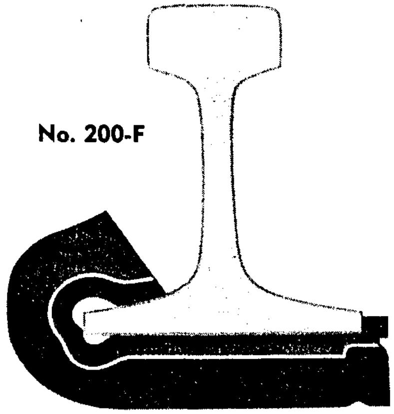
4. The weighted average loss - not to exceed 5 percent as determined in the sodium sulfate soundness test in accordance with ASTM C88.

5. Determination of weight per cubic yard - in accordance with the ASTM C29.

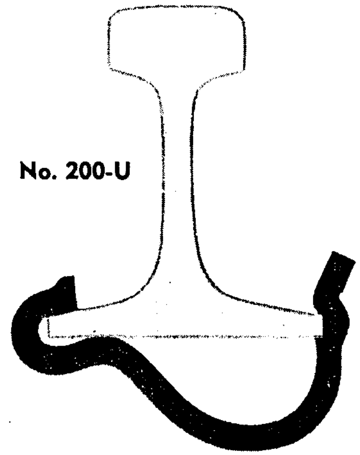
6. Samples shall be secured in accordance with the current ASTM methods of Sampling, designation D75. Test samples shall be reduced from field samples by the means of ASTM C702.

RAIL ANCHORS

No. 200-F



No. 200-U



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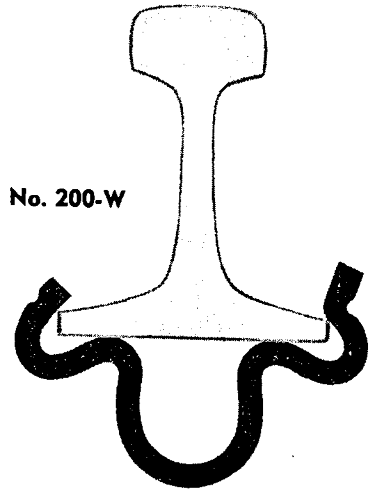
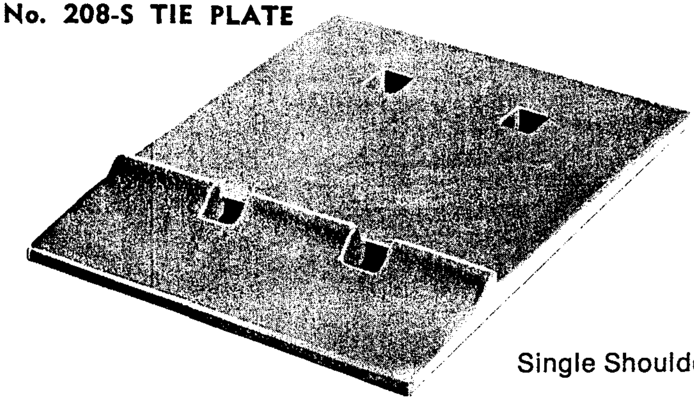


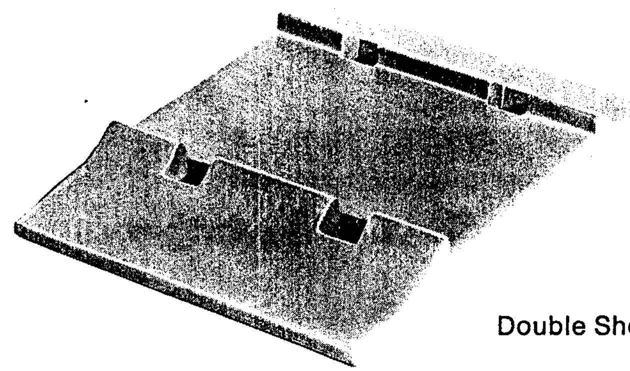
Rail Ancors are manufactured in one piece construction from spring steel or equal, heat-treated and designed to eliminate creepage of track. They provide a large bearing surface against both rail base and tie, avoiding undue cutting and wear, thus prolonging the life of the wood ties. They are easily applied by standard maul or a tool similar to a claw bar, can be used on new, undersized or worn bases and may be removed or reapplied in other locations.

No. 208-S TIE PLATE



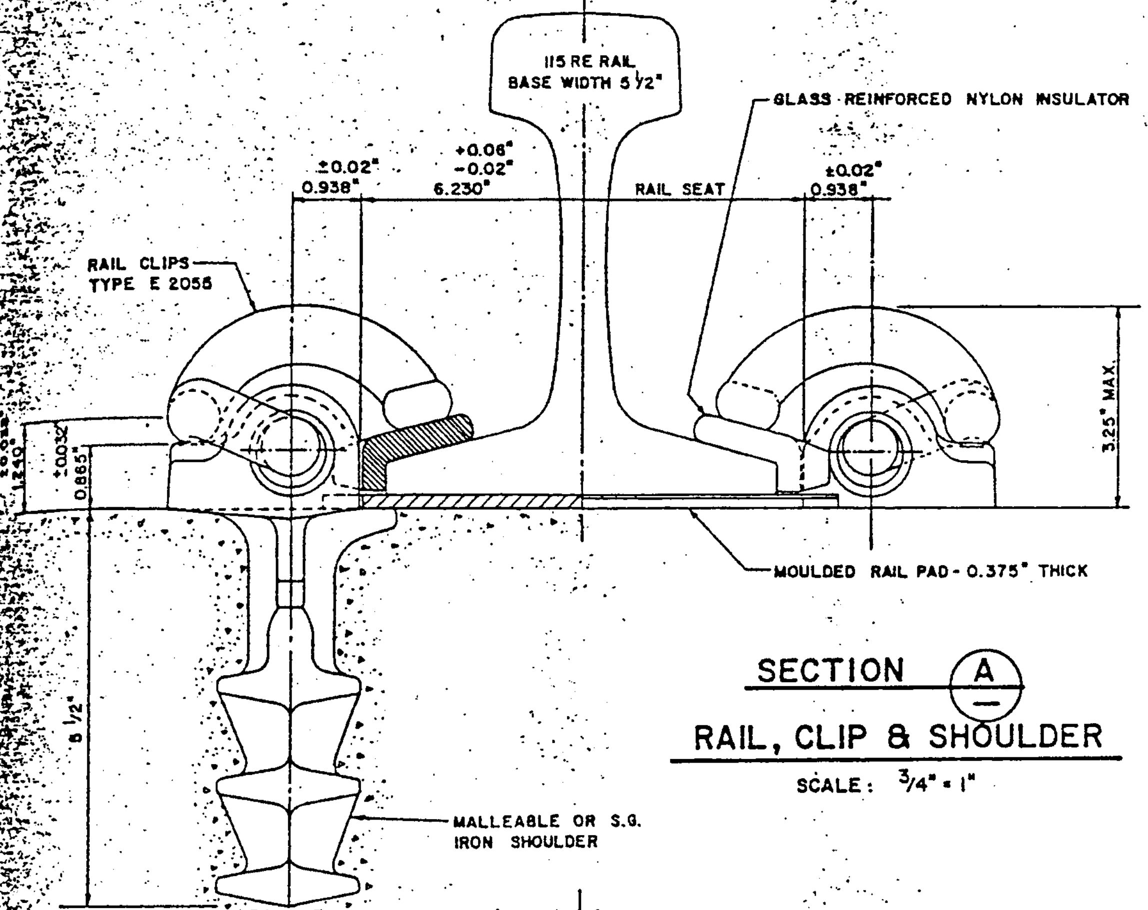
Single Shoulder

No. 208-D TIE PLATE



Double Shoulder

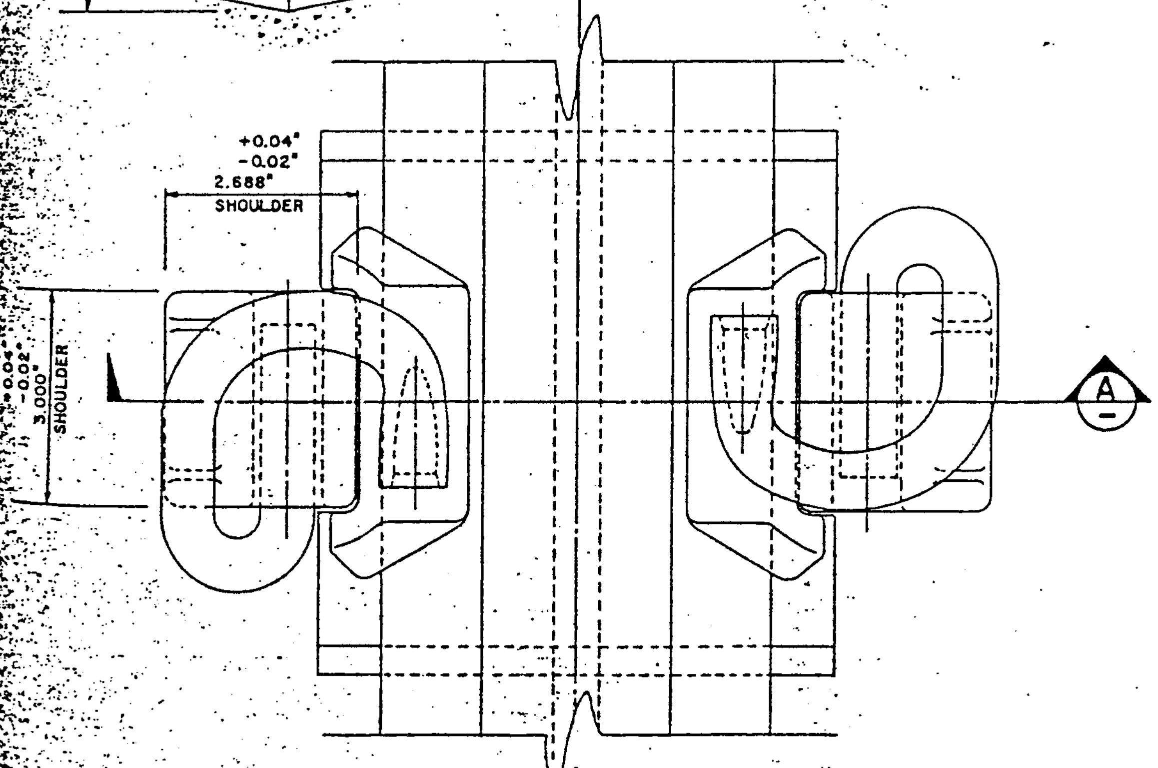
The use of single or double shoulder tie plates makes a more stable track and greatly lengthens the life of wood ties. Punched and sheared from hot-rolled steel sections, tie plates provide proper cant, uniform bearing surface for the rail and better load distribution to the ties. They hold the rail to gauge, providing more uniform wear to rail head and protect against undue wear to ties. Tie plates are designed with a long end or field end to be located outside of the rails. In the case of single shoulder tie plates, the shoulder is placed on the field end of the plate. The gauge end or short end of the plate is located inside of the rails. When ordering, identification of the rail section or the width of the rail base should be specified. Quality relaying tie plates are also available from our stocks which offer appreciable savings on railroad trackage and industrial sidings.



SECTION (A)

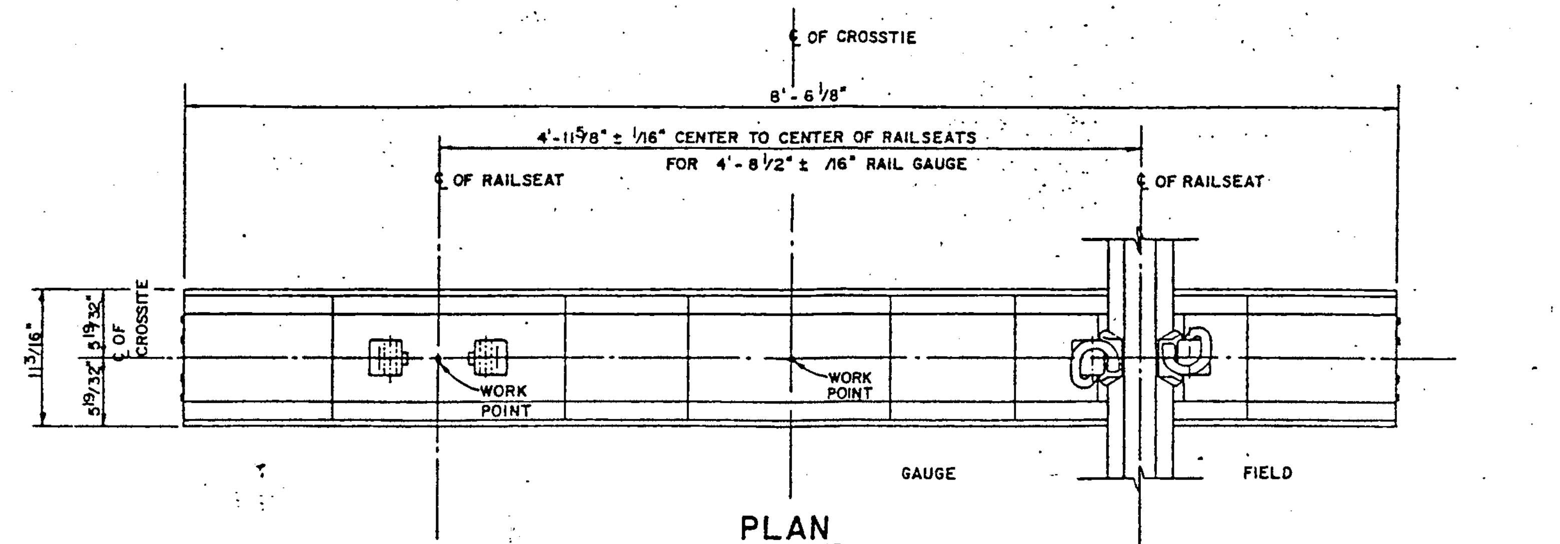
RAIL, CLIP & SHOULDER

SCALE: 3/4" = 1"



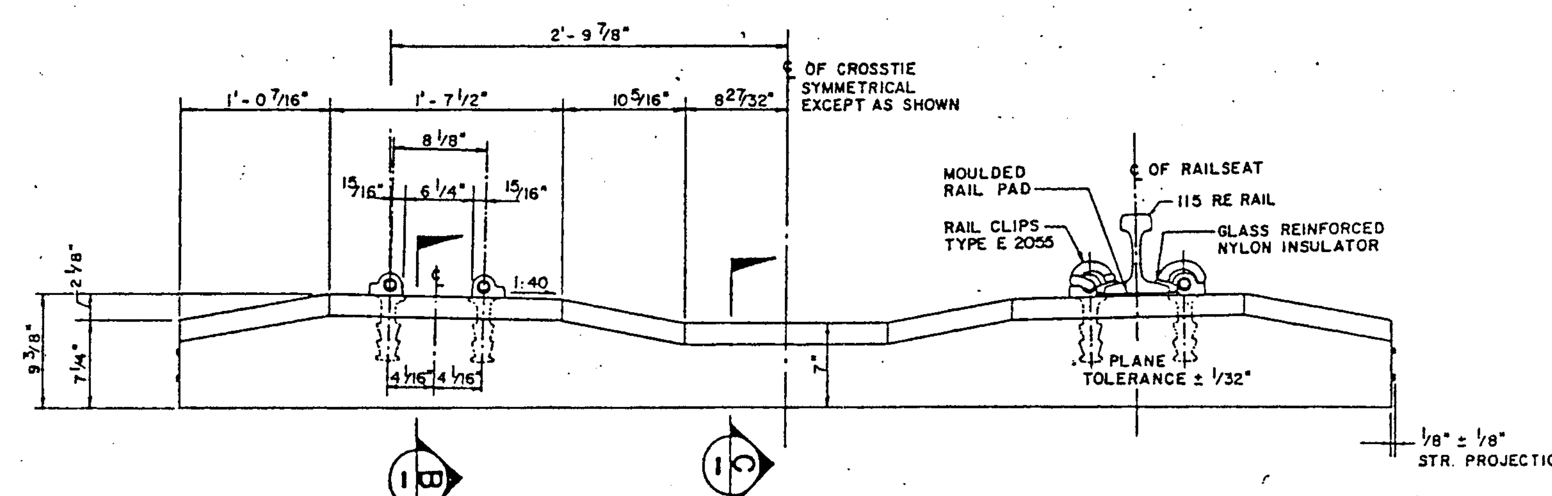
RAIL FASTENING ASSEMBLY

SCALE: 3/4" = 1"



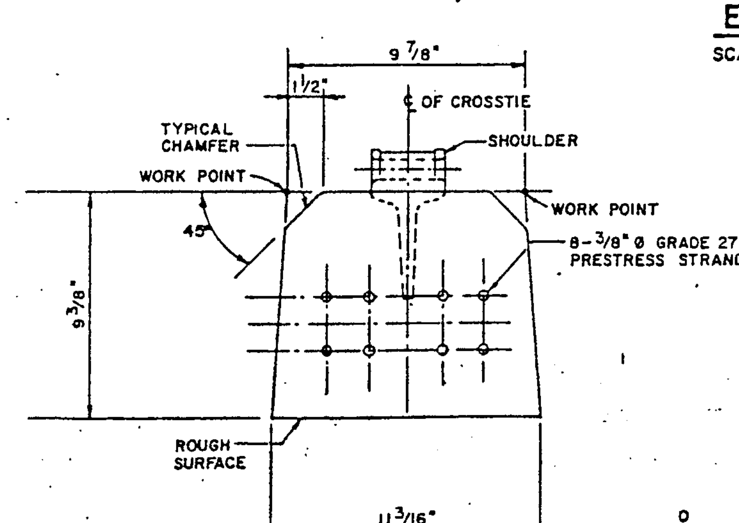
PLAN

SCALE: 1 1/2" = 1'- 0"



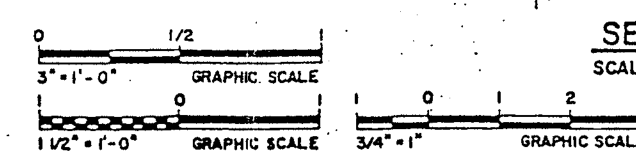
ELEVATION

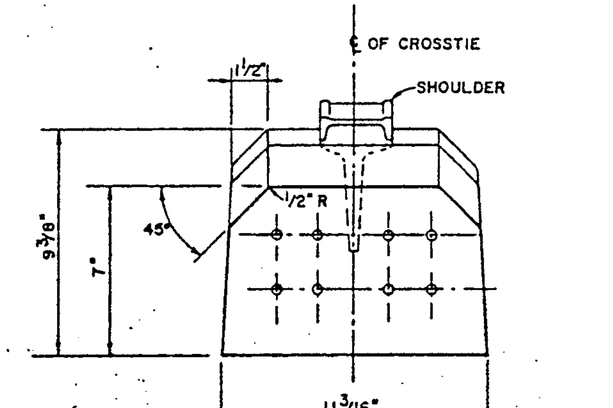
SCALE: 1 1/2" = 1'- 0"



SECTION (B)

SCALE: 3" = 1'- 0"





SECTION (C)

SCALE: 3" = 1'- 0"

5/5/87	ISSUED FOR BID		
DATE	DESCRIPTION	BY	APP.

Information confidential: all plans, drawings, specifications, and/or information furnished herewith shall remain the property of the Los Angeles County Transportation Commission, and shall be held confidential, and shall not be used for any purpose not provided for in agreements with the Los Angeles County Transportation Commission.

DESIGNED BY
DRAWN BY
CHECKED BY
APPROVED BY
DATE 5/20/87

REGISTERED PROFESSIONAL ENGINEER
WAYNE K. SAN FILIPPO
No. 19837
EXP. 9/30/89
CIVIL
STATE OF CALIFORNIA

LOS ANGELES COUNTY TRANSPORTATION COMMISSION

The Long Beach-Los Angeles Rail Transit Project

LACTC

DMJM

SUBMITTED:

Southern California Rail Consultants

A Joint Venture of
Parsons Brinckerhoff Quade & Douglas, Inc.
Kaiser Engineers (California) Corporation
Daniel, Mann, Johnson, & Mendenhall

APPROVED:

LRT TRACKWORK INSTALLATION

RAIL CLIP ASSEMBLY DETAILS

CONCRETE TIES - SHEET 1 OF 2

CONTRACT NO. R01-T08-C258

DRAWING NO. TK-1333

REV.

SHEET NO. 137

SCALE AS NOTED

6.4 STANDARD TYPE OF CONSTRUCTION

There are two classes of LRT tracks:

- o Mainline track is that used by vehicles carrying revenue passengers.
- o Yard and secondary tracks are all other tracks that do not carry revenue passengers, such as tracks constructed for the purpose of storing, maintaining, or switching transit vehicles.

Trackwork for these two classes of track may be of three basic types of standard trackwork construction:

- o Ballasted track
- o Ballastless track
- o Embedded track.

These types of track may be further classified as guarded track and special trackwork.

A. Ballasted track shall be the primary type used for trackwork constructed at grade. It shall consist of subballast, ballast, crossties, rails, and fasteners. It shall also be used for trackwork on aerial or bridge structures of less than 150' in length when bounded by at-grade sections of track.

The minimum depth of subballast measured from the bottom of the ballast to the top of subgrade shall be 12" for mainline track and 6" for yard and secondary tracks.

The minimum depth of ballast from the bottom of tie to the top of subballast shall be 8" for all the tracks except for ballasted embedded track where the depth of ballast shall be 12". Ballast slopes shall be 2:1, and the shoulders shall be 12" wide. The depth of ballast beneath the bottom of tie on ballasted-deck aerial structures shall be 8". The final top of ballast elevation shall be 1" below the top of tie.

No. 4 ballast (1-1/2" to 3/4") shall be used on all mainline trackage, except at grade crossings and embedded tracks where No. 5 (1" to 3/8") shall be used to reduce settlements. No. 5 shall also be used for the yard in order to provide a better walking surface.

Approach concrete slabs shall be used to support the ballasted track at the transition to ballastless track. Depth of ballast under the ties shall be 12" minimum.

B. Ballastless track shall be the primary type used for trackwork constructed by direct-fixation methods on aerial structures, bridges, and in subway structures. It shall consist of a supporting structural slab and a fastening system to hold the running rails to the concrete surface. This direct fixation type of track can also be used for certain types of embedded track construction.

C. Embedded track shall be the standard type used where LRT tracks are located in city streets, crossing the streets at grade or constructed at the maintenance facilities. These tracks can be either ballasted or ballastless with the standard tee or girder rail. The recommended type of embedded track for installations in streets of downtown Los Angeles and Long Beach and for intermittent at grade crossings within the mid-corridor, shall be determined during preliminary engineering.

6.5 RAIL

Running rail shall be 115 RE section, either shop or field welded in continuous lengths, with insulated joints as required by LRT signal track circuits. Standard running rail shall be control-cooled carbon steel, No. 1 rails in accordance with the requirements of AREA.

Wear-resistant rail shall be used in areas where heavy rail wear is anticipated. Wear resistant rail may be fully heat treated or of special alloy, depending upon cost and availability. Wear resistant rail shall be used for:

- All special trackwork
- Curves in mainline track with radii of less than 1,000'
- Curves in yard track with radii of less than 300'
- Through stations extending 300' beyond the ends of the platforms.

Seldom-used secondary, emergency, or storage tracks with sharp curvatures shall not be provided with wear-resistant rail.

Depending on the selected type of embedded track, running rail for these tracks may be grooved girder rail that shall be compatible with the selected wheel profile.

Rails in curves with the following sharp radii shall be precurved using standard shop practices:

- o Standard tee rail for curves of 300' radii or less.
- o Girder rail for curves of 500' radii or less.

Shop-welded joints shall be used wherever feasible; field-welded joints shall be used between strips of shop-welded rails, where rail handling may be a problem or where the rail requires pre-curving. The use of standard bolted joints shall be restricted to special trackwork, and epoxy-bonded bolted joints shall be used to join welded rail strings of incompatible chemical compositions. All joint bars shall be the 6-hole, 36"-long bar conforming to the AREA specifications.

6.6 GUARDRAILS OR RESTRAINING RAILS

A. Guardrails or restraining rails are provided on severe curvatures to prevent derailments from wheels climbing the outer rail and for reducing wear on the gauge side of the outer rail.

Track with sharp curvatures shall have the inside running rail guarded in accordance with AREA plans and specifications. It shall be installed in the following tracks:

- o All mainline tracks with a radius of 500' or less.
- o All yard and non-revenue secondary track with a radius of 100' or less.

These requirements do not apply to special trackwork.

The guarding protection shall be provided by using vertically or horizontally mounted guardrails, set to flangeway openings based on the selected wheel profile.

For curved embedded tracks where a girder rail is specified, the girder guard rail shall be used.

Guardrails shall extend beyond the curve onto tangent track on each end of the curve a minimum distance of 35 feet.

B. Emergency guardrails or check rails are sometimes provided in an attempt to contain the car wheels in the event of a derailment. They are normally provided on bridges and aerial structures; however, their value and effectiveness are questionable, especially in the case of high-speed derailment.

If emergency guardrails are required, then they shall be installed near the gauge side of the inner rail at a distance of approximately 12" from the running rail.

6.7 TIES

All ballasted mainline and yard tracks shall use concrete ties spaced 30" center to center for tangent and curved track of a radius greater than or equal to 500'. In curves of radii less than 500', concrete ties shall be spaced 24" center to center.

For ballasted embedded track, the tie spacing shall be 24" center to center.

Concrete ties shall conform to AREA specifications.

Timber ties shall be used for special trackwork installations and for certain types of embedded track construction. Standard timber ties shall be 8'-0 in length, conforming to AREA Size 4, spaced 24" center to center or as required by the types of embedded track surfacing.

Timber ties for special trackwork shall be spaced as established by AREA and with the trackwork standard drawings. Switch ties shall be 7" x 9" and of various lengths as required.

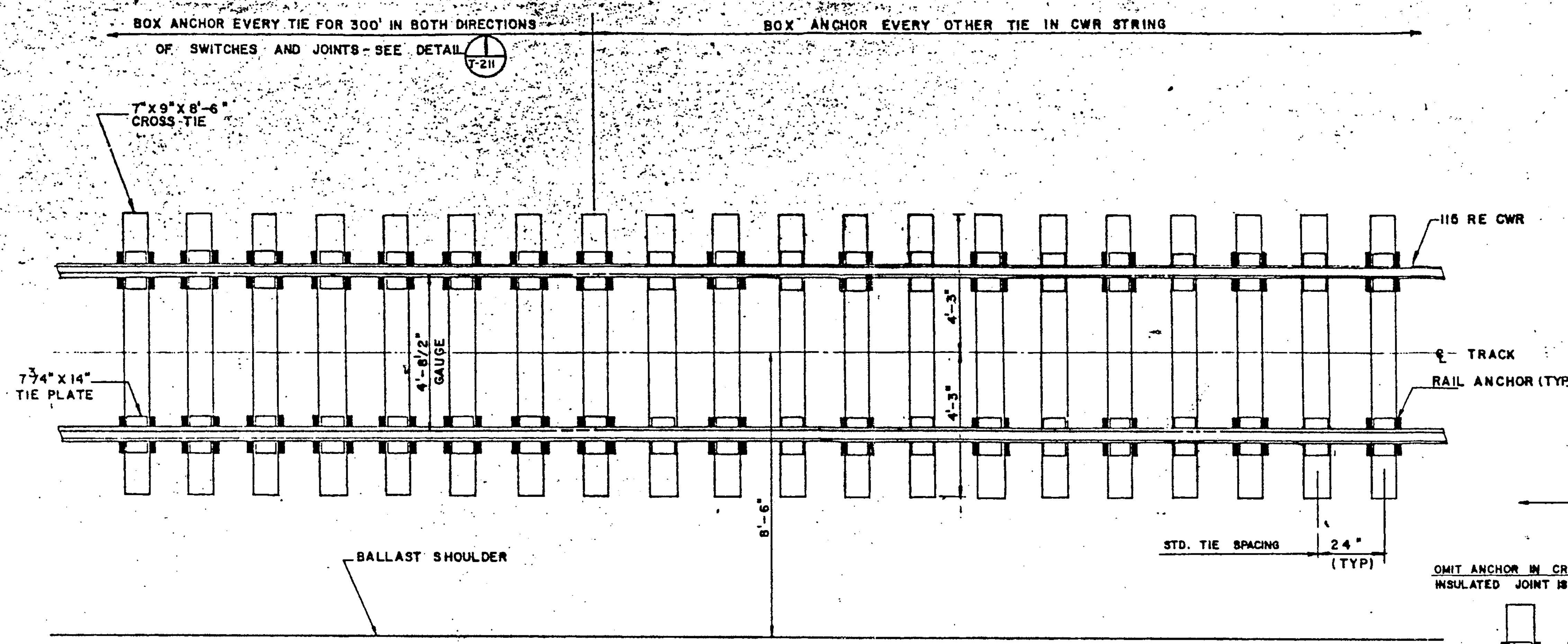
6.8 FASTENINGS

Rail shall be fastened to its support in a manner that depends upon the track construction. Interchangeability of parts and hardware uniformity are important factors in the selection of the standard fastening systems. Details of these fastening systems will be developed during final design. Ballasted and ballastless tracks shall use a fastening system consisting of a non-threaded elastic rail fastener of a proven design, which electrically isolates the rail from the tie and the ballast or track concrete.

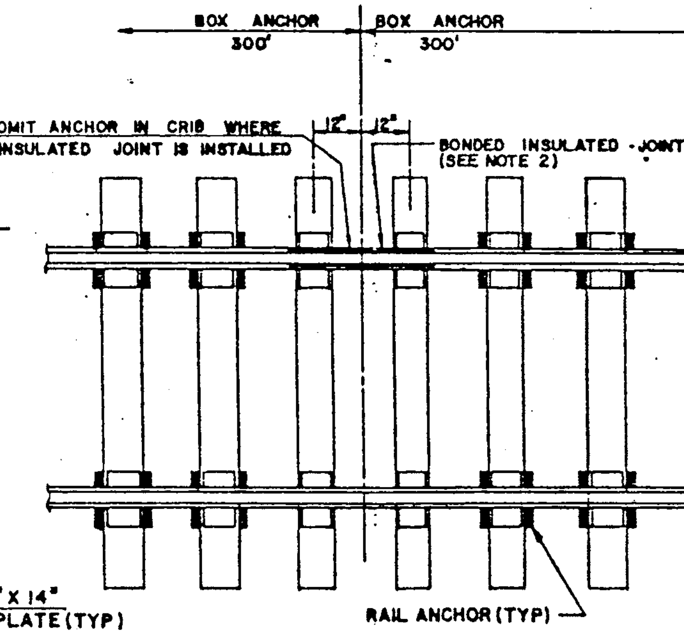
Ballasted track with concrete ties shall use rail hold-down fasteners consisting of spring clips, insulators, elastomer pads and anchor bolts.

Direct-fixation fasteners shall use a fastening system consisting of spring clips, insulators, elastomer pad, and anchor bolts. Direct-fixation fasteners shall be spaced 30" center to center.

Ballasted track with timber ties shall use an identical fastening system with screw spikes replacing the anchor bolts.



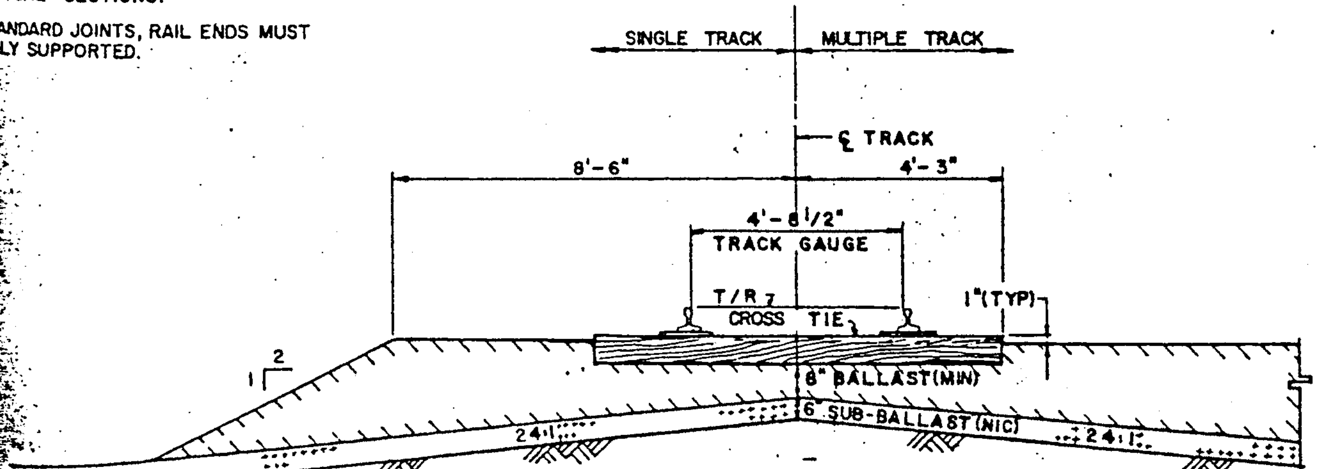
PLAN
SCALE: 1/2" = 1'-0"



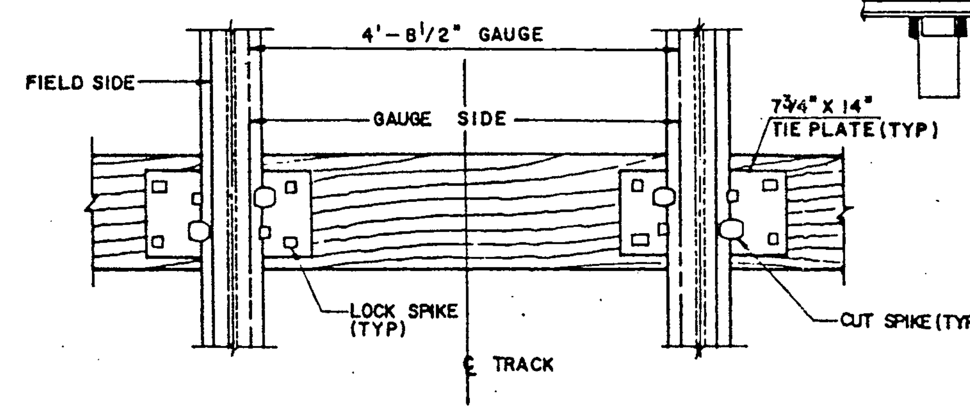
DETAIL 1 T-211
SCALE: 1/2" = 1'-0"

NOTES:

1. THE DIMENSIONS AND QUANTITIES SHOWN ON THE TYPICAL SECTION ARE THE MINIMAL DIMENSIONS AND QUANTITIES. DO NOT USE FOR ESTIMATING PURPOSES. SEE INFORMATION DRAWINGS FOR ACTUAL SECTIONS.
2. FOR STANDARD JOINTS, RAIL ENDS MUST BE FULLY SUPPORTED.



TYPICAL SECTION
SCALE: 1/2" = 1'-0"



SPIKING FOR TIMBER TIES
NTS

RAIL ANCHOR PLAN
SPIKING PLAN

REV	DATE	BY	SUB.	APP.	DESCRIPTION

THE PREPARATION OF THIS DRAWING HAS BEEN FINANCED IN PART THROUGH A GRANT FROM THE U. S. DEPARTMENT OF TRANSPORTATION, URBAN MASS TRANSPORTATION ADMINISTRATION, UNDER THE URBAN MASS TRANSPORTATION ACT OF 1964, AS AMENDED, AND IN PART BY THE TAXES OF THE CITIZENS OF LOS ANGELES COUNTY AND OF THE STATE OF CALIFORNIA

DESIGNED BY J. Leclair
DRAWN BY R. C. Spain
CHECKED BY Paul T Bates
IN CHARGE Joseph B. Valencia
DATE 15 JUL 85

REGISTERED PROFESSIONAL ENGINEER Joseph B. Valencia C 25756 CIVIL STATE OF CALIFORNIA

SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT
METRO RAIL PROJECT
RTD

SUBMITTED Joseph B. Valencia
DMJM/PBQD/KE/HWA A JOINT VENTURE GENERAL CONSULTANTS
APPROVED

LA CBD TO NORTH HOLLYWOOD
TRACKWORK INSTALLATION
STANDARD YARD TRACK CONSTRUCTION
NON ELECTRIFIED

CONTRACT NO. A610
DRAWING NO. T-211
REV
SCALE AS NOTED
SHEET NO. 91

C E Jones

Rail Manufacture

CHAPTER I

MANUFACTURE OF STEEL RAILS

The Open Hearth

Western Pacific's rail is made by the "Open Hearth" method, most of it at the Colorado Fuel & Iron Corporation plant at Pueblo, Colorado. The open hearth is a huge furnace of steel and brick, which is capable of handling slightly over 100 tons of molten steel at a time. Colorado Fuel & Iron Corporation has sixteen open hearths. Each one has a set of oil or gas burners which are capable of maintaining a temperature of over 3,200 degrees Fahrenheit inside the open hearth.

The Heat

Each batch of steel produced in an open hearth is called a "heat." Materials necessary to make steel are primarily pig iron, scrap, ore, and limestone. All the ingredients of a heat are loaded in oblong steel "Charging Boxes" which are loaded on narrow-gauge cars and hauled to the open hearth. A "Charging Machine" picks up each box, shoves it through the

"Charging Door" of the open hearth, turns it upside down, and withdraws it. Under the intense heat of the flames, the mixture melts down into a bubbling white-hot liquid.

At precisely the proper moment, an opening is made in the open hearth, and the entire hundred or more tons of molten metal are allowed to run into a large brick-lined ladle. This is called "tapping the heat."

Work begins immediately, to charge the next heat. Each open hearth can produce about two heats every twenty-four hours.

Due to the nature of the operation, it is impossible to make the heats exactly alike. Therefore, a careful record is kept of each heat; its weight, its ingredients, its temperature, etc. One ingredient particularly important to the railroads is carbon. This is because, while the total carbon content is less than one percent of the whole, it adds to the hardness and toughness of the steel. The railroads select the rails with the higher carbon content for use where the wear is greatest, such as on curves, etc.

If the final quality of the heat does not measure up to the rigid specifications for rail, it is slated for some lower-grade product like tie plates.

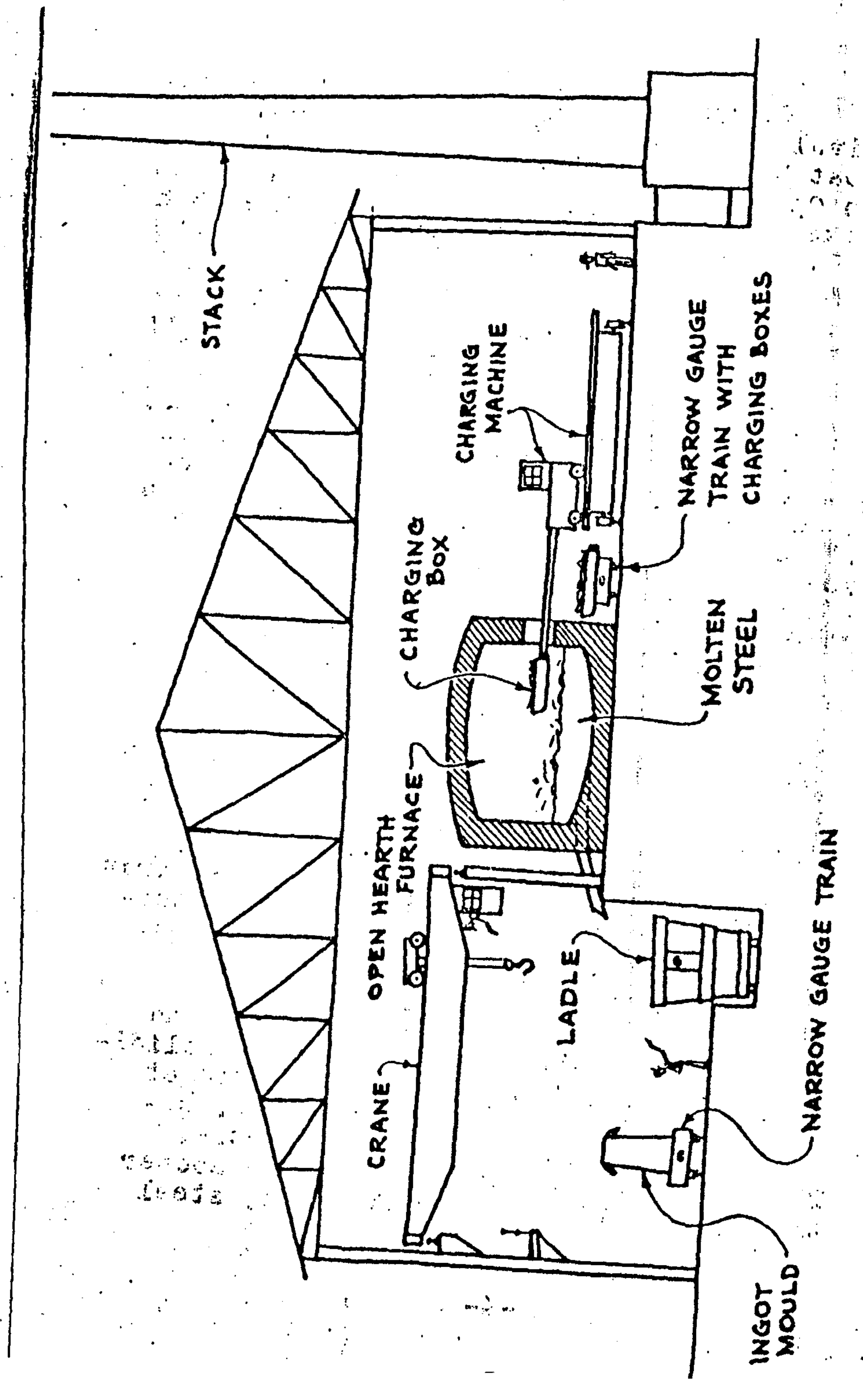
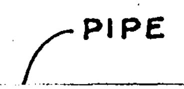


FIGURE 1

shrinks as it cools; so, as the outside cools and shrinks, the still molten metal at the center settles downward to fill the space created by the shrinkage. This ... causes a cavity to appear



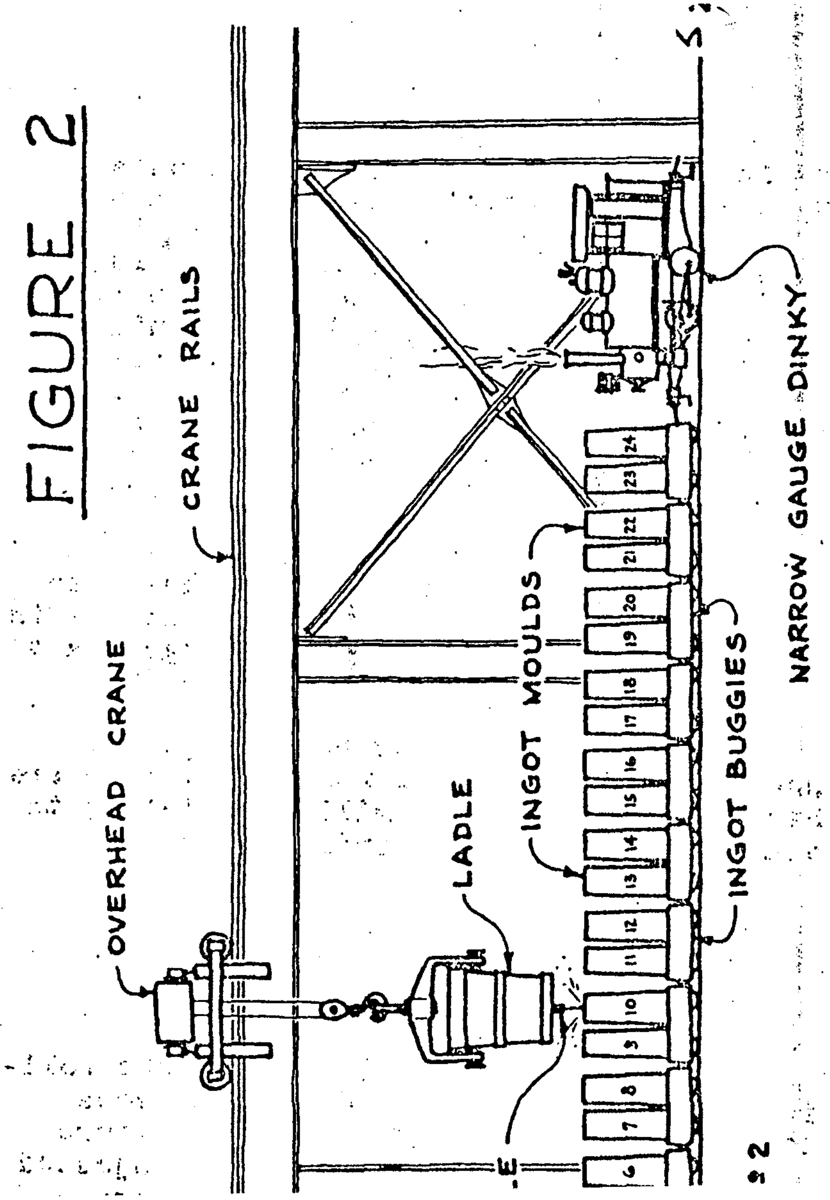
...ty

Colorado heats are numbered consecutively by open hearths. For instance, Heat No.8342 is the 342nd heat produced in Open Hearth No.8 during the year. Likewise, Heat No.16036 would be the 36th heat out of Open Hearth No.16.

The Ingot

After the molten metal has run from the open hearth into the ladle, an overhead crane picks up the ladle and carries it to the ingot molds. These molds are vertical cast iron boxes about two feet square inside and about seven feet high. About twenty-four molds are placed on narrow-gauge railway cars for the pouring or "Teeming" process. The ladle is spotted over the first of the molds, and a stopper is lifted from the bottom of the ladle. When the first ingot mold has flowed full of steel, the stopper is replaced and the ladle moves over to the next ingot mold. An average heat will fill from 19 to 23 ingot molds. The first ingot poured becomes Ingot No.1, and succeeding ingots are numbered in the order they are poured.

The ingots are allowed to cool and ...



Blooming

The ingot is laid on its side, on a
set of power driven rollers. The rollers
trundle the ingot to the "Blooming Mill,"
a large machine that is faintly reminisc-
ent of a washing machine wringer. The
ingot is forced between a pair of steel
rolls which are a bit closer than the
ingot is thick. The ingot comes out a
bit thinner and longer than it was. The
rolls are then brought closer together
and reversed, the ingot is flopped over,
and the rollers which carry it are re-
versed so the ingot heads back to the
Blooming Mill and gets squeezed again.
The ingot passes back and forth until it
is about nine inches square and about
fifty feet long.

It will be noted, by referring to
Figure 4, that the pipe is still present
in the ingot, only it has been narrowed
and elongated. Most of the cavity has
been closed, but the discontinuity of the
metal still exists.

The ingot has now been reduced to a
size where it becomes necessary to start
shaping the rail. Before starting on the
shaping process, the ingot is cut into
two pieces, because, if the full ingot
were to be rolled in one piece, it would
result in a rail over 200 feet long,
which would be too unwieldy to handle.
The cutting is done on the "Blooming
Shears," a machine that literally bites
off the nine-inch-square bloom.

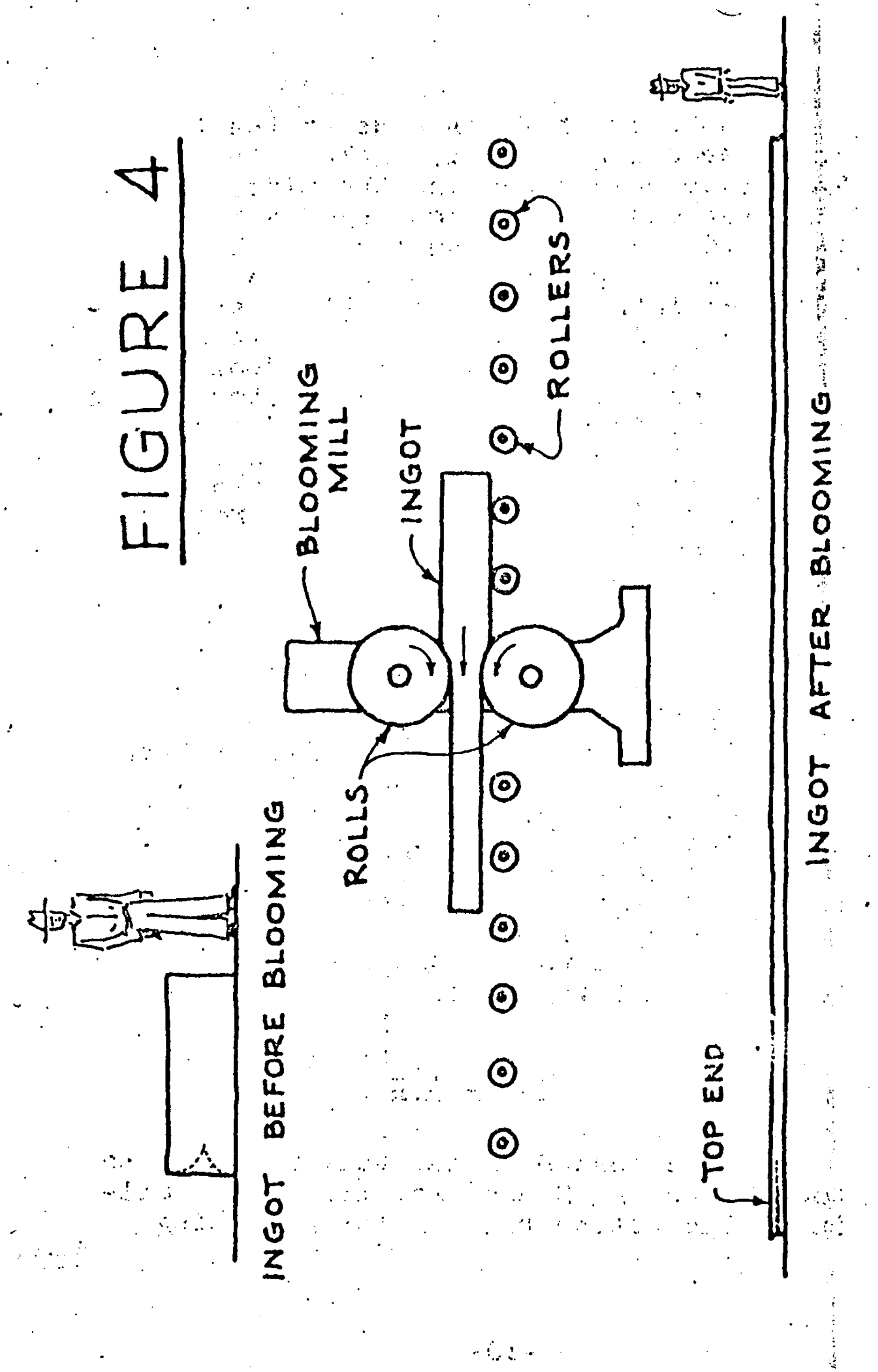


FIGURE 4

The first bite is made at the top end, far enough back to include the pipe. The piece which contains the pipe, called the "top discard," is conveyed out and scrapped. Sometimes an ingot with an extra long pipe gets by with some of the pipe remaining, which condition is detected later, as we shall see. The ingot is then cut in two at about its midpoint and another cut is made near the bottom end to remove the imperfect butt called the "bottom discard." The two pieces remaining are called "Blooms." These blooms, still red hot, continue on to be rolled into three rails each.

Roughing

The bloom now approaches the "Roughing Stand," a rolling mill similar to the Blooming Mill, except that the surfaces of the rolls are shaped so that, with each pass through the rolls, the bloom begins more and more to resemble a rail. It also grows in length as its sectional area is reduced. After nine trips back and forth, the bloom is ready for its finishing pass.

Finishing

The almost-finished rail now goes to the "Finishing Stand" for its final rolling. The bottom roll in the Finishing

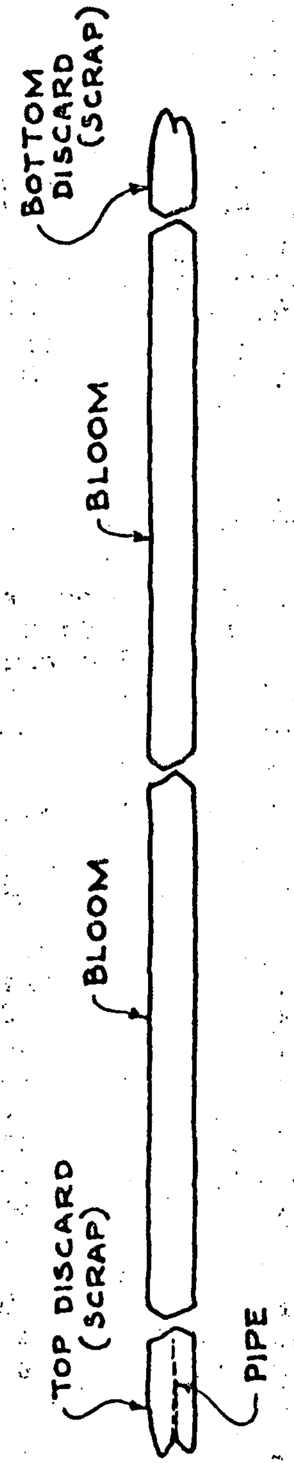


FIGURE 5

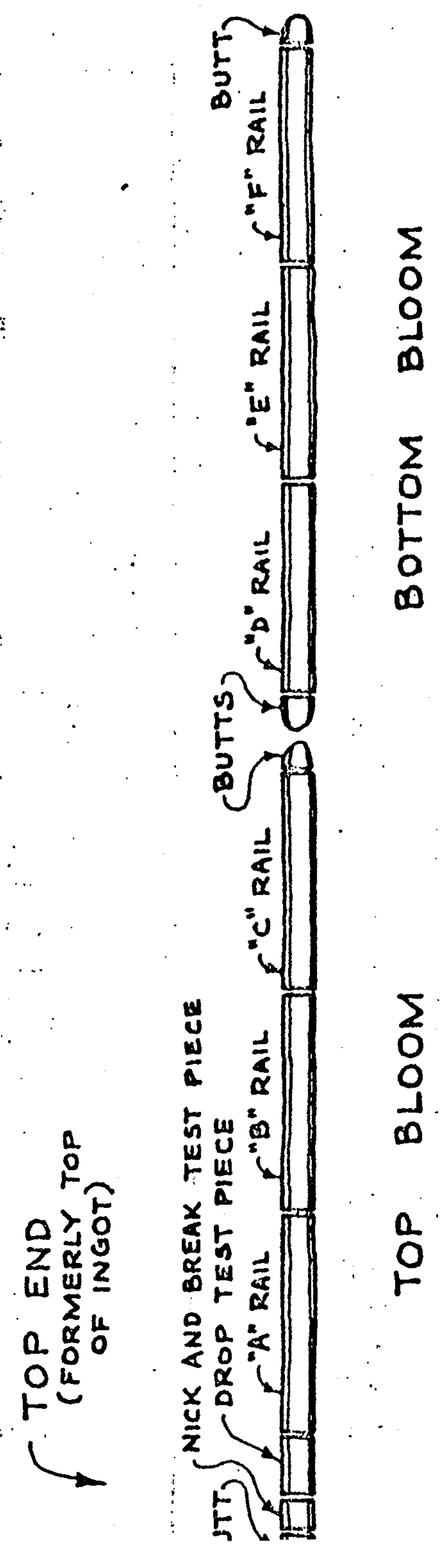
Stand has carved into its surface the letters which form the "Branding" of the rail, which shows the year and month rolled, size of the rail, name of the mill, and "CC" to designate "Control Cooled." When the rail comes from the finishing stand, it is about 130 feet long.

Hot Saw

The finished rail now approaches the "Hot Saw" to be cut into 39-foot lengths. The hot saw is a high-speed circular saw which cuts through the red-hot rail section in less than one second, in a spectacular shower of sparks.

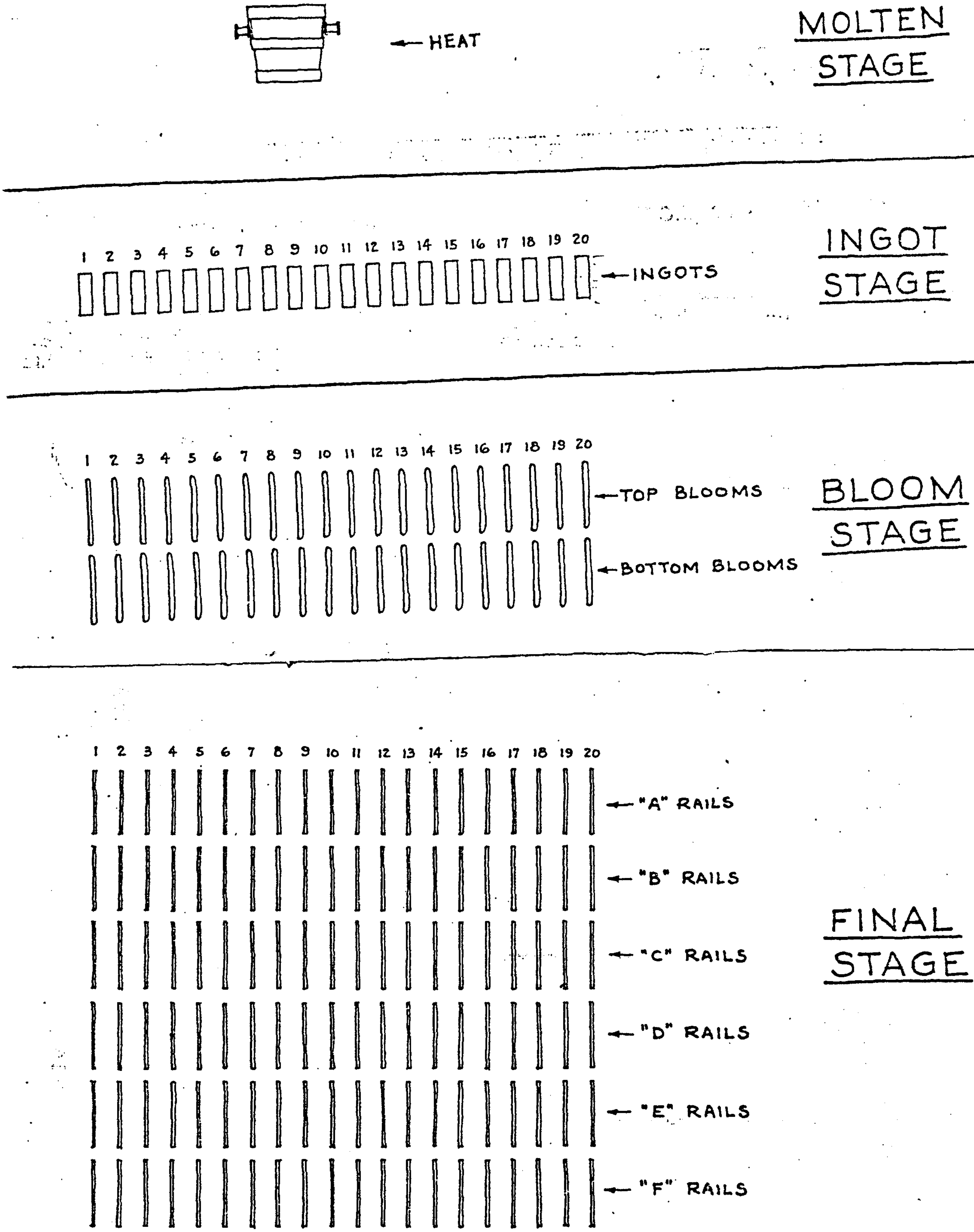
The section of rail made from the top bloom is first cut near the top end, to remove the imperfect butt end. Next a piece about fourteen inches long is cut off as a "Nick-and-Break Test Piece." On about every tenth ingot, a five-foot-long "Drop Test Piece" is cut off the rail from the top bloom. The main section is then cut into three 39-foot rails, and the short butt end remaining is scrapped. The section of rail made from the bottom bloom of the ingot is cut similarly, except that no test pieces are cut.

One 39-foot rail leaves the hot saw every 25 seconds, and each rail has spent about 5½ minutes under the rolls since leaving the soaking pit in ingot form.



THE INGOT AFTER HOT SAWING

FIGURE 6



HEAT
MOLTEN STAGE
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
INGOTS
INGOT STAGE
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
TOP BLOOMS
BOTTOM BLOOMS
BLOOM STAGE
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
"A" RAILS
"B" RAILS
"C" RAILS
"D" RAILS
"E" RAILS
"F" RAILS
FINAL STAGE

FIGURE 7

Stamping

The six rails which have come from the ingot are carried on rollers from the hot saw to the "Stamping Wheel." Each rail, which is lying on its side, with the branded side down, is stamped on its upper side, in the web, with its heat number, ingot number, rail letter, and letters "CC" (which designate control cooled rails), or "CH" (which designate control cooled end hardened rails), by a wheel which has the stamping dies mounted on its rim. The top rail of each ingot is lettered "A", the next one "B", and so on. (See Figure 6)

Section Inspection

An inspector is stationed where the rails come out of the stamping wheel. He removes one red-hot rail for every heat, from the roller line, and subjects it to rigid inspection. The rail is weighed, its section is checked with templates, its height and width of base are measured, and its surface is scrutinized for defects. This inspection is witnessed by the Western Pacific man and also by the millwrights, who go back and adjust the rolling mills if any variations or flaws show up in the rail.

The Hot Bed

The rails, now finished with the rolling process and still red hot, are carried on rollers to the "Hot Bed." This is nothing more than a set of skids on which the rails are lined up, side by side, for cooling. The rails are allowed to lie there until they cool to just under 1,000 degrees, the temperature at which they lose the last of their red color.

Control Cooling

The rails are then picked up by large magnetic cranes and lowered into insulated steel "Control Cooling Boxes," each one big enough to hold 100 rails. A lid is put on each box as it is filled, and the box is not opened for at least ten hours, until the rails are under 300 degrees. This process is called "Control Cooling" and its purpose is simply to slow down the cooling of the rails between the temperatures of 725 and 300 degrees.

Control cooling was first used in the late 1930's to combat the "Transverse Fissure." Every section foreman is more familiar with transverse fissures than he cares to be. It is a mysterious "disease" of the rail, which starts without warning inside of the rail, grows erratically, then causes a sudden break of the rail.

Drop Test

The five-foot-long drop-test piece of rail which is cut from the top end of the second, middle, and last ingot of every heat, is stamped with its identification, and is put into a miniature "control cooling box" so that it cools under the same conditions as the rails it represents. When it is cold, it is placed under the "Drop Test Machine." The piece rests "Head" up on a pair of supports which are four feet apart, and a one-ton weight called the "tup" is allowed to fall on it from a height of twenty feet. An inspector measures the amount that the rail has bent under the blow. A 115-lb. rail will usually take a 3/4" permanent set at the first blow. Every third drop-test piece is given a total of five blows to see how it stands up under such punishment. Most rails will bend through 45 degrees without breaking. This test is also witnessed by the Western Pacific inspector.

If a drop-test piece should break under the first blow of the tup, all of the "A" rails of that heat are rejected and scrapped, and another drop test is made of the "B" rails.

Straightening

Going back now to the control cooling boxes, we find the rails, now under 300 degrees, being lifted from the boxes and sent on their way to the "Finishing Mill." The first finishing operation is at the "Straightening Presses."

Rails are quite crooked after cooling, because of the handling they have received while hot and soft, and because of the cooling stresses. Each rail is moved under a press on rollers. The "Straightener" stands at the end of the rail and squints along it against a strong light. He determines where the "crooks" are and signals to his assistant the "Gagger" where to apply the pressure to straighten the rail.

The straightener, when squinting against the light, sometimes discovers "blister" flaws in the rail. Blisters are the final form of the little bubbles which occur at the bottom tip of the pipe in the ingot, and are closely related to pipe. These little bubbles are rolled flat in the rolling process, but they open up in the cooling, to form low bumps in the web of the rail, and are detected in the course of inspection.

Milling and Drilling

The straightened rail goes to a pair of milling machines which smooth the ends of the rail and cut off the rough burrs left by the hot saw.

The rail then moves to a pair of multiple drill presses which drill the bolt holes.

End Hardening

After drilling, the rail moves under a set of burners which heat about 2-1/2 inches of the top of the rail at each end. When the metal reaches red heat, it is subjected to a sudden jet of cold air. This treatment hardens the metal of the rail where it is subjected to the pounding of car wheels as they jump over the gap between rails.

End hardening is a development which reduces end batter and low joint conditions, thereby considerably reducing wear in the joint-bar area.

Inspection

The rails, which are now ready for track except for end beveling and filing, are laid out in groups of 60 or 70 for inspection. Men with air grinders and files touch up the ends of the rails during the inspection operation.

Two men called "Rail Turners" turn the rails so their bases are up, and a pair of mill inspectors called "Rail Walkers," and the Western Pacific inspector, walk back and forth on the inverted rails, searching them for flaws. If a large flaw is found, the rail is marked for scrapping, or, if the flaw is near enough to the end of the rail, it is marked for cutting back. If a minor flaw is found, the rail is classified as a No.2 rail.

The rail turners then turn the rails on their sides so that the stamped side is up. The inspectors then refer to their notes and mark each rail as to whether it is high or low carbon. They also refer to the list of ingots which showed pipe in the nick-and-break test. The "A" rails of these ingots are found and marked for special attention.

The rails are then turned head up, and again the inspectors walk back and forth, searching and marking. The inspectors then inspect the ends of all "A" rails for pipe, with particular attention to those which showed pipe in the test piece.

The last check is made for "crooks," the term used for crooked rails, by squinting along each rail from each end.

Three crews of inspectors are required, to handle the work, and the Western Pacific man spends part of his time with each crew.

Painting

At the completion of the inspection, the rail turners paint the ends of the rails in accordance with the inspectors' chalk marks. All the No.2 rails are painted white and a "2" is stamped on each end of each rail. All "A" rails are painted yellow. "A" rails are separated from the other rails because they come from the top of the ingot, which is considered the least desirable. Scrap rails are painted red. High carbon rails are painted blue, and low carbon rails are left unpainted.

Sorting and Loading

An overhead crane, equipped with magnets which can pick up thirteen rails at a time, sorts each bed of inspected rails. Red rails are dumped on a car and routed back to the open hearth, for remelting. White, yellow, blue and plain rails are sorted and loaded on cars for shipment to the customer.

"Crooks" are taken to the "Restraightening Press" and are reinspected, painted and loaded.

Rails marked for cutting back are taken to the "Cold Saw," where the defective end is cut off, and the rail is redrilled.

Short rails coming from the cold saw are reinspected, painted green, and loaded.

It is interesting to note that the mill has no provision for carrying a stock of rail. Rails must be loaded on cars immediately, as they are finished, or a serious "traffic jam" occurs in the inspection and loading area.

Records

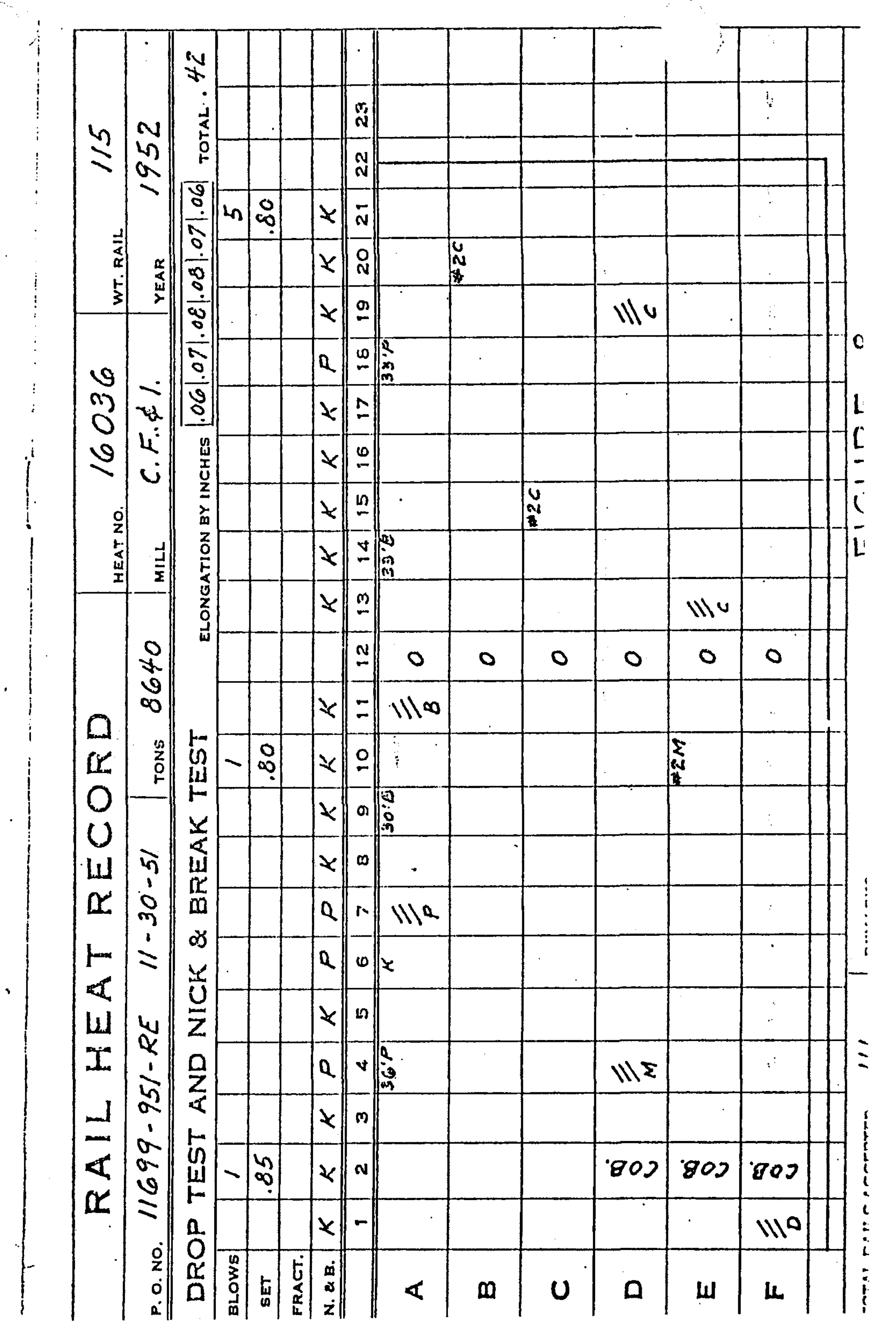
As the cars of rail leave the steel mill, the Western Pacific inspector telegraphs the car numbers, contents, and departure dates to the General Office, so that arrangements can be made to unload the rail as soon as it shows up.

The inspector then sits down at his desk at the mill and prepares a very important record. This record shows, in very compact form, the history of every heat of rail that was rolled for Western Pacific. The information is entered on two sides of a 5" x 8" card which will later be filed in the Engineering Department, to remain there for the entire life of the rail.

Figure 8 shows the front side of the card, filled in to show an imaginary heat. While few cards show so many defects, we have made the entries here to show the simple code that is used.

Referring to the card, we see right away that the card covers Heat 16036 which was rolled into 115-lb. rail in 1952, at CF&I, to Western Pacific's Purchase Order No.11699-951-RE, dated November 30, 1951.

We can see that there were 21 ingots cast from the heat. We also see that "Drop Test" pieces were cut from Ingots 2, 10, and 21. No.2 was given one blow and



took a permanent set of .85 of an inch. No.10 also received one blow and set .80 of an inch. No.21 was given five blows and set .80 of an inch after the first blow. If the piece had broken on say the fourth blow, the entry in the "Blows" line would have been "4B" and the nature of the fracture would have been entered on the line marked "Fract."

The line marked "N&B" shows the outcome of the "Nick-and-Break" test. We can see that Nos.4, 6, 7, and 18 showed pipe (P) and that all the others were OK (K). There was no test made for Ingot No.12, for the reason that the ingot was omitted (O); that is, Ingot No.12 was not rolled into rails because of some defect.

Looking at Ingot No.4 a bit closer, we see that, in addition to the pipe in the Nick-and-Break test, the "A" rail also showed pipe, and that it was cut back to a 36-foot rail to eliminate the pipe. Likewise the "A" rail of Ingot No.18 was cut back to eliminate pipe. The pipe in Ingot No.6 was not serious because the "A" rail was clear; however, in Ingot No.7 we find the entire "A" rail scrapped on account of pipe. (The three little lines mean "scrap")

Ingots 9 and 14 evidently had some blister present, for we see the "A" rails cut back to 30 and 33 feet for blister (B). Rail 11-A also had a blister, but it was close to the middle of the rail, so it was scrapped.

Something must have gone wrong with the bottom bloom of Ingot 2 in the rolling process, for we see that the D, E, and F rails are marked "COB" (Cobbled). Such cobbled rails are usually fished out of the machinery, partially rolled, and are scrapped.

Rails 10-E, 15-C, and 20-B were classified as No.2 white rails, one of them marked "M" (Mechanical) for a rolling defect, the others marked "C" (Common) for defects that were in the steel before rolling. Rails 4-D, 13-E, and 19-D were scrapped for the same kind of defects but of a more serious nature.

Rail 1-F was scrapped on account of being damaged (D). It may have been dropped by a crane or banged against a car while loading.

So - of the 126 possible rails in the heat, Western Pacific received only 111, and, what is more important, we know which of the 126 we didn't get and why.

The reverse side of the card shows a lot of technical data which we will not attempt to explain.

HEAT NO.	16036	CHEMICAL ANALYSIS				
YEAR	1952	CARBON .74-.74	MANGANESE .82-.81	PHOSPHORUS .019	SULPHUR .039	SILICON .14

OPEN HEARTH				
DATE 1-28-52	ADDITIONS TO LADLE: Mn. 2400, Si. 900, Co. 200	MINS. LADLE HELD 0 39	COND. MOLDS GOOD	NO. FULL INGOTS 21
			TEEMING O.K.	SHORT INGOTS —
WEIGHT OF HEAT 222,800			COND. INGOTS O.K.	BUTTS AND STICKERS 0-1

BLOOMING			SHEAR DISCARD TOP	SHEAR DISCARD BOT.	SAW DISCARD TOP	SAW DISCARD BOT.
	TIME INGOTS IN MOLD	HEATING O.K.				
NO. OF INGOTS BLOOMED 20	TRACK TIME 5 25	BLOOMING O.K.				
NO. BLOOMS PER INGOT 2	TIME IN PITS 4 50	COND. BLOOMS O.K	6.5	4.4	1.2	.6

ROLLING			
	NO. RAILS SCRAPPED 6	TOTAL NO. 1 RAILS 108	TOTAL SHORT RAILS 4
TOTAL RAILS ROLLED 117	NO. RAILS SHIPPED 111	TOTAL NO. 2 RAILS 3	TOTAL "X" RAYLS 0

SLOW COOLING

BOX NO.	NO. RAILS	INGOT NUMBERS	TEMP. CHGD.	TEMP. 7 HRS.	TEMP. DRAWN	TIME IN BOX
5	75	1-14 (omit 12)	860-990	470	300	16 30
20	42	15-21	860-995	460	300	16 15

REMARKS:

FIGURE 9

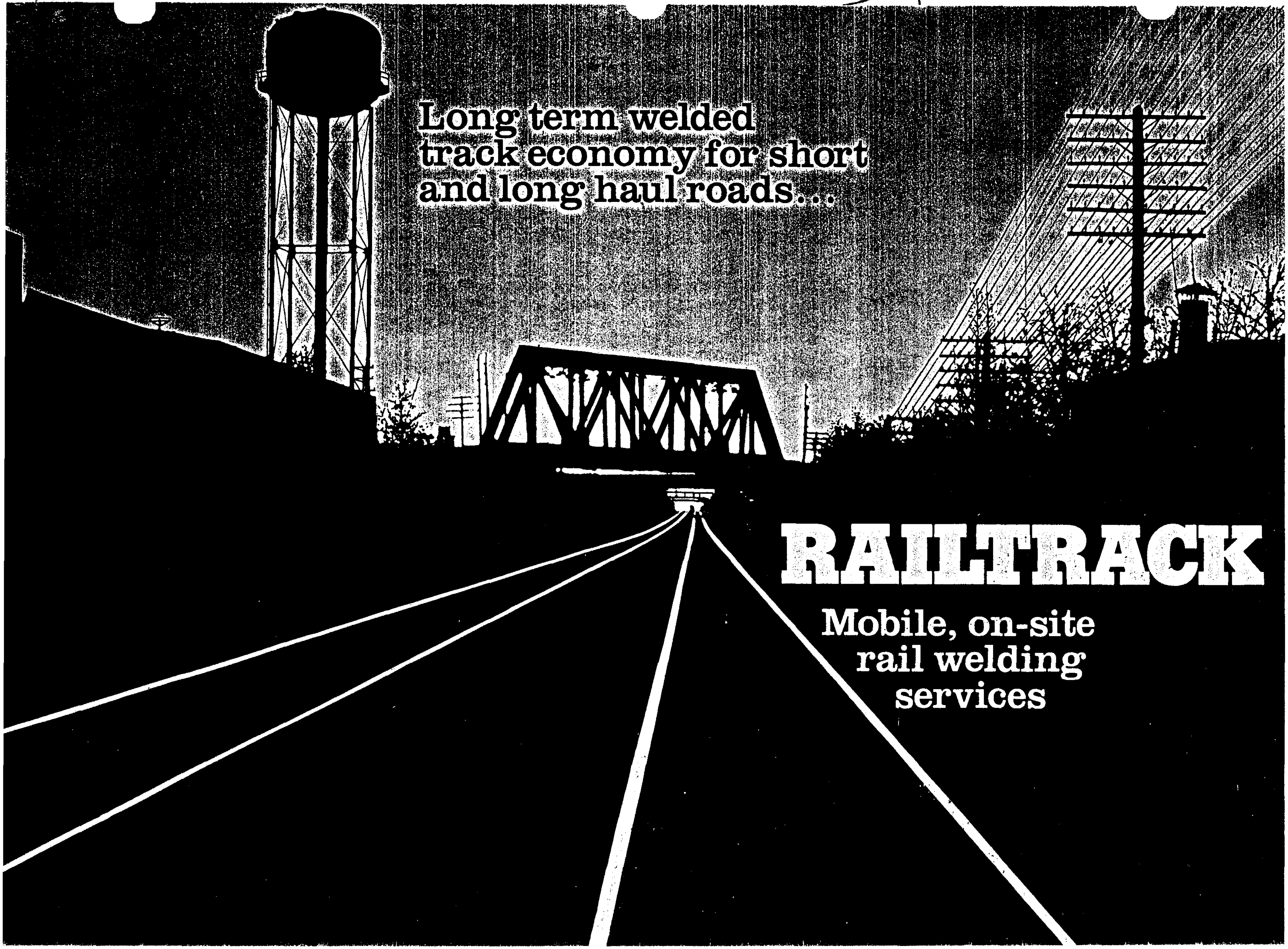
W. P. FORM #2700 1M-2-51 NG BY E.T. DATE: 2-3-52

If the heat is good, and its rails give normal service, this information on the back of the card will probably never be looked at again. However, if the heat should give trouble later, both railroad and steel mill people will be intensely interested in the information.

With the completion of the cards, the inspector comes home, the cards are filed, and the rail is laid in track, and another chapter is written in the Western Pacific's never-ending improvement program.

Now let us go back and see why that rail was bought in the first place. Rail is pretty expensive material, and it is certain that railroads do not buy it unless they are quite sure they need it. And, when approval is sought from the Board of Directors, for a rail expenditure, the Board needs something more to consider than one man's word that he thinks it is about time that a certain section of track got new rail.

The following chapter will attempt to explain how the Engineering Department keeps a current set of records that show at a glance the condition of the rail over the entire system, and how these records automatically indicate when any section of track should be considered for rail renewal.


Long term welded
track economy for short
and long haul roads...
RAILTRACK
Mobile, on-site
rail welding
services

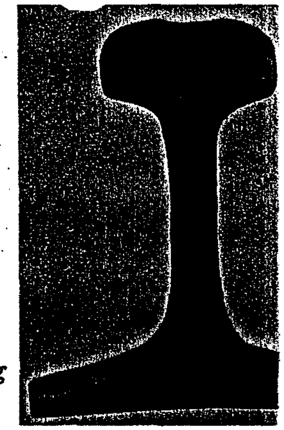
Over 60 thousand miles of American track is now welded into continuous, low-maintenance rails. CWR lasts longer and increases tie and ballast life.

Until now, fixed rail welding plants were economically infeasible for the short lines and branch lines of larger railroads.

Now, there's Railtrack. A full scale rail welding plant, offering all of the quality and consistency you'd expect of a stationary plant, coupled with the economy, availability and mobility of a plant on wheels.

Railtrack—a miniaturized version of a full scale rail welding plant...ready to roll to wherever you need it and start making welds in just 36 hours after arrival at the job site.

The Railtrack mobile rail welding plant consists of eight specially designed semi-truck trailers that contain everything needed for flawless, consistent, heavy-duty rail welding.



Top of head and bottom base only - nothing is done on the sides.

Trailer #1—The Transfer Table— As many as 20 standard 39 foot rails are loaded onto the conveyor chains. Then, one by one, they are aligned and fed into...

1

115 RE. British rail "chromo"

Trailer #2—The Polishing Trailer— Here, the ends of the rails are polished and prepared for welding. In the case of relay rail, saws crop off rail ends prior to the polishing operation. The polished rail segments then move, automatically into...

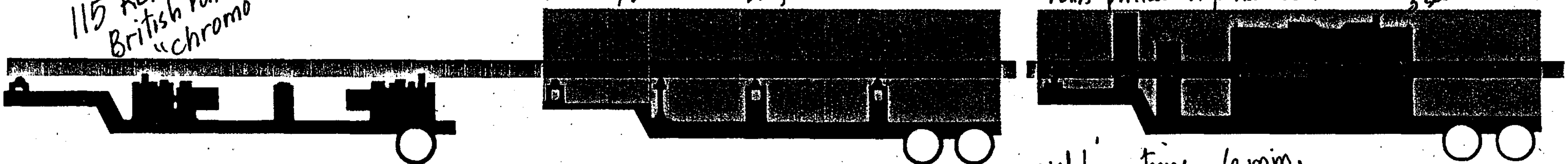
2

Rails w/scales and surface rust

Trailer #3—The Welding Trailer— This trailer houses a unique, full size electronic railwelding machine. The hydraulically-controlled welding electrodes clamp the rail ends into alignment. Then, with the rail ends held rigidly in place, as much as 650 kilowatts of power produce the weld. The welded length of rail then passes into...

3

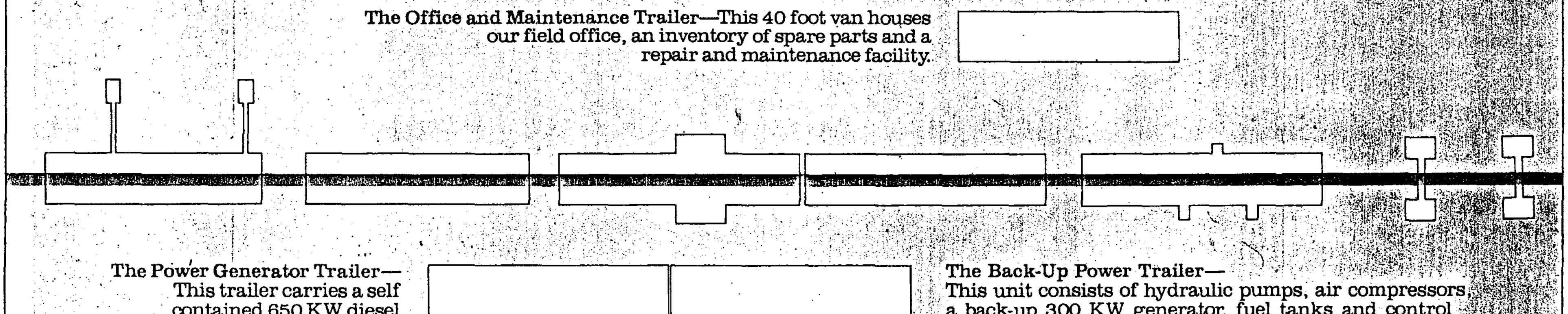
rails pulled together 11 times every 3 seconds



welding time, 6 min.

Support Trailers—The whole rail welding operation is supported by just three auxiliary trailers.

The Office and Maintenance Trailer—This 40 foot van houses our field office, an inventory of spare parts and a repair and maintenance facility.



The Power Generator Trailer—This trailer carries a self contained 650 KW diesel generator complete with 1200 amp circuit breakers, fuel tank and control panel.

The Back-Up Power Trailer—This unit consists of hydraulic pumps, air compressors, a back-up 300 KW generator, fuel tanks and control panels. The entire Railtrack operation is completely self contained and totally mobile. The first welds can be produced within 36 hours of arrival at the site.

Macro-pnotograph of a typical Railtrack weld cross section. Welds produced by the Railtrack system meet or exceed AAR specifications. Full test results are available upon request.

Trailer #4—The Stripper and Straightener Trailer—
Automatically, the excess metal is stripped from the weld. And power-ful hydraulic jaws bend and torque the rail to remove any end kinks or twists. The weld is then rough ground and the continuous length of rail moves to...

grinding done on the head only

2+1

4

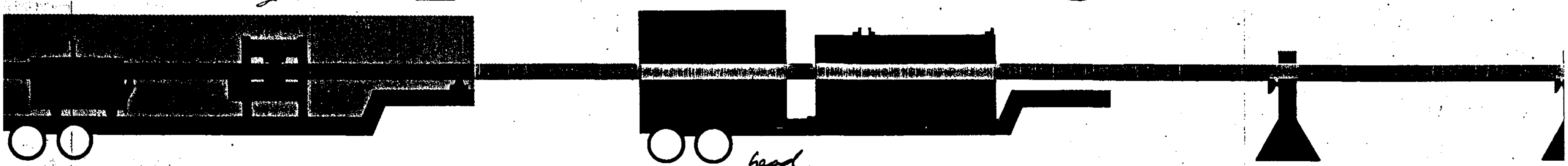
Trailer #5—
The Inspection and Pusher Trailer—
The weld is now ready for testing and finishing. The weld is finish ground to AREA tolerances and a magnaflux testing unit examines the joint for coalescence and integrity.

The Pusher Unit then delivers quarter mile lengths of welded rail, ready for stock piling or immediate laying.

Railtrack's unique rail dollies can deliver as many as eight quarter mile lengths of CWR to the installation site without the use of a costly locomotive work train. All that is required to move the rail train is a heavy duty ballast regulator.

5

Point MAN



- The head side, web and base are first grounded.
- Magnaflux powder (earth dust) brushed on the head and web, and base, none at the bottom of the base.
- Magnet turn on.
- Check of any powder attached.

magnetic coil.

Railtrack, inc.®
312/323-7990

Railtrack is the unique rail welding service that enables all rail lines t enjoy the economy of running on welded rail.

Let us show you the mechanics and the economics...

shall be cut, rewelded and retested at no cost to the Commission.

PART 2 - PRODUCTS

2.1 EQUIPMENT FOR FLASH BUTT WELDING INTO CONTINUOUS WELDED RAIL STRINGS

A. The following welding plant components shall be provided by the Contractor as a minimum:

1. rail storage rack for 78 foot rail sections;
2. feed table with rollers;
3. power generators;
4. finishing table with rollers;
5. crane for loading rail sections at the welding site complete with spreader bar to handle 78 foot rail lengths;
6. shelter for welding components to permit welding during inclement weather;
7. hydraulic press for aligning and straightening rails;
8. welding head with electric current monitoring equipment;
9. rail pusher; and
10. all other equipment necessary to the electric flash butt welding process.

B. The Contractor shall maintain all its equipment in good working order at all times.

2.2 FIELD JOINING OF CWR SECTIONS

Thermite welding materials and equipment shall be as manufactured by "Boutet", "Orgotherm", "Elektro-Thermit", or other approved equivalent. Welding kits and all apparatus required to produce finished welds shall be supplied by the Contractor.

PART 3 - EXECUTION

3.1 RAIL STRAIGHTENING

A. Prior to welding sections, each section will be inspected for the tolerances specified in Exhibit 16. Any rail not within these tolerances shall be straightened to within the specified tolerances.

B. Any rail sections that cannot be straightened shall be cut back a sufficient distance to achieve the specified tolerances.

3.2 RAIL CUTTING AND DRILLING

A. All rails cut for any reason shall be cut clean and square by means of Construction Manager accepted rail sawn or abrasive cutting discs. Torch cutting of rail is prohibited.

B. Holes will not be permitted in the rail, except as noted on the Drawings.

3.3 RAIL END PREPARATION

A. Rails used for electric-flash butt welds shall have their ends saw-cut or abrasive disc-cut. Flame cutting rail ends shall not be permitted. The head and base of the rail for a length of approximately six inches from welding end shall have mill scale removed down to bright metal. All burrs shall be removed from the area where the welding current carrying electrodes contact on head and base of the rail.

B. Rail ends for thermite welding shall be prepared in accordance with the recommendations of the welding kit manufacturer.

3.4 WELDING

A. Electric Flash Butt Welding

1. The Welding Supervisor shall be responsible only for the welding equipment and its operation, during the entire period in which rail welding is taking place.

2. Welding site locations and the approximate number of welds to be produced at each site shall be determined by the Contractor and agreed with the Construction Manager. Information on four welding sites may be obtained from the Construction Manager and used by the Contractor in determining its welding program.

3. All electric flash butt welds shall be forged to point of refusal to further plastic deformation and have a minimum upset of 0.5 inches with 0.625 inches as standard. If flashing of electric flash butt welds is interrupted because of malfunction or external reasons, with less than 0.5 inches of flashing distance remaining before upsetting, rails shall be reclamped in the machine and flashing initiated again. The upset cylinder shall not bottom out during the upset portion of the weld cycle. After the welding cycle is completed and while the weld metal is still hot, the upset metal shall be sheared off from the head, web, and base of the rails. Post weld straightening may be permitted if performed before the surface temperature of the weld falls below 500 degrees Fahrenheit. Quenching the weld metal shall not be permitted. The welding machine shall be capable of automatically recording pertinent data including pre-

heating impulses, flashing time, upset current, time and platen travel during flashing.

4. CWR strings shall be fabricated so that the branding of all individual rail sections appears on the field side of installed track.

B. The thermite welding method and procedure shall comply with the AREA specification for "Thermite Welding - Rail Joints" as found in Chapter 4 of the AREA Manual for Railway Engineering, and with the welding kit manufacturer's recommendations and the detailed specifications required by Paragraph 1.6.E of this Section.

3.5 FINISHING AND ALIGNMENT

All heavy grinding used in the finishing process shall be performed while the rail is hot. Trimming and grinding of rail welds shall result in the weld being within the following tolerances:

A. The top and sides of the rail head shall be finished to within plus or minus 0.005 inches of the parent section.

B. The top, bottom and sides of the rail base shall be finished to within plus 0.010 inches or minus zero inches of the parent section.

C. The web and underside of the head of the rail shall be finished to within plus 0.125 inches or minus zero inches of the parent section.

D. Finishing shall eliminate cracks visible to the unaided eye. Notches created by offset conditions shall be eliminated by grinding to blend variations.

E. Protrusions and gouges in the weld areas shall be removed and the weld area shall be blended into the rail contour in a manner which will eliminate fatigue crack origins.

F. The crown of the rails at the weld shall not be greater than 0.040 inches in three feet or 0.060 inches measured 48 inches from the weld. No dip in the adjoined rails will be permitted.

G. The alignment of the rails shall not deviate more than 0.040 inches in three feet or 0.060 inches measured 48 inches from the weld.

3.6 REPLACEMENT OF DEFECTIVE WELDS

The defective weld shall be cut out, and a new section of rail not less than 15 feet long shall be inserted, welded with two thermite welds and retested at no cost to the Commission.

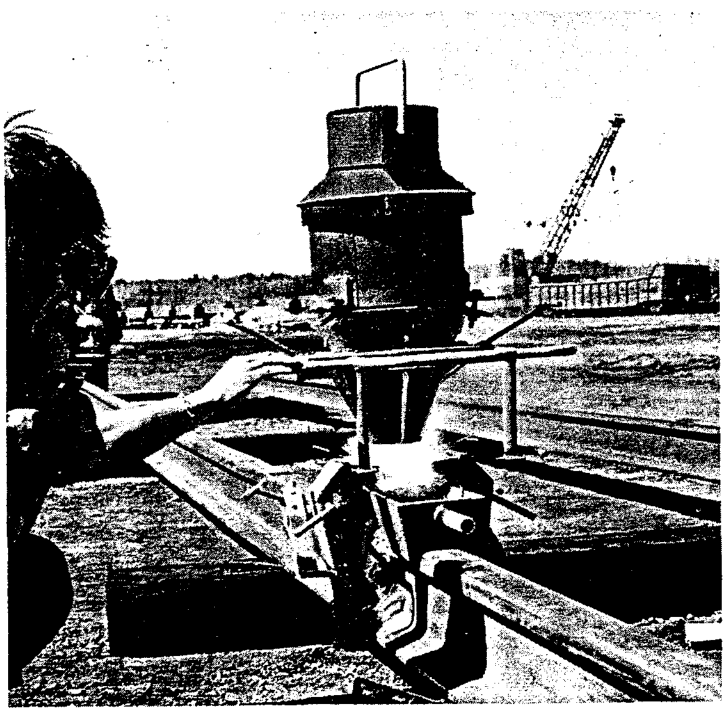
3.7 RECORDS FOR ELECTRIC FLASH BUTT WELDING

A. On a weekly basis a record shall be submitted to the Construction Manager documenting the production of each string of CWR. Included shall be the following:

CALORITE

LIMITED PRE-HEAT THERMITE WELDING

- New Track Construction
- Improving old trackage with new or old rail
- Welding compromise joints

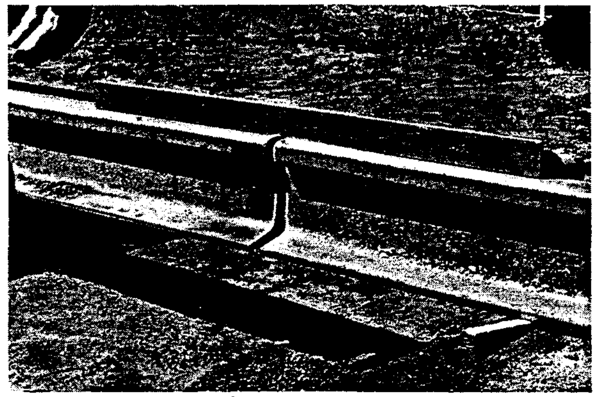


—IE MODERN, EFFICIENT WAY TO WELD ANY RAIL

CALORITE, INC.

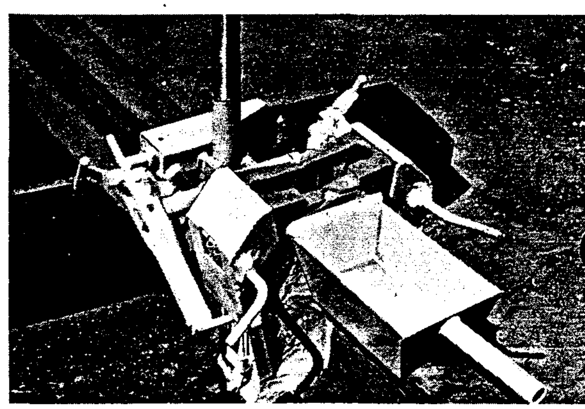
THE CALORITE THERMITE PROCESS HAS BEEN USED TO WELD RAILS FOR OVER 75 YEARS...

Five steps to better welds.



1. PREPARE THE RAIL

Clean and gap rail ends, cutting with a saw, grinding disc or, if necessary, by a guided torch to obtain the correct interval. Align rail vertically and horizontally, following instructions in the field manual. Relocate ties, if necessary, to allow for mold installation.

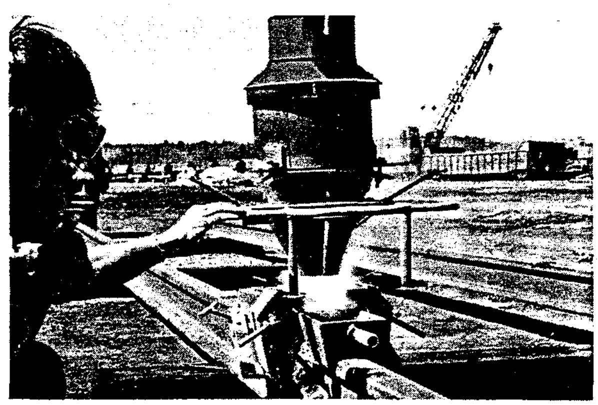


2. INSTALL MOLDS

Attach the mold clamp to the rail. Position and seat the molds and clamp them in place. Seal all joints with fusal paste (fire clay) according to directions. Place crucible on stand and then install thimble.

3. PRE-HEAT

Using a simple propane torch designed to fit in mold opening, heat the rail ends for 4-5 minutes. This is necessary to remove all traces of moisture and bring rails to a temperature adequate for welding. While rail is heating, pour charge into crucible.



4. WELD

Swing the crucible so that the outlet is centered over the mold opening. Ignite thermite match and insert in the charge. In less than 40 seconds the charge will be transformed into molten metal at 4500°F, melt the fusible plug and flow into the joint, completing the weld.

5. FINISH

After removing hardware and allowing 1-3 minutes for cooling, the mold and excess metal are removed. Surface grinding completes the weld and track is ready for service.

NOTE: It is extremely important to carefully follow the instructions contained with the Calorite Kit. Do not take short cuts. *Do not substitute any part of the welding apparatus with homemade or otherwise obtained components.*

[1]THERMITE WELDING—RAIL JOINTS

1980
GENERAL

Thermite is defined as a mixture of finely divided aluminum and iron oxide. When the aluminum and iron oxide react, the reaction is called a thermite reaction. Thermite welding is accomplished with the heat produced by the thermite reaction. Filler metal is obtained from the iron reaction product and pre-alloyed steel shot in the mixture.

When ignited, the reaction within the thermite mixture develops a temperature approaching 5000°F and produces a filler metal at about 3500°F which, when introduced into a gap between the rails, welds or fuses the ends together. The reaction metal is generally iron which has been enriched with alloys to produce a filler metal assimilating the characteristics of the rail steel being welded.

In all aluminothermic or thermite welding processes, the reaction takes place in a separate crucible or in a reaction chamber integral with the mold. When complete, the resultant metal is tapped, either manually or self-tapping, into disposable prefabricated molds properly placed over the opening between the rail ends previously prepared for the butt welding.

Preheating of the rail ends, an important part of thermite welding, is applied differently by the various rail welding processes available today. Separate preheating equipment, operated independent of the reaction crucible, along with accessory clamps, etc., is common to some systems, while in other cases the preheat is supplied by an initial portion of the filler metal washing the rail end faces as it passes through the joint gap to a sump provided in the mold beneath the base of the rails to be welded.

Small hand tools, luting material, and cutting and grinding equipment are required with all processes.

WELDING

The basic requirements for thermite welds are:

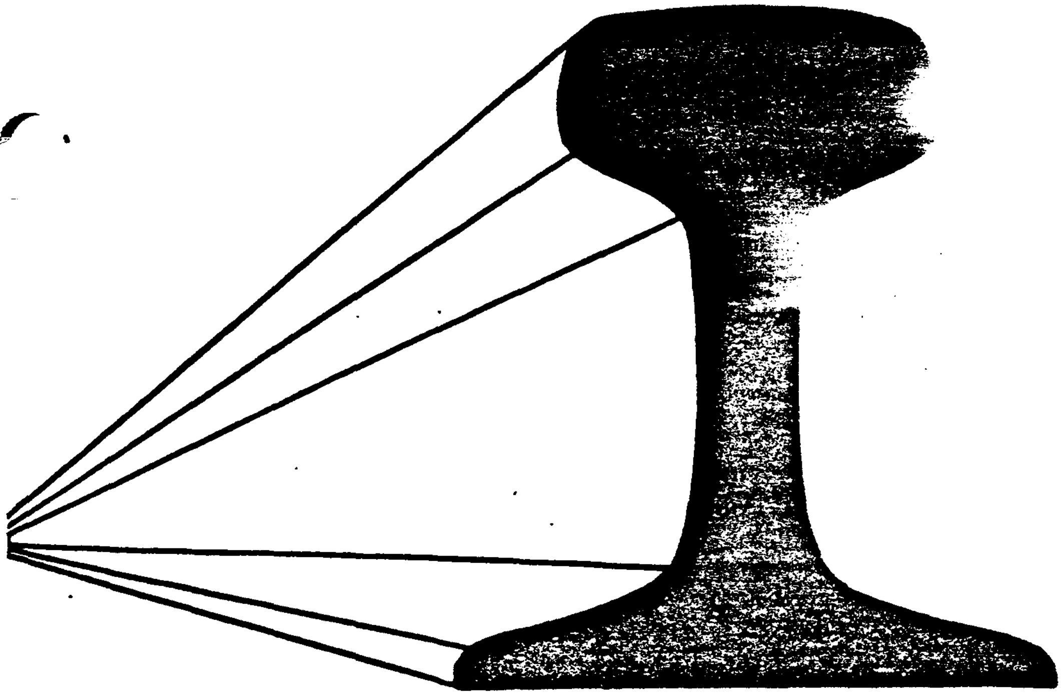
1. Remove moisture and all foreign substances such as dirt, grease, loose oxide, slag, etc., from the weld area.
2. Align rail ends properly. Proper joint gap and lateral and vertical positioning of the ends is imperative.

[1] References, Vol. 82, 1981, p.75.
[1] *Latest page consist: 6.7 to 6.9, incl., (1981).*

3. Apply mold in exact location over rail gap and seal properly.
4. Follow detailed manufacturers instructions for the specific thermite process being used without deviation.
5. It is assumed that flotation of impurities in the crucible and the mold, and proper gating and feeding, are provided for in the equipment and instructions supplied with the thermite package.

Following are minimum requirements for quality welds, good track alignment through the weld, and satisfactory riding characteristics over the welded joint:

1. The rail end faces should be square to the running surface of the rail. In order to obtain this condition, the rail should be properly aligned first if the gap is to be cut in track, or pre-cut square rail ends should be properly aligned and spaced.
2. The gap between the rail end faces should be between 5/8 inch and 1 inch, depending on the welding process and rail section involved.
3. The joint gap may be either flame, saw, or abrasive-disc cut with the saw or abrasive disc strongly preferred. If flame cut, the following must be observed: flame cuts should be reasonably smooth. The rail should be preheated prior to flame cutting. A precaution should be observed in the case of flame cutting in that the weld should be made as soon as possible, preferably within an hour, in order to prevent deep thermal cracks from forming on the flame-cut rail end faces. If flame cut, the rail ends should be thoroughly cleaned of the residual oxide resulting from the flame cutting operation.
4. All burrs should be removed from the cut rail ends at the joint gap, all fins and heat metal flow in relayer rail ground away, and loose oxides and foreign material removed from the weld area surfaces for at least 5 inches back from the ends of the rails. This permits close fitting of the molds and reduces contamination of the weld. Copper material from head bonds should be totally removed from within 2 inches of the rail ends. It is desirable that holes should not be allowed within 6 inches of the weld gap, and holes within 2 inches of the weld shall be prohibited.
5. Sufficient preheat to promote good fusion is required. Some thermite mixtures require external preheating and some do not. If manufacturers specify preheating, strict adherence to the prescribed times is imperative. Preheating may be accomplished with oxy/acetylene, air/fuel gas, air/gasoline, oxy/propane, or a generated gas flame. If preheating is not specified by the manufacturer, the initial filler metal passing over the rail end faces acts as the preheat source.
6. The prefabricated molds used in any of the processes should be centered exactly with the center of the rail gap.
7. The luting or sealing of the molds to the rail should be performed with care so that the luting material is not introduced into the weld chamber. It has been found practical to use sand mixed with bentonite in proper proportions with a minimum of moisture in the mixture as a luting material.
8. Molds and charges stored for excessive lengths of time may absorb detrimental moisture. Manufacturers should be consulted for maximum recommended shelf life and charges stored beyond that time shall not be used. Molds should be stored in such a manner and environment as to prevent moisture contamination and freezing. Care should be taken when transporting from storage to the work site to protect charges and molds from the elements.



TRACK FOREMAN'S TRAINING PROGRAM

LESSON 1

THE TRACK STRUCTURE

1809 Capitol Avenue, Omaha, Nebraska 68102

LESSON 1

THE TRACK STRUCTURE

This lesson deals with the various parts which come together to form a complete track structure. It covers the proper names of each part, the purposes of these parts, some of the more common problems that develop and how the different parts relate to one another. Many of the details of construction, maintenance and inspection of these parts will be covered in following lessons.

The names which are used to describe the parts of the track structure in this lesson are widely used throughout the railroad industry. In most cases, they are not the only names in use. You may find cases where equally acceptable names are commonly used on your railroad. There may be other cases where slang names are in use locally. There is probably nothing wrong with using such a slang name in giving instructions to someone working under your direction, if he is more familiar with such a name. You should know the generally accepted names of these parts and use them in discussion with railroad officers, representatives of governmental agencies, suppliers, or shippers.

INFORMATION ON RAIL

Consider the way equipment loads act upon the track structure and how each part is related. The loads are first transferred from the wheels to the rails. We shall first consider the rails. The type of rail which is in general use is known as tee rail, except for a limited amount of rail in track built within paved streets. The principal parts of the tee rail are known as the head, the web and the base. When rail is placed in track, the side of the rail which faces the center of the track is known as the gage side. The side of the rail towards the outside of the track is known as the field side.

Tee rail comes in many sizes and with some minor variations in shape. Rail is usually identified according to its weight per yard and by the shape of its cross section. For example, 119 RE rail means that a piece of this rail 3 feet in length weighs 119 pounds and that its shape is according to the design recommended by the American Railway Engineering Association. (AREA)

Most railroads have a number of differently sized rails in track. This is because the trend over many years has been for the size of rails to increase to meet the demands of cars and locomotives of ever increasing capacity. Usually, the older and lighter rail sections will be found in yard and industrial tracks and in branch lines with lesser density of traffic.

All rails have certain information on each side of the web that tells a good deal about the rail. At times it may be necessary to do a good bit of scraping or cleaning with a wire brush to read these marks. On one side, the characters will be branded with raised letters and figures. An example would be as follows:

119 RE   CC   Name of Mill   1974   1111111

This means that the rail is of the 119 pound RE section. CC stands for control cooled. The name of the mill at which the rail was manufactured will be identified. The year and the month (seven vertical strokes indicating July) in which the rail was manufactured is shown.

On the other side the characters are indented. Following is an example:

CT   287165   B   12

CT means that the rail is heat treated. The following numbers indicate the heat number from which the ingot is poured. The letter B indicates that it is the second rail from the top of the ingot. This is followed by the ingot number.

New rails also are classified as No. 1, No. 2, "A" and "short." No. 1 rails are those found to be free from injurious defects and flaws of all kinds. No. 2 rails may have a few surface imperfections or had sharp kinks or camber in them before being run through the straightening presses. Before shipment, the top of the rail head will have a white mark painted on it about 3 feet from the rail end. "A" rails are rolled from steel cut close to the top of the ingot and may contain some porosity which could develop into "piped" rail during rolling. The top will have a yellow mark painted at one end. The "shorts" are rails shorter than the conventional 39 feet and may vary between 25 and 38 feet. The top at one end is painted green on these rails.

A track foreman should become familiar with the various sections of rail in use on his railroad. There are two dimensions for each section of rail that he should know. One is the width of the base and the other is the height of the rail. It is recommended that you make a list of the rail sections on your railroad and write down these two measurements beside each one. Refer to them frequently until you have memorized them.

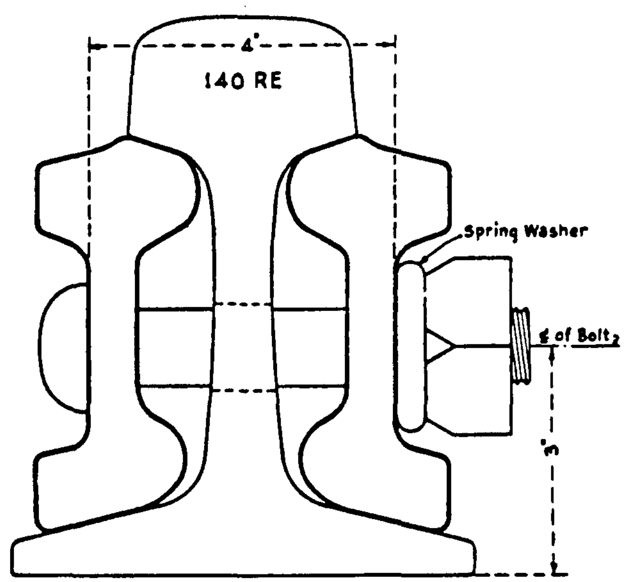
The wheel loads have to be passed on from the rail to the other parts of the track structure. The rail acts as a beam or girder in distributing the load. Although the tie which is directly under a wheel receives more of the load than the adjacent ties, it does not receive the full load. The greater the girder strength of a rail, the better it can distribute the load over a greater number of ties. By controlling the maximum load which a tie receives, the wear on the ties and the breakdown of the ballast support can be kept within reasonable limits. This greater girder strength is one important advantage of the heavier rail sections. Another advantage is that lower internal stresses are set up by a wheel load in heavy rail than in light rail. This means that heavy rail is less likely to break under traffic.

Just as the unit weight of rail has tended to become heavier over a long period of time, so have rails tended to become longer. There are still many rails in track that were manufactured to 30-foot or 33-foot lengths. A good many years ago, there was a general changeover to 39 feet as the standard length. Although some efforts were made to adopt longer lengths, particularly 60 feet and 78 feet, 39-foot rails remained the most common length manufactured. Even though the present trend is towards continuous welded rail, most new rails which are welded are 39 feet in length. Some rail will continue to be laid as jointed rail for a number of reasons. The greatest part of the rail in track is jointed rail and will continue to be so for some time. Therefore, rail joints continue to be a very important part of the track structure.

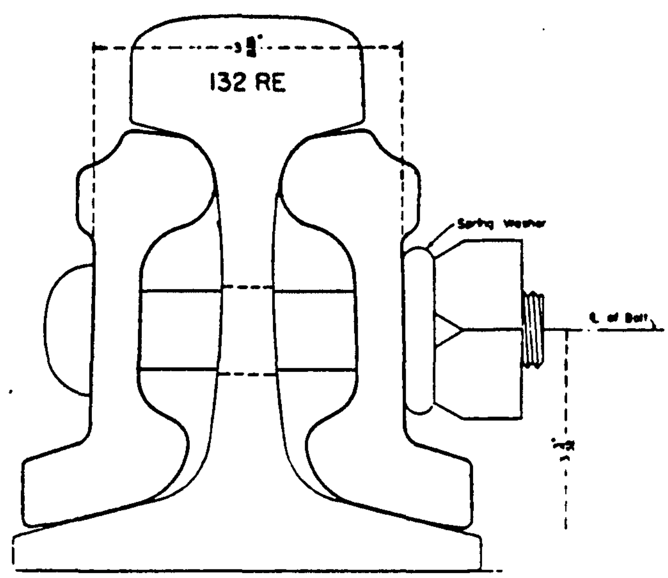
DESCRIPTION OF RAIL JOINTS

An ordinary rail joint consists of two joint bars plus the required number of bolts, nuts and spring washers. The two joint bars are considered to be a pair and usually have holes for either four or six bolts. The joint bars may be either of the toeless type or may have a toe or base angle. They may be of either the head contact or head-free type, depending upon the portion of the area under the rail head where the bars make contact. Figure 1 illustrates the difference between head-contact and head-free joint bars.

The bolts which are used to secure the joint are known as track bolts. These bolts usually have an oval or elliptical neck under the bolt head. The joint bars usually have alternate holes which are oval in shape; the intermediate



HEAD CONTACT JOINT



HEAD FREE JOINT

FIGURE 1

holes are round. When the bars are matched up to form a joint, one on the gage side and one on the field side of the rail, an oval hole is always opposite a round hole. See Figure 2. By inserting each bolt from the side with an oval hole, the oval bolt neck fits into the oval hole in the joint bar. As long as the bolt is fully inserted, the nut can be tightened or loosened without the bolt turning. This arrangement requires that alternate bolts within a joint be inserted from opposite sides of the rail.

This pattern has a potential advantage should a derailed wheel pass by the joint. Such a wheel is more likely to strike the nut which protrudes considerably, than the rounded bolt head which protrudes very little. Under such conditions, it is unlikely that more than half the bolts in a joint will be broken or severely damaged.

This can be an appreciable advantage in restoring the track to service quickly, if such derailed equipment traveled several miles before being detected.

The usual practice is for track bolts to be ordered with nuts and for them to be shipped together. They are frequently accounted for as a unit. The spring washers are more commonly treated as a separate unit.

In addition to the ordinary rail joint, there are a number of joints for special purposes. One of these is the insulated joint electrically insulating one rail from the next. These are used to isolate signal circuits or circuits controlling automatic crossing protection. Figure 3 illustrates one type of insulated joint. Another type of rail joint is the compromise joint, used to match heads of adjacent rails of different sections. A typical compromise joint is shown in Figure 4. A joint of more recent development which is being used on a number of railroads is one which employs the use of adhesives between surfaces where the joint bars and the rail are in contact. These joints are designed to connect lengths of continuous welded rail. The adhesives transfer much of the stress that occurs in welded rail due to temperature changes. Otherwise these stresses would have to be carried by the track bolts.

With the exception of the adhesive-type joints, rail joint assemblies are usually expected to permit a small amount of movement between the rail and the joint bars. This provides for the expansion and contraction of rail in which stresses are to be relieved as the temperature changes. Bolt holes in the rail are usually oversize in relation to the diameter of the track bolts

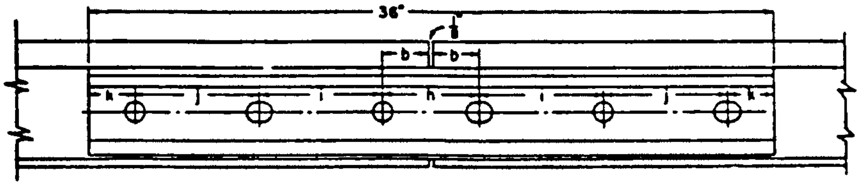


FIGURE 2 - JOINT BAR SHOWING ROUND AND OVAL BOLT HOLES

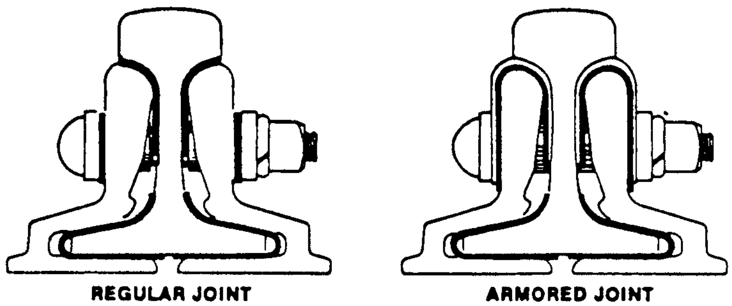


FIGURE 3 - CROSS SECTIONAL VIEW OF AN INSULATED JOINT

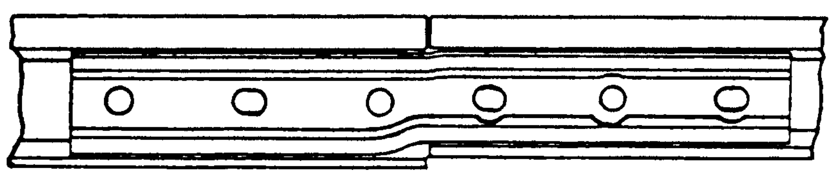


FIGURE 4 - COMPROMISE JOINT

in order to permit such movement. Some railroads require that a lubricant be applied during rail-laying operations to the areas where the rails and joint bars come in contact. This reduces the frictional resistance to such movement in a joint with tight bolts.

When laying jointed rail, there is usually a small opening left between rail ends, unless the temperature is very warm when the rail is being laid. The proper way to do this will be discussed in another lesson. It should be remembered that much of the rail traffic which passes over a rail joint does so while there is a small opening between the rail ends.

Rail joints are normally designed to carry loads that the rail can carry. They generally do quite well if all parts are in good condition and well maintained. Nevertheless, it is in the joint area that maintenance work is most frequently required. The present trend toward the use of continuous welded rail is due to the high cost of maintaining rail joints and the fact that joints are weak spots in the track structure.

There are a number of reasons why a rail joint deteriorates. If only one of these conditions is present, in time, some of the others will appear. If left uncorrected, the deterioration of the joint occurs at an ever-increasing rate. The gap between the rail ends, even though small, causes an appreciable amount of pounding or impact because of the heavy loads being carried. In time, this impact can cause batter to appear on the head of the rail end located on the receiving rail end. On tracks with a substantial amount of traffic in both directions, such as a single track operation, this battered condition may be equally severe on both of the rail ends in a joint.

The vibrations caused by loads moving over a joint can also cause bolts to lose tension. If this condition is not promptly corrected excessive movement takes place in the areas where the joint bars and rails make contact. Again, if not corrected, this will cause wear on these surfaces so that the bars become incapable of providing full support, even if the bolts are retightened. Any of these conditions can cause excessively high impact forces, that may result in a breakdown of the joint in additional ways.

Having considered the part played by the rail which receives the loads from the traffic moving over the track, and the rail joints which connect the rails; we should next examine those parts of the track structure which support the rail.

FUNCTION OF TIE PLATE

The first of these parts is the tie plate. Most railroads have very few tracks, if any, constructed without tie plates. Such tracks are usually of little importance and need not be considered here. Why are tie plates used? It is easy to see that a tie plate causes the load being transferred from the rail to the tie to be spread out over a greater area than would be the case if the rail were laid directly on the tie. It is not uncommon to see cases where tie plates become embedded in the ties so that the tie plates are below the top of the ties. This condition is generally described as plate cutting. It is most common in tracks carrying a high density of traffic. This condition would occur in relation to the rail base if tie plates were not used and it would develop at a much faster rate.

As an example, suppose the load on a rail is such that when a wheel is directly over a certain tie, the load going from the rail to the tie is 24,000 pounds. Suppose that the rail base is 6 inches wide, no tie plate is used and the tie is 8 inches wide. The total bearing area of the tie receiving this load is the 6 inch rail base times the 8 inch tie width. The pressure on the wood can be calculated as follows:

$$\frac{24{,}000 \text{ pounds}}{6 \text{ in.} \times 8 \text{ in.}} = 500 \text{ pounds per square inch}$$

Next, consider the same load on the same tie. This time a tie plate is used which measures 8 inches by 12 inches. The pressure on the wood is:

$$\frac{24{,}000 \text{ pounds}}{8 \text{ in.} \times 12 \text{ in.}} = 250 \text{ pounds per square inch}$$

Although the total load on the tie is the same, the pressure on any particle of wood has been reduced by one half. This can have a considerable effect on the life of the tie.

The size of tie plate has tended to increase over a long period of time just as the weight of rail has. This, too, has been done to better meet the demands of ever increasing loads moving over the track structure. The situation on most railroads is such that there are in use a number of different sizes and types of tie plates. Each track foreman needs to have a good working knowledge of the tie plates in use on his own railroad. There are a number of different things to look for when learning to recognize the various types which you can expect to work with.

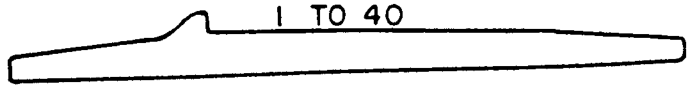
One thing to check is the size of the tie plate. This can be determined by measuring the length and width of the tie plate.

Another characteristic to look for is whether the tie plate is of the single-shoulder or the double-shoulder type. Although the present trend is to double-shoulder tie plates, many plates are in track of the single-shoulder type. Shoulders are the raised lips on the top of the tie plate intended to contact the outside edge of the rail base. Single-shoulder plates are designed for a shoulder on the field side of the rail only. Double-shoulder plates have shoulders for both the field and gage sides. Figure 5 shows both a single-shoulder tie plate and a double-shoulder tie plate.

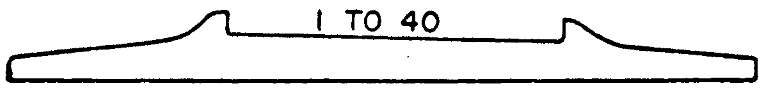
Most tie plates are designed for one width of rail base. This applies to all double-shoulder tie plates, and is determined by measuring the flat width between the two shoulders. On single-shoulder plates, it is determined by measuring the distance from the inside edge of the shoulder to the nearest edge of the hole for the gage side rail-holding spike. Some single-shoulder tie plates can accomodate rails of more than one base width. This is done by providing more than one hold for a rail-holding spike on the gage side. The holes are at different distances from the shoulder to provide the necessary clearance for various rail-base sizes for which the tie plate is intended.

Still another consideration in classifying tie plates is the hole punching for insertion of spikes. Such holes can be classified into four categories. There are gage side and field side rail-holding spikes and there are gage side and field side plate-holding spikes. Look at Figure 6 and identify each type. Rail-holding spikes are intended to hold the rail in place. In most situations, one gage side and one field side rail-holding spike are required per tie plate. Some railroads require the use of a second gage side rail-holding spike under certain conditions. Where this is done, the main purpose is to provide additional restraint against the possibility of a rail being rolled over or pivoted about the field side of the rail base by loads imposed. When this is required, it is usually on curves, particularly sharp curves. Sometimes it is specified in territory with heavy traffic or at locations which have had a history of such problems.

Plate-holding spikes, where used, have two purposes. If properly driven into a sound tie, plate-holding spikes secure the tie plate firmly to the tie. This reduces the tendency for the tie to become plate cut which exists when



SINGLE SHOULDER TIE PLATE



DOUBLE SHOULDER TIE P LATE

FIGURE 5

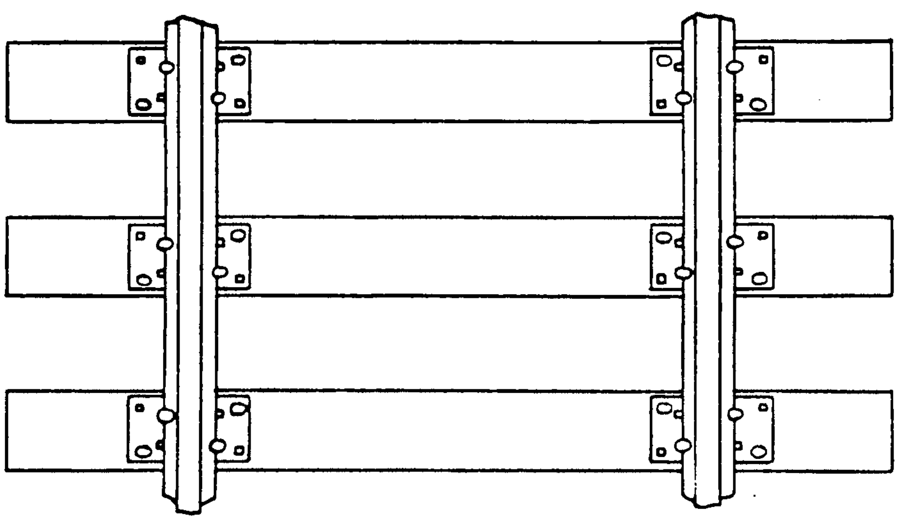


FIGURE 6 - TYPICAL SPIKING PATTERN

movement occurs between the tie and the tie plate. Another advantage of plate-holding spikes is increased gage holding capability. When wheel loads are such that they tend to spread the rails or widen the gage of the track, the field side of the rail base bears against the field side shoulder of the tie plate. The amount of restraint against this movement which the tie plate provides is dependent upon the total number of spikes in the tie plate and the soundness of the tie. Some railroads do not have traffic conditions which justify the use of plate-holding spikes. Some may require their use under certain conditions, especially on curves. Where used either one or two plate-holding spikes per tie plate may be specified. It is essential that you become familiar with your own railroad's requirements for spiking, both as to the number required, and the pattern of placing them in relation to each other. Spiking patterns are important because the relative location of one spike to another can affect the tendency of a tie to develop splits and to slew its right-angle position.

One more thing that must be considered in the use of tie plates is the cant of the rail seat. Formerly, all tie plates were designed so that the base of the rail would be parallel to the top of the tie. All of the newer tie plates are canted, usually with a slope of 1:40 but, sometimes with a slope of 1:14 or 1:20. The rail seat is designed so that the field side of the rail base is slightly higher than the gage side of the rail base. This results in the entire rail being slightly tilted towards the center of the track. Figure 5 illustrates canted tie plates.

While this has certain advantages such as improved contact between wheel and rail, the important thing to remember is the relation of one type of tie plate to another. It is poor practice to use flat and canted tie plates interchangeably. If this is done, the rail cannot be seated uniformly on both types of tie plates. This can result in a tendency for the rail to twist, possibly break, and for the development of plate-cut ties and bent tie plates. To further complicate the problem, some railroads use tie plates with various amounts of canting. The amount of cant is usually described as a ratio of vertical to horizontal distances. Again, it is necessary that you know what cants are used on the various tie plates on your railroad. For example, mixing tie plates with a 1 to 20 cant, with tie plates having a 1 to 40 cant is just as bad as mixing flat tie plates with those having a 1 to 40 cant.

TIES ARE MOSTLY WOOD

In this study of the track structure, the next part that will be considered is the one that receives the load from the tie plate. In North America, these parts are known as cross ties and commonly referred to as ties. The most common material used for ties is wood. In recent years, a considerable amount of interest has been shown in substitute materials such as reinforced concrete, steel and plastics. Studies are also being made of the practicability of wood in different forms such as laminates and wood chips with adhesives. The great majority of ties presently in track is solid wood. This situation will no doubt continue for some time; therefore, this discussion will be concerned principally with the solid wood tie.

The number of different types of wood used in the manufacture of ties is considerable. One of the things which governs this is the species that are available in any geographical area. Each type of wood has qualities of its own that are different from those of other types of wood. Some woods have more strength, more resiliency or more resistance to decay than others. Unfortunately, the most desirable woods are not always available in the quantity desired. This may result in a railroad accepting several types of wood for the manufacture of ties. In some cases, the railroad may require that ties of certain woods be used only in designated tracks or that some woods shall not be used in certain tracks. Such rules can vary widely because of local conditions. Because of this, it is not possible to recommend here how each species of wood is to be used. What is important for the track foreman to know is the standards which his company has for various types of ties and what is expected of him regarding the selection of ties for any kind of track.

Ties also vary in size. While not all railroads use ties of the same length, in most cases, a railroad will use ties of uniform length except for minor variations. Differences in size usually occur in the thickness and the width. Most ties which are used in yards are six inches thick. Depending upon a railroad's standards they may be in the range of 6 to 8 inches in width. Most main-line ties are usually seven inches thick and in the range of 7 to 9 inches in width. Either one or the other grouping or an intermediate group may be used on branch lines. Due to variations in practice among railroads, the specified use of ties according to size is another subject which the track foreman needs to determine for his own situation.

We have seen how the rail spreads the load from a wheel among several tie plates, and how the tie plates distribute the load over a greater area of the tie so that the tie does not wear out quickly. The tie also needs adequate support for the loads which it in turn passes on to the ballast. The process is similar in that the tie spreads the load which it receives from the tie plate. When it is passed on to the ballast, the pressures are further reduced from those which exist between the tie plate and the tie. This better enables the ballast to provide adequate support for the tie.

So far, we have been considering the vertical loads which are placed on the various parts of the track structure. In addition to the part played by the tie in supporting these vertical loads, a number of other types of loads are placed upon the tie. One such load is that which tends to spread the rails outward, increasing the gage. Such loads may be minor or may be very great. Things which determine such loads are curvature, superelevation of track, the nature of the traffic and local operating conditions such as speed and braking. It has been shown that tie plates and spiking can be important in helping to control this type of load. The tie, of course, is the part of the track structure which keeps the rails in their position relative to each other. The ability of a tie to do this is one of the most important things to determine in deciding whether the tie is defective.

EFFECT OF LATERAL ACTION

Loads which tend to spread the rail outward are known as lateral loads. If such a load is pushing outward against one rail without an opposite load against the opposite rail, this load will be tending to push the track out of alinement as well as tending to increase the gage of the track. The resistance to this type of lateral load comes from an interaction between the tie and the ballast. At this point, we should consider the part played by the tie. The resistance provided by the ballast will be discussed later.

Try to visualize a situation where a train is trying to push the track in a lateral direction; that is, off to one side. This might occur when the train is moving through a curve at a substantial speed, tending to push the track towards the outside of the curve. Another situation where such a lateral load might occur is where a hard run in of slack in the track takes place. First of all, this lateral load or push to one side, is spread out by the rail so that the job of resisting it is done by several ties, not just the tie right under the wheel. Now let's consider just one of the ties that is involved in resisting this push or helping to keep the track in alinement. Since the load is trying to move the track to one side, it is trying to push the tie along its long axis. If the end of the tie was tight against a solid concrete curbing, it probably would not move. Generally, this is not the case. It can be seen, however, that resistance at the end of the tie is very important.

Part of this resistance depends on how good a job the ballast does. Part of it depends on the size of the tie. A seven-inch by nine-inch tie with an end area of 63 square inches will probably develop more resistance in contact with the shoulder ballast than a six-inch by six-inch tie with an end area of 36 square inches. Important as it is, the end of the tie does not provide all of the resistance to these lateral forces. Anyone who has ever looked at the bottom of a tie which has been removed from a track after having been there for some time knows that this bottom surface of the tie has become indented. It has assumed a shape similar to the pieces of ballast with which it has been in contact. The harder and more angular the ballast is, the more pronounced the indentations will be. This bond between the tie and the ballast does not exist with a newly installed tie. It is considerably reduced after the track has been surfaced, breaking up the old contact between the tie and pieces of ballast which fit the indentations in the tie. It is important to be aware of these conditions when renewing ties or surfacing track. Except for a track which has been disturbed in such a way, it is possible for a considerable resistance to movement to be developed by this frictional bond between the tie and the ballast. This is particularly true when a train is on the track. The weight of the train increases this frictional resistance between the bottom of the tie and the ballast even though the train may create other forces which are tending to push the track out of alinement.

Another factor in resisting forces which tend to push the track to one side is the friction between the sides of the tie and the ballast in the cribs. If the ballast in the cribs is level with the top of the tie, more frictional resistance will be developed than would be the case with partly filled cribs. The type of ballast used will also help determine the effectiveness of this resistance to lateral movement. Ballast which has become compacted will provide more resistance than ballast which has recently been disturbed by trackwork.

ANCHORS RETARD RAIL MOVEMENT

There is one other type of load placed on the track structure which the tie helps to resist. This is the type of load which tends to make the rails move lengthwise, that is to slide in the tie plates between the spikes. There are a number of conditions under which this tends to happen. They are generally related either to the traffic which moves over the track, to changes in temperature, to grades and to braking. (LONGITUDINAL FORCES)

RESTRAINT OF TRACK FROM CHAPTER 7 "BALLAST"

The second requirement of the FRA ballast standard is that the ballast will restrain the track laterally, longitudinally, and vertically under dynamic loads imposed by railroad rolling equipment and thermal stress, exerted by the rails. In most ways, the ability to restrain the track laterally and longitudinally is inter-related. Most lateral displacement results from failure to restrain the track longitudinally. It has been shown that rail tends to creep longitudinally. The main reasons are the influence of rail traffic and temperature changes within the rails.

If rail is permitted to move longitudinally, at some point in the track and at some period of time, higher than normal compressive stresses will develop in the rails. If these compressive stresses become large enough, the track will begin to move laterally, or vertically, or buckle. This can be extremely dangerous. It can happen quite suddenly, in front of or under a moving train. A serious derailment may result.

Such hazards can be avoided if the rails are restrained from moving longitudinally. This restraint must be provided by other parts of the track structure. Anchors are applied to the rail. Rail anchors, if properly applied, will keep the rails in the same position relative to the anchored ties. If the ties, to which anchors are applied, are not adequately restrained, the rail will still be free to move longitudinally. It is necessary that these ties be restrained from creeping.

The ties must be restrained by the ballast. The amount of restraint provided by the ballast can be very small or it can be considerable. There are several things which determine how much restraint should be provided.

The amount of ballast in the cribs between ties is one of the more important factors in the restraint of ties. You should know what your railroad's standards are for the amount of ballast in the track structure. Many railroads require that ballast cribs be full to the top of the ties, at least for welded rail. Such standards should never be ignored, even for short periods. If the standard is not met, temporary operation of trains may be justified, but at reduced speed. Consideration must be given to existing and probable rail temperatures. Any such expediency should only be for short periods, until adequate ballast is provided. Slow-speed train operation may minimize immediate danger. It must be recognized that insufficient ballast may permit some longitudinal movement. A later application of ballast will not correct this. This could combine with some subsequent condition, such as a high rail temperature, to cause excessive compression.

Since it is the rails which tend to move, it is necessary to provide some means of securing the rails. This is done by devices known as rail anchors. There are a number of types of rail anchors in use. Most of them are clipped around the base of the rail. They are applied at a point on the rail where one edge of the rail anchor will bear snugly against the side of the tie. Other types of anchors are secured through a tie plate hole as well as to the base of the rail. In the latter case, the anchor is capable of resisting rail movement in both directions. In the first case, an anchor can only resist rail movement in one direction. It is necessary to provide anchors on both sides of ties if there is a likelihood of rail movement in either direction.

Whatever method is used the rail is, in effect, anchored to the ties to prevent this type of movement. If movement of the rail is to be prevented, the ties must also be prevented from moving. This is another job which the ballast must perform. The amount of resistance which will be developed between a tie and the ballast which surrounds it, depends upon some of the same conditions which determine the resistance to lateral movement of the track. This includes the bond between the bottom of the tie and the ballast, the amount of ballast in the cribs, the type of ballast and whether the ballast is compacted or loose. In addition to all of these conditions, which are variable, the loads which tend to make the rail move can also vary widely. The recommended practice is to anchor enough ties so that there will be enough resistance to prevent movement of the rail.

PART PLAYED BY BALLAST

It has already been necessary to give some consideration to the ballast in dealing with the function of the tie. At this point we should take a further look at the part played by the ballast in the track structure. We have seen how the loads which are placed on the track structure are transferred through the various parts of this structure until they reach the ballast. In turn, it has to resist these loads so that the track remains in place. These include the vertical load, which is the weight of the equipment moving over the track, lateral loads, which tend to push the track out of alinement and longitudinal loads, which result from the tendency of the rails to creep lengthwise. Ballast is expected to resist all of these loads. It is also expected to do other things. It should further spread the large vertical loads which it receives from the ties so that when they are in turn passed on to the roadbed, they are spread over larger areas with lower pressure. Ballast should also be capable of quickly draining itself of water. In addition to supporting and transferring loads placed upon it, ballast should have sufficient strength so that it does not break up or pulverize under repeated loads.

A wide range of materials is used for ballast. During the steam engine era, cinder was used extensively, especially in yards and branch lines. With the present limited availability of such materials, many tracks so ballasted are being converted to other materials. Even so, there is still a good deal of track mileage with cinder ballast. Materials which are most frequently used include crushed rock, crushed slag from both blast furnaces and open-hearth furnaces and gravel. Various materials are used for making crushed rock ballast, depending on what is available locally as well as a balance between price and quality.

Usually a railroad specifies what type of ballast is to be used in various types of tracks. The top quality ballast will normally be used in high-speed, heavy-traffic main tracks. If this material is available in limited quantities, a second best material may be used in lighter traffic branch lines. Another possible variation in ballast specifications might occur when ballast of a smaller size is used for yard work. This is sometimes done at such locations because it is easier for employes to walk on than the usual standard size.

When a train passes over a track and a wheel load is passed to a tie and then to the ballast directly under the tie, all of the load is not transferred straight downward to the roadbed below. Part of the load begins to spread outward in a diagonal direction from each bottom edge of the tie. Again we see the sort of thing happening that has happened in the case of the rails, tie plates, and ties. A distribution of the load from a smaller area on top, to a larger area where it is passed on to the support below, results in a lower pressure being placed on the supporting material. It can be seen that this is necessary when the strength of each of these materials is considered.

Starting with the steel rail which has considerable girder strength, then the tie plate made of relatively flat steel, followed by the wood tie, next by a material such as crushed rock or slag, and finally, the natural soil, a pattern of materials of decreasing strength can be seen. It is only by this process of spreading the load over a larger area in order to reduce the pressure on the weaker material below, that it is possible to support the loads which trains place on the track structure. In the case of the ballast, with the load being spread diagonally downward and outward from the bottom of the tie, the depth of the ballast is important. If there is only two or three inches of ballast under the tie, there is not going to be much spreading of the load. A substantial depth of ballast can provide for a good distribution of the load. Usually a depth of ballast in the range of 12 inches is adequate to distribute the loads well. In some cases, even more is desired.

One of the things that determines how well ballast resists the loads placed upon it, is how well the individual pieces of ballast interlock to form a bond. One of the things which contributes to this is how well the ballast is compacted. A new track or one that has been recently disturbed because of maintenance work will have relatively loose ballast. A track which has had a good deal of traffic over it since the ballast was last disturbed will have relatively compacted ballast. Some interest is now being shown in the use of machines to help compact ballast which has recently been disturbed. It is possible that this practice might be used more in the future. Another thing that helps determine how much of a bond the ballast develops is the type of ballast. A crushed rock with sharp, angular edges will bond together better than gravel with mostly rounded surfaces. The gravel will have more of a tendency to roll like marbles when a load is placed upon it.

It would be possible to increase this bonding of the ballast by the addition of smaller pieces of material to fill the openings between the larger pieces of ballast. Unfortunately, if this is done it reduces the ability of the ballast to do another of its jobs which is to drain itself effectively. If the presence of fine particles of materials results in water from rainfall becoming trapped in pockets within the ballast and only seeping away slowly, problems can be expected. For this reason, it is important to determine that new ballast does not contain fine materials not permitted by the specifications. Keeping ballast free of materials which interfere with drainage and removal of such materials if they do get into the ballast are very important to good track maintenance. Such work will be covered later.

Ballast which cannot withstand the loads placed upon it crumbles under the loads or which deteriorates due to exposure to the weather, will lose its ability to support the loads and will also contribute to the fouling of the remaining ballast. Since some tracks are subjected to much more severe traffic conditions than others and since top quality ballast is not always available in enough quantity to meet all needs, it is important for any track foreman involved in unloading ballast to be certain that the proper ballast is being unloaded in the proper location.

A good track structure will have under the ballast another layer of material which is known as sub-ballast. There are two principal jobs which sub-ballast is expected to do. One of these is to catch water draining downward from the ballast and to reduce the amount of water continuing downward toward the soil, draining as much as practicable to one or both sides of the track. It will be diverted away from the roadbed by ditches or other drainage structures. Some water does penetrate to the soil under the sub-ballast. If this causes the formation of mud pockets, a second function of the sub-ballast is to retard any upward movement of the mud into the ballast as the result of the pumping action of the track when a train moves over it.

For these reasons sub-ballast is expected to have different qualities than ballast. Cinder was formerly used extensively as sub-ballast. Present day new track construction relies extensively on quarried materials containing mostly fine screenings. It is important that the top surface of the sub-ballast be sloped downward towards the sides of the track to promote the water run-off. This description of sub-ballast refers to the type of construction that is usually used when new tracks are built in the present era. Most tracks were built many years ago and a wide range of conditions will be found with regard to sub-ballast and ballast conditions in the normal course of maintenance.

Sub-ballast is laid upon whatever the local material the roadbed is constructed. This can cover a wide range of soils or rock depending on what is natural to the area. It might be located directly upon the natural surface of the ground or more frequently the roadbed consists of fills or cuts.

ROADBED MATERIAL

The fills may have been made of select materials that provide good support for heavy loads or they may have been built of whatever was closest at hand, regardless of quality. They may or may not have been adequately compacted. The side slopes of the fills may have been constructed at a suitable angle to provide good support or they may have been made as steep as possible creating other maintenance problems. There may have been adequate drainage facilities built at the bottom of the fill to handle whatever runn-off of water that may occur. In other cases, this may have been ignored.

In the case of cuts, a wide variety of conditions may also be found. There may or may not have been sufficient excavation to provide for ditches capable of carrying off the water and of keeping the water table well below the track. The sides of the cuts may have been sloped or benched to eliminate problems from slides or they may not have been. There may have been springs located when the cut was excavated which may or may not have been adequately drained. The soils of the roadbed in the cut may or may not have been found to be of a type that will provide good support. If not, they may or may not have been replaced with more suitable conditions.

All of these undesirable conditions which have been described can cause maintenance problems within the track structure. The source of the problem may or may not be easy to locate. The symptoms may need correcting, whether it be irregular track surface, mud pockets, or some other condition. Chances are these symptoms will keep returning unless the source of the problem is located and corrected.

In this lesson we have been mostly concerned with how the basic track structure is put together and the reasons tracks are so constructed. It is not a perfect structure. It is a flexible structure that requires a considerable amount of maintenance. Yet it has served well for a long time. During this time, it has undergone many changes. This process is a continuing one. Changes will continue to be made in the design of railroad tracks, the materials used and the methods employed to construct and maintain them. All who make a career in the field of track maintenance and construction will have to keep abreast of those changes as they occur.

Very little has been said in this lesson about how to maintain a railroad track or the proper methods to use in building one. These subjects will be covered in depth in following lessons. If, in this introductory lesson, you have acquired a good understanding of why tracks are constructed as they are and how the loads that are placed upon the track affect the track, you will better understand the reasons for the procedures which will be described in future lessons.

LESSON 1

EXERCISE QUESTIONS

1. Describe two things which are commonly done to provide for expansion and contraction of jointed rail.

2. Plate-holding spikes can help prevent wide gage. True or false.

3. Name two special types of rail joints.

4. Joint bars have oval holes so that rail end gaps can open and close. True or false.

5. When installing ties, you normally place one rail-holding spike on the field side, and one rail-holding spike on the gage side of each tie plate. You are instructed to install an additional rail-holding spike in each tie plate. On which side would you install the additional spike?

6. A 100 pound rail, 30 feet in length weighs about 3,000 pounds. True or false.

7. A tie which is 7 inches thick by 8 inches in width is most frequently used in which type of track?

   Main Line   Yard

8. If all other conditions are equal, in which type of ballast are defects in track alinement most likely to occur?

   Crushed rock   gravel

9. Some of the following conditions have an important effect on whether rail will move longitudinally (lengthwise). Others have little or no effect. Indicate the conditions described which are important in preventing such movement of the rail. A). The number of rail anchors on the rail. B). The amount of shoulder ballast. C). The number of spikes in the tie plates. D). The amount of ballast in the cribs between the ties. E). Having double-shoulder tie plates. F). Having 6-hole joint bars. G). Having anchors placed snugly against the sides of ties.

10. Explain three things that ballast is expected to do.

11. Describe two times at which ballast is likely to be relatively loose and uncompacted.

12. Explain two things that sub-ballast is intended to do.

13. What are two problems that are likely to occur on a fill because of the way it was constructed?

14. What are two problems that may be found in cuts?

15. What three kinds of load may be placed on the ballast by the ties when a train is moving on a track?

16. Some of the following are reasons for using tie plates. Some are not. Indicate the valid reasons for using tie plates. A). To hold the rails to gage. B). To reduce wear on the base of the rail. C). To increase the life of the ties. D). To keep track bolts tight. E). To reduce the amount of ballast that is needed.

17. When single-shoulder tie plates are used, should the shoulder be on the gage side or the field side of the rail?

18. Why is a substantial depth of ballast below the bottom of the ties important?

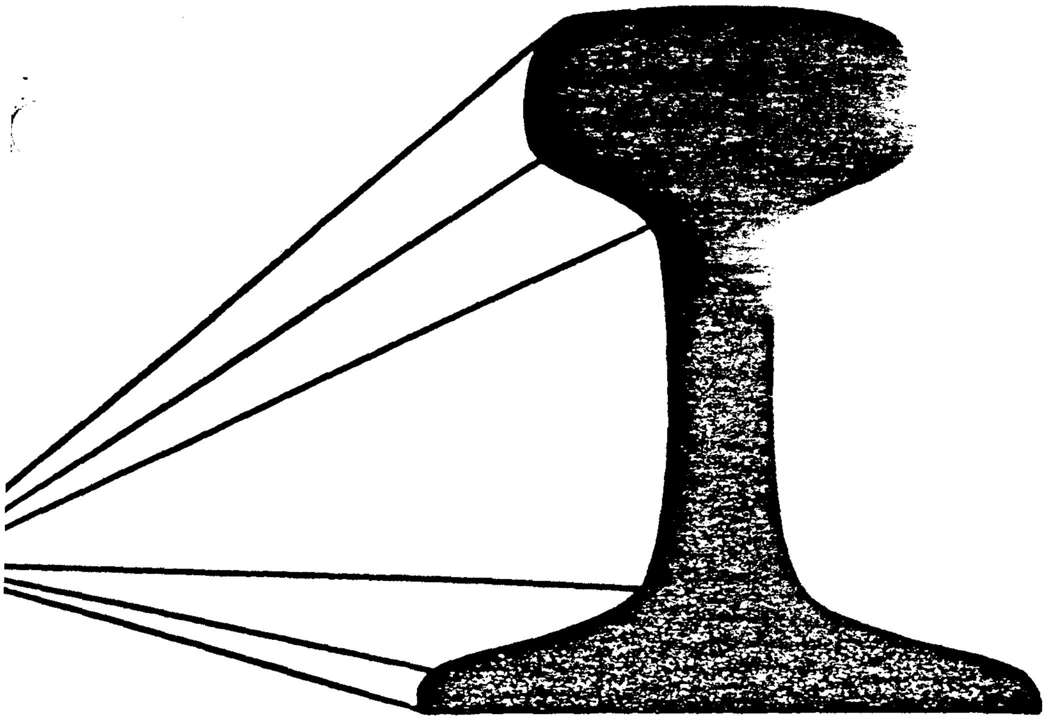
19. Is it good practice to inspect ballast loaded in cars before unloading it in track. What should you look for?

20. Identify two sizes of rail used on your railroad. Indicate the weight, section, base width, and height of each.

Weight _____ Section _____ Base Width _____ Height _____

Weight _____ Section _____ Base Width _____ Height _____

Submit your answers to these questions to The Railway Educational Bureau in the prescribed manner. Be sure to include your name, file number, address, company's name and lesson number on the upper right hand corner of your paper.



TRACK FOREMAN'S TRAINING PROGRAM

LESSON 14

WELDING AND GRINDING

The Railway Educational Bureau
1809 Capitol Ave., Omaha, Nebraska 68102

LESSON 14

WELDING AND GRINDING

INTRODUCTION

Several techniques of welding and grinding are used in various ways in the maintenance of the track structure. These procedures are very useful in improving the quality of the track, and prolonging the life of track materials. The abilities required of those who perform this work range from semi-skilled to highly skilled. Acquiring the skills of a welder or grinder operator requires training under the direction of a competent instructor. The extent of the training needed will vary with the particular procedure which is to be mastered. Finally, qualification or certification should be based upon a practical demonstration of competence to a designated examiner.

It is not the intention of this lesson to attempt to train students in the skills required of welders and grinder operators. Some Track Foremen have acquired these skills, but such abilities are not generally considered to be part of the foreman's job.

Many decisions to perform welding or grinding work on some part of a track structure, are based on inspections and recommendations of a Track Foreman. Many welding and grinding procedures are performed incident to a track maintenance project, which is being progressed under the direction of a Track Foreman. This lesson is intended to provide him with sufficient understanding to determine when to use these procedures and to adequately supervise those who do this work.

PART 1 -- WELDING

Some of the grinding operations which are frequently performed on various parts of the track structure are carried out independently, while others are done incident to welding procedures. Welding will, therefore, be considered first. The procedures to be examined are:

1. Rail end welding -- may be done by either the oxy-acetylene or electric arc process.

2. Engine driver burn welding -- done by the oxy-acetylene process.

3. Switch point welding -- done by the oxy-acetylene process.

4. Frog welding -- Manganese castings done by the electric arc process. Other portions may be done by the oxy-acetylene process or the electric arc process.

5. Rail end butt welding (in track) -- done by the thermit process.

6. Rail end hardening -- done by the oxy-acetylene process.

7. Cutting of rail and other steel parts -- done by the oxy-acetylene process.

THE OXY-ACETYLENE WELDING PROCESS

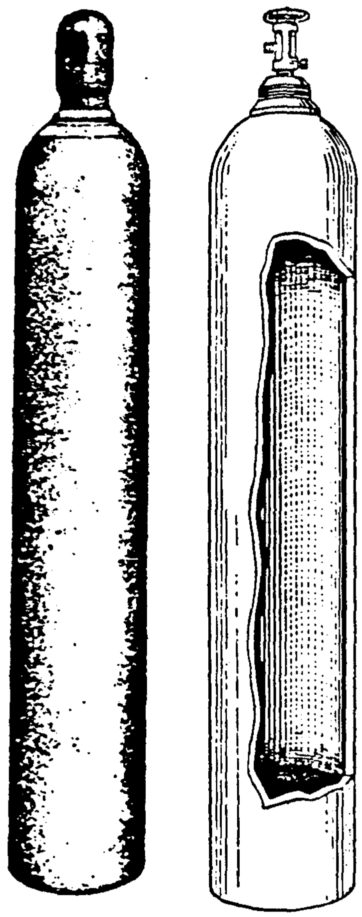
Acetylene is a combustible gas. When burned in combination with oxygen in proper proportions and pressures, an extremely hot flame is produced. Oxy-acetylene flames are capable of cutting through, fusing together or heat treating steels and other metals. The oxy-acetylene process is highly versatile, having many practical applications. Oxygen and acetylene are commonly stored at high pressures in portable cylinders. The ability to readily bring these materials and the other equipment used in oxy-acetylene welding to a job site adds to the usefulness of this process.

OXYGEN AND ACETYLENE CYLINDERS

Oxygen cylinders are characteristically long and of relatively small diameter. The usual dimensions are 57 inches in length and 9 inches in diameter. When completely filled with oxygen, these cylinders are pressurized at 2,200 pounds per square inch and weigh about 175 pounds. Figure 1 illustrates a typical oxygen cylinder.

These cylinders are not designed to be kept in a vertical position, unless they are supported in a manner that will prevent them from falling over. When laid in a horizontal position, they must be secured, if necessary, to prevent rolling.

Acetylene cylinders are considerably different from oxygen cylinders. Acetylene in its free form should not be stored at pressures above 15 pounds per square inch, in the interest of safety. To safely overcome this limitation, and to get practical quantities of acetylene into a cylinder, the acetylene is stored in a different manner. The cylinders are packed with a porous material. The openings of this material are then filled with acetone,



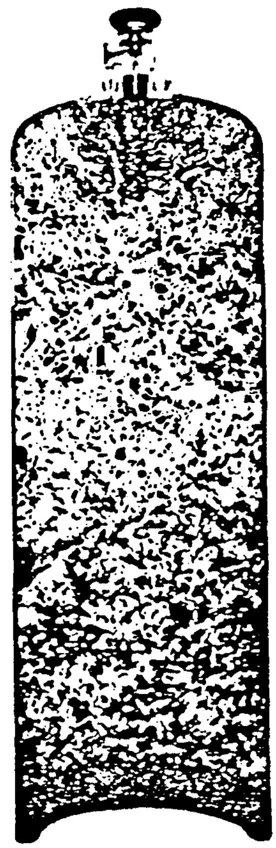
The Linde oxygen cylinder is made from a seamless steel shell and, when full, contains 244 cu. ft. of oxygen at 2,200 lb. per sq. in. pressure at 70 deg. F.

Courtesy Union Carbide Corp. Linde Div.

Fig. 1

a liquid chemical. Acetone has the ability to absorb large quantities of the gas acetylene. In this dissolved condition, acetylene can be stored safely.

It is important, both in use and in storage, to keep acetylene cylinders in a vertical or near vertical position. This is necessary to keep the liquid acetone away from the valve at the top of the cylinder. Acetylene cylinders are not as long as oxygen cylinders and are larger in diameter. This permits them to be stored and used in a vertical position when on a solid, level foundation and not subject to being bumped. Figure 2 depicts a typical acetylene cylinder. When being transported, either by truck or by on-track equipment, they must be supported against falling. A full size acetylene cylinder will have a pressure of about 225 pounds per square inch when full, and will weigh about 240 pounds.



Acetylene cylinders are packed with a porous filler which contains acetylene which is dissolved in acetone.

Courtesy Union Carbid Corp., Linde Div.

Fig. 2

Care must be exercised in the use and storage of oxygen and acetylene cylinders, both because of the pressures involved and the nature of the gases. The pressures which have been indicated are for full tanks at 70 degrees Fahrenheit. Excessive heating of the cylinders can produce leaking or an explosion of the cylinder. They should be stored away from fire hazards, furnaces, radiators, or steam pipes.

They should not be subjected to rough handling, dropping or falling over. Care must be exercised to avoid damage to the valve. When a cap is provided, it should be kept on the cylinder whenever it is not in use.

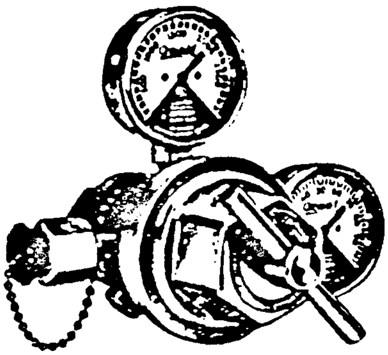
A leaking cylinder should never be used. If a cylinder leaks with the valve closed, it should be moved to an outdoor location away from any source of ignition. The valve can then be opened slightly, so that the acetylene can escape slowly. When empty, the tank should be marked defective, kept separate from other tanks and the manufacturer notified.

OXYGEN AND ACETYLENE REGULATORS

It has been shown that it is necessary to store oxygen and acetylene in the cylinders at high pressures, in order to get practical quantities of the gases in the containers. These pressures are not practicable for use at the welding torch or blowpipe. Working pressure of acetylene must not exceed 15 pounds per square inch. Oxygen pressures which are used may at times be higher, but still at relatively low pressure. It is, therefore, necessary to provide a means of reducing the pressures of the gases as they leave the cylinders to the desired working pressures. The pressures desired are not always the same for all types of work. A means of adjusting to the desired pressure is needed.

As the gas within a cylinder is used, the pressure within a cylinder drops. If the working pressure dropped correspondingly, this would have an unsatisfactory effect on the welding. A means of providing constant working pressure is needed. These are the functions of the oxygen and acetylene regulators. Figure 3 pictures an oxygen regulator and Figure 4 an acetylene regulator. Each has two gauges; one indicates cylinder pressure, and the other indicates the working pressure.

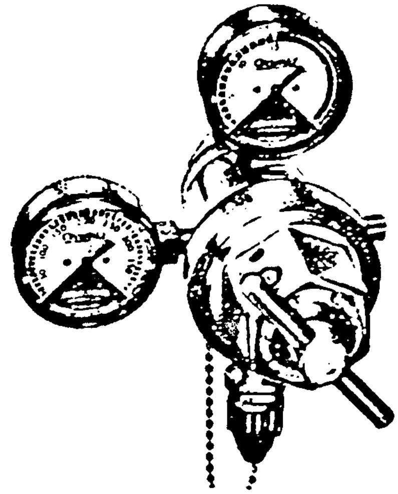
Regulators can be readily damaged through rough handling. Damaged regulators can be dangerous, if they permit the uncontrolled escape of the gas. Damage during the course of a job can also make the entire set of welding equipment unavailable at a time when you are depending on it. Regulators can also be damaged by opening the cylinder valve quickly, and exposing the regulator to sudden high pressure. Always open cylinder valves slowly. Suspected leakage of gas from regulators can be detected by using soap and water. Regulators known or suspected to be defective should be inspected and repaired at a repair station authorized by your employer.



This is an Oxweld R-64 oxygen regulator, used for welding operations. An R-65 cutting regulator is similar in appearance except that the right-hand gauge face is graduated to 200 or 400 lb. per sq. inch.

Fig. 3

Courtesy Union Carbide Corp., Linde Div.



The Oxweld R-66 acetylene regulator is similar in its operating principles to the oxygen regulator, but is not designed for as high-pressure operation. The nut for connecting to the acetylene cylinder valve has a left-hand thread, which is standard practice for acetylene regulators.

Fig. 4

HOSES

Specially designed hoses are required to connect the regulators to the torch or blowpipe. Figure 5 shows typical hoses. Red is the standard color used for acetylene hose and green for oxygen hose. Hose connections are marked as being for oxygen or acetylene. The oxygen hose connections have right-hand threads and the acetylene connections have left-hand threads. This prevents using the oxygen hose for acetylene and vice-versa.

Oxweld double hose is actually two pieces of hose joined by a web. This arrangement eliminates the breakdown of the adjacent sides of the hose walls and consequent intermingling of the gases.

Fig. 5

Hoses should be inspected about once a week for leaks. This can be done by immersing the hose in water while connected with normal working pressure.

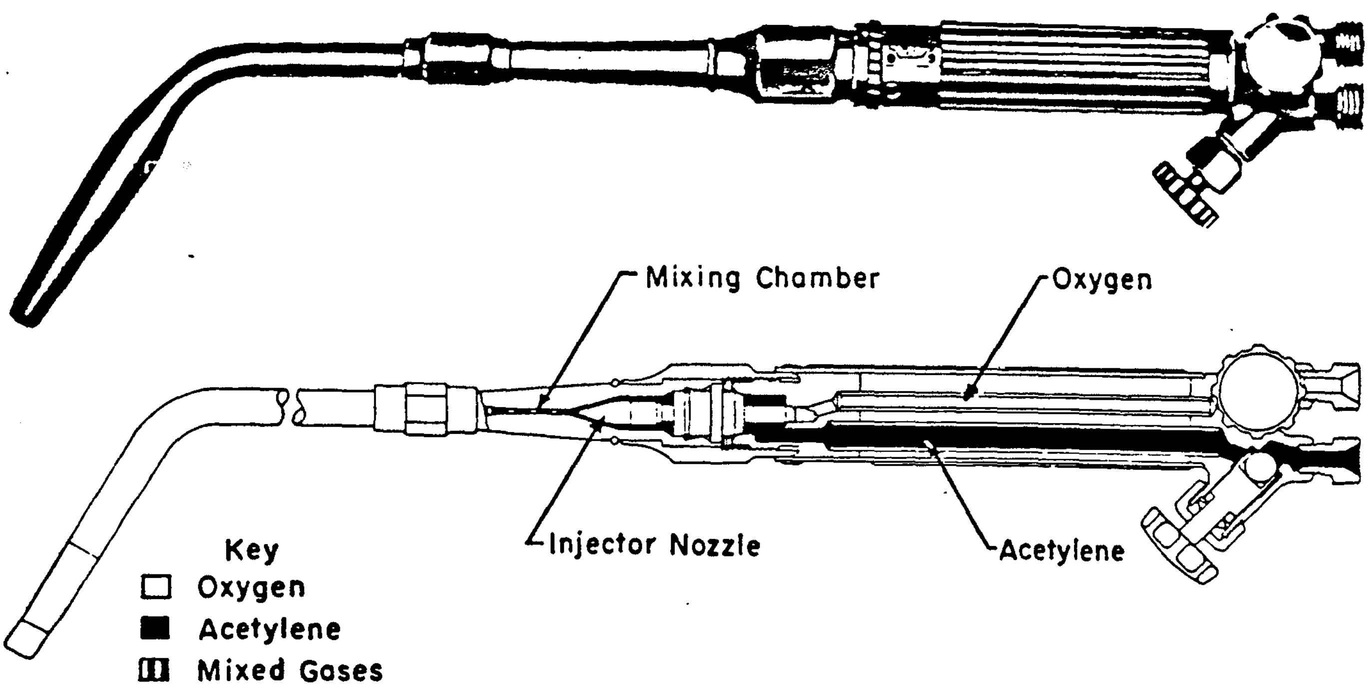
Various welding operations require different types of flame. It is not necessary for the Track Foreman to have a complete knowledge of flames and welding techniques. It may be sufficient to understand that oxy-acetylene welding flames can be classified into three groups:

Neutral flames -- with equal amounts of oxygen and acetylene.

Carburizing flames -- with an excess of acetylene

Oxidizing flames -- with an excess of oxygen

The flame is controlled by the blowpipe or torch. Both the green oxygen hose and the red acetylene hose are connected to the blowpipe. The oxygen fitting has a right-hand thread and the acetylene fitting has a left-hand thread, so that they cannot be interchanged. There are valves adjacent to each hose connection so that the flow of each gas can be controlled independently. There will be inter-

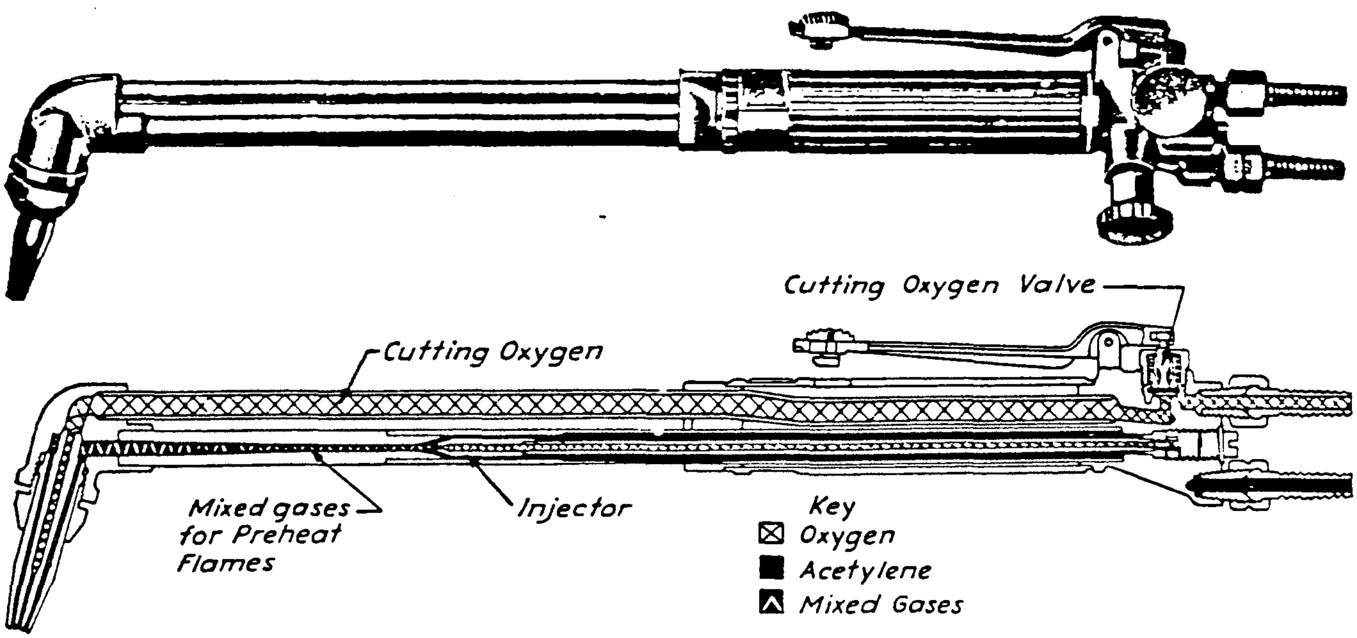


This injector type Oxweld W-17 blowpipe illustrates a blowpipe designed for both low and medium-pressure operation. The injector used in this blowpipe is shown in Fig. 36.

Courtesy Union Carbide Corp., Linde Div.
Fig. 6

changeable tips provided, with various size openings, to accommodate different types of work. The oxygen and acetylene are mixed within the blowpipe. The amount of each gas will depend on the blowpipe valve settings and the regulator pressures. Figure 6 illustrates a welding blowpipe.

Cutting blowpipes are somewhat different. In addition to providing for the mixing of the gases, as is done in the welding blowpipe, a separate supply of oxygen is passed through the blowpipe. This is ejected through a separate hole in the tip adjacent to the hole from which the mixed gases escape. The mixture of oxygen and acetylene is required to heat the metal. After sufficient heating, the separate supply of oxygen is required to cut the metal. Figure 7 illustrates a cutting blowpipe.



The gases for the preheating flames in the Oxweld C-31 cutting blowpipe are mixed by the injector principle. Injector principle blowpipes can be operated from low-pressure acetylene generators as well as from medium pressure supplies.

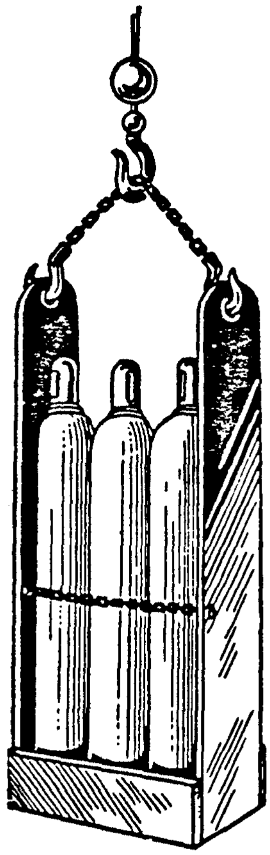
Courtesy Union Carbide Corp., Linde Div.

Fig. 7

While these tools are of fairly rugged construction, it is possible for leaks to develop. A blowpipe should never be used if it is leaking. If dirt gets into the hose connector fittings, leakage may result. It may also damage the threads. If any part of a blowpipe is suspected to be leaking, soap and water can be used to detect a leak.

Here are some tips for using oxy-acetylene equipment safely:

1. Avoid rough handling of cylinders. If necessary to handle with hoisting equipment, never use a magnet or sling. Place them in a suitable container from which they cannot fall (see Figure 8).



Do not move cylinders with apparatus connected. Use a safe cradle or boat—never a sling or electric magnet.

Fig. 8

Courtesy Union Carbide Corp., Linde Div.

2. The welder and other employees near the work must wear proper goggles.

3. Use a friction lighter to light blowpipes, not a match.

4. Keep cylinders away from excessive heat.

5. Don't release acetylene where it might cause fire or an explosion.

6. Never use oxygen as a substitute for compressed air.

7. Never lubricate any part of the oxy-acetylene apparatus.

8. Never use acetylene at a pressure in excess of 15 pounds per square inch.

9. Never use equipment which has a leak.

10. Never hang a blowpipe or hoses on regulators or cylinder valves.

ELECTRIC ARC WELDING

Electric arc welding is the only suitable method for some types of welding, such as the welding of manganese frogs. In other situations, it is optional. Rail end welding is an example. Electric arc welding can be more economical than oxy-acetylene welding, particularly where there is a large volume of work.

It is not always as convenient to make the necessary electric arc welding equipment available at a job site, as it is with oxy-acetylene equipment. A generator is required to produce the needed electric current. This consists of high current (or amperage) at relatively low voltage. The generator is normally powered by an internal combustion engine. The generator set may be truck mounted, trailer mounted or mounted on an on-track piece of equipment. Heavy wire cables are used to carry the current from the generator to the point of work. The end of one cable is clamped to the frog or rail to be welded. The end of the other cable is attached to the welding rod.

If there are access roads convenient to the track location where the work is to be performed, rubber tire equipment can function efficiently. If a job is to be done such as welding all rail ends in a stretch, and absolute use of track can be obtained, on-track generators will serve nicely. Consider a job such as a frog, which is to be welded, which is a considerable distance from an access road. Rail traffic is heavy, and on-track equipment is not practicable. In this case, a generator must be loaded to on-track equipment, transported to the work site and unloaded adjacent to the work. When the job is completed, the process must be repeated. Usually, hoisting equipment must be made available. This can be much more cumbersome than moving oxy-acetylene equipment which can frequently be done by two workers.

WELDING RAIL ENDS

This type of welding involves depositing additional steel on the head of rails, close to the ends of the rails.

The purpose is to restore a smooth running surface to the rail head in the rail end area. This procedure is used to eliminate batter and chipped ends and to make a smoother transition where vertical mismatch exists.

The irregularities which develop on the running surface of the rail head can be measured with a steel straightedge and either feeler gages or a taper gage. Measuring procedures vary between railroads. You should determine what standards your railroad has for:

Length of straightedge to be used

Positioning of straightedge

Minimum depth of buildup

Maximum depth of buildup

Maximum length of weld

Method of marking weld limits

Once you become familiar with your company's standards, you can determine minimum limits at which welding is justified as well as maximum limits at which it is permitted. You will then be able to make recommendations for rail end welding based on actual conditions, rather than on judgment.

There are two general types of situations in which rail end welding may be employed. One of these involves random conditions in which one or more joints require welding. Examples of this would include the case where a defective rail has been replaced with a rail having a head that does not match well with the adjacent rails. Another example would be where a joint has become battered much more than other joints in the area. Isolated joints like these do not lend themselves to high production methods. Getting the welding equipment to the point of work may be time consuming. The welder may not be able to complete his work promptly, if other phases of the job are still underway.

At other times, there may be a situation where all or most of the joints in a stretch of track are battered to the extent that a welding program is recommended and approved. This type of job requires organization of the work so that it progresses smoothly. The welding may be done by either the electric arc or oxy-acetylene process. Electric arc welding will be somewhat faster, if the equipment can be kept at the point of work, either by exclusive use of track or by parallel access road. If oxy-acetylene welding is used, a procedure should be set up for efficient handling of the cylinders, since an extensive project will require a sizable number of them.

Regardless of whether a random joint or a programmed stretch is to be welded, any other defects in joint maintenance should be corrected prior to welding. Loose bolts should be tightened. Worn or cracked joint bars should be replaced. Joint ties, with defects that result in poor support should be replaced. The joint should have good surface and be well tamped. If there is an excessively wide rail end gap, this should be adjusted. The existence of any of these conditions probably contributed to the battered condition, and if not corrected, the battering process would repeat itself.

The intention in welding rail ends, is to restore the running surface to conform to the rail head contour, as it exists beyond the battered area. The weld does not restore the rail head to the contour it had when new, unless this is the condition which exists beyond the batter.

The process of depositing welding steel on the rail head will not result in the smooth running surface which is desired. This must be accomplished by grinding. Weld metal is applied so that the surface is slightly higher than required. The surface can then be brought to the desired level by grinding. Final surface can be checked with the same equipment used to determine the extent of the batter. Your railroad may also specify tolerances permitted in the final job.

Part of the grinding process should include rail end cross-grinding. To do this properly, the welding should extend full height to the end of the rail. No attempt at beveling should be done while welding. This is accomplished by cross-grinding. Neither the surface grinding nor the cross-grinding should be done until the surface has cooled so that a hand can be held to it.

ENGINE DRIVER BURN WELDING

Engine driver burns are caused by slipping drive wheels. They heat the portion of the rail head with which they are in contact sufficiently to permit the slipping wheels to displace some of the steel. In addition to the depression which this causes, there may be upset metal adjacent to the depression, in the direction toward which the wheel is spinning.

Severe depressions or numerous burns within a rail length are cause for replacing the damaged rail. In less severe cases, the rail can be repaired by welding. The oxy-acetylene process is normally used for this work.

If there is upset metal present, this should be removed first, by grinding. Within the depressed area, the surface metal has been damaged due to excess heating and uncontrolled cooling. This should be removed by grinding, before any welding is done. As grinding progresses, small shatter cracks may be detected within the rail head. Grinding should proceed until all such cracks are removed. If grinding extends too deeply, the rail will have to be replaced or protected with joint bars after completion of the welding. Unless your railroad specifies some other limit, it is recommended that the depth at which this becomes necessary should be 3/8 inch.

When depositing the welding steel to build up the depressed area, it is necessary to avoid overheating the rail. Overheating can lead to a permanent sag in the rail, particularly if a train passes over it while hot. The temperature which the rail attains in the vicinity of the work depends on the length of time that the welding flame is applied to the work. In the case of long burns, it is necessary to stop after completing part of the weld, and allowing the rail to cool before proceeding. This is no real detriment to the progress of the work, since engine burns occur in groups, and the welder can rotate between the various burns in the group. If your company does not specify otherwise, it is recommended that the maximum length of weld be limited to 3 inches, until the rail has cooled so that it can be touched.

Surface grinding is necessary to provide a smooth running surface. Sufficient welding steel must be applied to permit grinding. Grinding should only be done after the rail has cooled. The grinding operation should restore the affected area to the same contour as the surrounding portion of the rail.

SWITCH POINT WELDING

Many railroads repair the tips of switch points that are worn, chipped, cracked or broken, by welding. On some lines this is permitted in any track, regardless of the allowable speed. Other railroads restrict this practice to slower speed tracks; some limit it to yard tracks. In addition to determining what your company permits, you should also find out the maximum length of weld permitted.

Before a switch point is welded, any lip on the stock rail or back side of the switch point should be removed by grinding. The switch point should then be adjusted, if necessary. If the switch needs surfacing, this should be done before welding.

All defective steel must be removed before welding begins. This is done by grinding with the switch point in the open position. This may cause the switch point to be in a condition which renders it unsafe for movement of trains, until the full point is restored. You must establish a proper understanding with operating personnel, so that the route can be removed from service during progress of the work, if its condition so requires.

When it appears that grinding has progressed to sound metal, a careful inspection must be made to see if any hairline cracks remain. If all cracks cannot be removed, arrangements should be made to replace the switch point. It may be necessary to restore the point to service temporarily, by welding, until a replacement switch point can be obtained.

Most welding of switch points is done by the oxy-acetylene process. Welding steel is applied to the switch point while in the open position. Work should begin at the tip and work back toward the undamaged portion. It may be necessary to close the switch point occasionally to be certain that the weld metal does not interfere with the proper closing of the point.

The welding operation must result in the placement of sufficient steel to provide a full contour switch point after grinding. Upon completion of the welding, the tip should be heated until cherry red. The switch point is then thrown to the closed position, and the heated portion is hammered to provide a good fit against the stock rail. After grinding, the point should have a proper taper. A blunt taper increases the risk of a wheel climbing the point. A thin tip increases the chance of breaking. The tip should be properly rounded and of the proper height in relation to the stock rail. A point with vertical taper may provide the opportunity for a wheel to climb on top.

FROG WELDING

The portions of most frogs that receive the most severe service is in the area where wheel loads are transferred to and from the point and the wing rails. This can result in vertical wear, crushing, chipping, cracking or breaking out of a portion of the running surface. At times, the rail ends at the toes and heels of frogs, require welding for reasons similar to ordinary rail joints.

The guarding faces of self-guarded frogs, sometimes require welding because of wear.

The portions of a frog constructed of open-hearth steel may be welded by either the oxy-acetylene process or the electric arc process. This includes any part of a bolted rigid frog, or the heel and toe joints of a rail-bound manganese frog. Any portion of a frog constructed of manganese steel can only be welded by the electric arc process.

Many frogs can be welded in track, while rail traffic is maintained, or by obtaining exclusive use of track for a period of time. Some frogs contain defects of such extent, that removal of the defective metal, would render the frog unsafe for traffic for a longer period of time. A frog in this condition should be replaced. Frogs with defects that cannot be welded under traffic, can frequently be welded after they have been removed from track. Many railroads do this work at a central shop.

Before welding a frog in track, all bolts should be tightened. If needed, the frog should be surfaced. The frog may be floating, or moving laterally, because of spike-killed ties. If this condition exists, it should be corrected.

Before starting the welding, it is necessary to remove any defective steel. This can be done with a grinder. It can also be done by electrode cutting. If the latter method is used, the surface must be ground before welding is started. If the reason for welding is worn surfaces and not defective metal, it is necessary to remove the work-hardened surface to a depth of at least 1/8 inch before beginning the welding.

While engaged in removal of defective metal, and depositing weld metal under traffic, relative elevations of the wings or risers and the point must be maintained in a manner that will avoid wheels imparting a heavy impact to the frog, as they pass over it. Weld metal must be applied so that there is enough to permit grinding the surface to provide the proper contour.

THERMIT WELDING

This process is used to weld adjacent rails together, in track. This creates a continuous rail, eliminating rail joints where the process is used. The most common use of this procedure is to join adjacent strings of continuous welded rail together. Thus, it is possible to eliminate all non-insulated joints over long stretches.

Thermit welding has several other useful applications in track work. It can be used to eliminate rail joints within grade crossings. Some crossings have highway traffic conditions that preclude closing more than half of the crossing at a time. In these situations, half of the crossing can be reconstructed and restored to traffic. When the second half is rebuilt, thermit welding can eliminate rail joints in the center of the crossing.

When a defect develops in a string of CWR, a length of rail can be cut out to eliminate the defect. Each end of the piece of rail which is installed, in place of the rail which is removed, can be thermit welded, so that joints are not introduced into the CWR stretch. Some railroads prefer to fabricate adhesive type insulated joints in a shop, rather than in track. These assemblies, consisting of two rails joined by the insulated joint, can be set in track with the ends being thermit welded.

Thermit welding is also useful in the elimination of rail joints within turnouts. One example is the practice some railroads employ of eliminating frog toe and heel joints. It is also useful in eliminating the joints between adjoining sections of turnouts constructed by the panel method.

There are several companies that manufacture the materials needed to make thermit welds. Each has certain differences from the others, but most parts of the process are similar. Unlike the procedures used in a welding plant where CWR strings are made, the rail ends are not butted tightly together. Each manufacturer specifies a certain gap that must exist between the rail ends to be thermit welded. These gaps range from 5/8 inch to 1 inch, depending on the brand used. The welding is accomplished by introducing extremely hot, molten filler metal into the gap between the rail ends. A mold retains the metal within the gap until it hardens. When it cools, it fuses to each of the rail ends.

It is not the intention in this lesson to instruct you in the making of thermit welds. This should be done by an employee who has been qualified in the techniques for the particular type of kit being used, by a competent instructor. There are several phases of the work in which Track Foremen are frequently involved. These will be examined.

At times, it will be necessary to shift a tie away from the location where a thermit weld is to be made. This is necessary to provide clearance for the mold which is fitted around the rail ends to retain the molten metal. You can soon become familiar with the amount of clearance required for the type of kit being used.

The need for a specific gap between rail ends has been mentioned. At times, it may be necessary to cut out a small amount of rail to provide the proper gap. In other instances, it may be required to draw rail ends together to attain the desired opening. It is then necessary to prevent changing thermal forces from either increasing or decreasing the rail end gap, during the period of preparation and welding. This can be accomplished by the use of a special jack assembly which is attached to both rails. These assemblies keep the adjacent rails the same distance apart, without infringing upon the clearance needed for the welding equipment.

If one or both rail ends have to be cut in order to provide the proper set-up, the cutting can be done with either an oxy-acetylene torch, a saw or an abrasive disc. The cuts must be square to the running surface. Torch cuts must be reasonably smooth. All burrs must be removed from the rail ends. The weld must be completed within one hour of making a torch cut to prevent the formation of shatter cracks.

The preparation should provide for obtaining a close fit of the mold and minimal contamination. Any rail head lips should be removed from relay rail. Grease, dirt, loose rust or mill scale should be removed from the portion of the rail that will be within the mold. There must not be any moisture on the rail.

The rail ends must be well matched. If relay rail is used, the running surface and gage side of the rail heads must be matched. Proper vertical and horizontal alinement must be secured, in advance of welding, and not be disturbed during the work. If the two rail ends form a dip, crown or lateral kink before welding, this defect will be permanent after the weld is made.

After these preparatory steps, the welder can proceed with setting up the equipment and making the weld. The mold is applied to the rail ends. The mold must be luted or sealed to the rail. A mixture of 4 parts of locomotive sand to one part of western bentonite with a minimum of moisture makes a satisfactory material.

The materials used to form the filler metal and to provide the heating reaction are placed in a crucible on top of the mold. Some of the processes require the rail ends to be preheated by flame. Others, accomplish this by the manner in which the molten material is introduced into the mold.

When the materials in the crucible are ignited, the reaction produces a very high temperature -- almost 5000 degrees F. As the reaction in the crucible progresses, slag separates and rises to the top, leaving the molten filler metal in the bottom of the crucible. Some of the systems in use have to be tapped manually, to allow the molten metal to enter the mold. Other processes are self tapping. When the material has cooled sufficiently, the mold and crucible are removed.

The next phase of the work is to remove excess filler metal from the rail. This can be done with a chisel, with a grinder to provide the finished surface, particularly on the rail head. A cutting torch must not be used in this operation.

Thermit welding needs to be done under the direction of someone well trained in the process being used. There are several operations involved which are basic to track labor. At times, several track laborers may be assigned to assist in this work, so that the welder can attain maximum productivity.

RAIL END HARDENING

New rail which has bolt holes drilled at the mill is normally end hardened at the mill. If the rail is shipped without bolt holes for welding into CWR, it is not end hardened. There are times when it is necessary to cut and drill rails at the job site. This is particularly true around turnouts and other special trackwork, and for the proper location of insulated joints.

Rail ends cut in this manner should be end hardened, to reduce the tendency to become battered under traffic. The end hardening should be done promptly upon installing the rail in track.

It is not necessary to end harden special heat treated rails, nor rail ends which are to be thermit welded. Relay rail has a greater surface hardness than new rail because of the cold rolling effect of previous traffic. End hardening is not generally performed on relay rail.

The process of end hardening involves heating the first few inches of the rail end with an oxy-acetylene welding blowpipe, to a temperature of about 1550 degrees F. To be effective, this heating should be done quickly. The rail end should then be allowed to cool rapidly. Use of a shield or box on the rail head is desirable. This is for the purpose of retaining as much of the heat as possible on the area being worked. The heated area will cool more rapidly if the adjacent portion of the rail does not have a chance to warm up.

The heating process will normally take less than a minute. The shield is then removed to promote rapid cooling. The welder can confirm his judgment of temperature by the use of a Tempilstik.

OXY-ACETYLENE CUTTING

The oxy-acetylene cutting blowpipe or torch is an extremely useful tool in trackwork. It is widely used in cutting rail. Bolts which have become too rusted to remove with a wrench can readily be cut off by this process. Many other uses occur in special situations.

While this provides a quick method of cutting rail to a desired length, there is a disadvantage. Sometimes small shatter cracks develop along the cut edge. These are not visible immediately after the cutting operation. They can grow under traffic, and in time, can cause a broken rail. For this reason, many railroads permit rails to be cut by this method, only if they are to be used in slower speed tracks.

Once a rail is cut, it is necessary to provide bolt holes adjacent to the new rail end. It is sometimes a temptation to cut the bolt holes with this method, rather than to use the much slower process of drilling the holes. There is a considerable likelihood of broken rails developing from holes cut with an oxy-acetylene torch. It is not good practice to make bolt holes by this method.

BUTT WELDS

Lengths of continuous welded rail are fabricated in a central shop; therefore, the Track Foreman normally does not get involved in these operations. The presence of these welds in track may be of some concern to him, though. Procedures vary between railroads as to the amount of grinding that is done to remove upset steel in the weld area. The rail head area will be ground to a smooth finish. If the underside of the rail base is not completely finished, each weld must be over a tie crib. This will necessitate shifting some ties. Should the rail creep, this upset metal will cause problems when the weld reaches the closest tie.

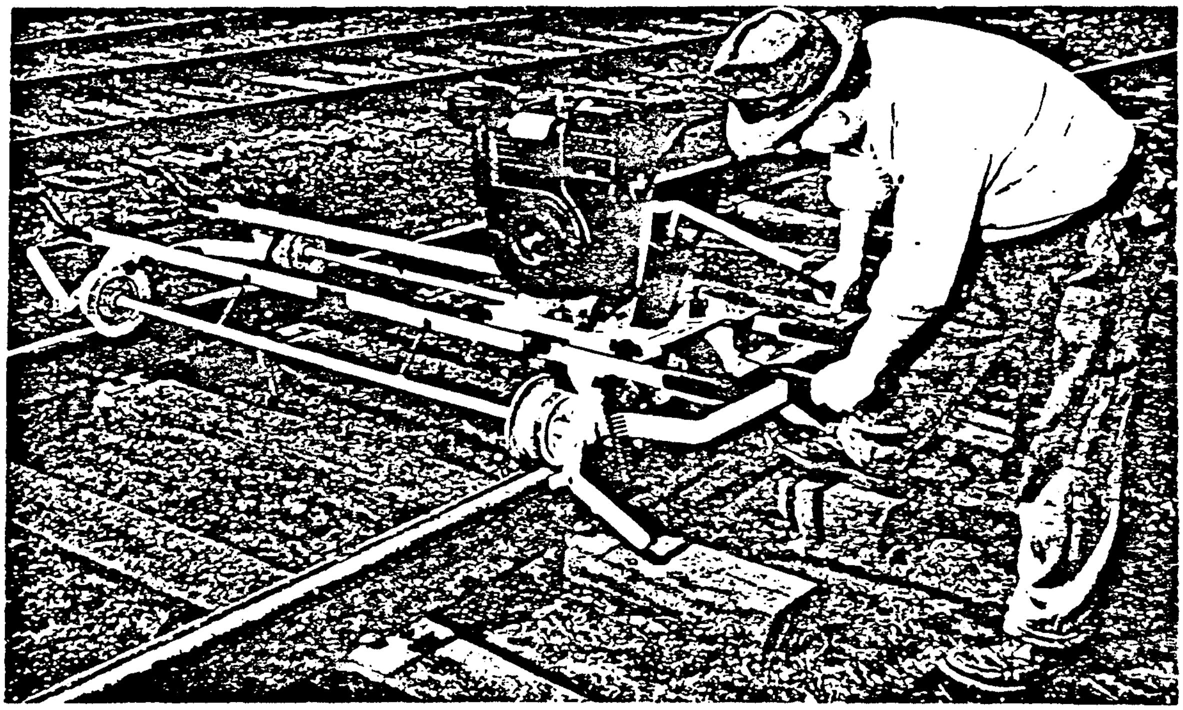
Normally, complete removal of upset metal is not carried out on the web, the top of the base or underside of the head. Should it be necessary to install joint bars for any reason, such as a broken weld, the weld area must first be ground smooth. The weld can also create problems around switches. It is necessary to avoid welds where switch points fit against a stock rail base, or within the limits of heel blocks.

PART 2 -- GRINDING

TYPES OF GRINDERS

There are several types of grinding machines in general use for track work. Most of them are powered by gasoline engines. Figures 9, 10, and 11 show three types which are widely used.

The grinding machine shown in Figure 9 is used for rail end cross-grinding. With a machine such as this, cross-grinding can be done neatly and accurately. The carriage upon which this machine is mounted, permits the engine and grinder to be readily positioned over either rail.

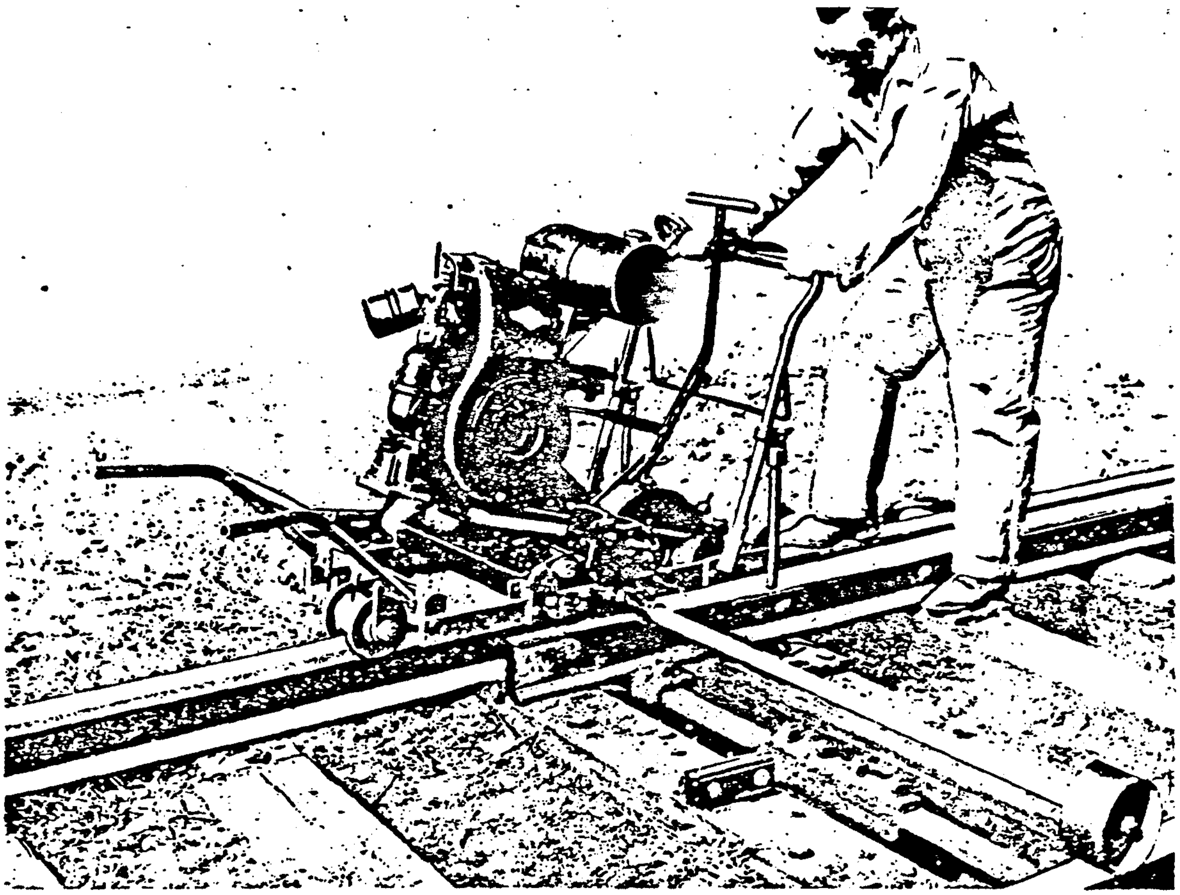


Courtesy Railway Track-Work Co.

Fig. 9

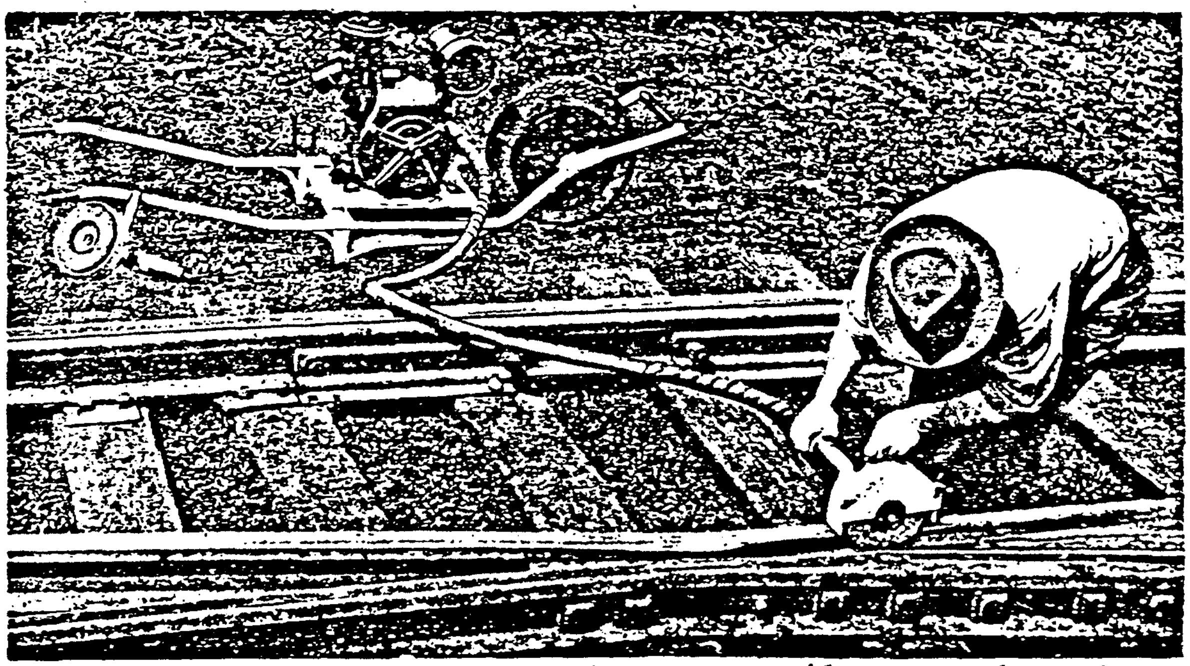
The grinder illustrated in Figure 10, is highly effective for removing lips from the gage side of stock rail heads and from the back side of switch points. Where it is desired to provide a recess in the side of the stock rail head to better protect the switch point, this type of grinder is the preferred machine to use. This machine can serve as the power source for a flexible shaft attachment, leading to a grinding head similar to the one shown in Figure 11.

The type of grinder pictured in Figure 11 is highly



Courtesy Railway Track-Work Co.

Fig. 10



Courtesy Railway Track-Work Co.

Fig. 11

versatile. It is shown here as it might be used on a frog. This type of grinder can remove defective metal prior to welding a frog. It can provide the final finish after a frog has been welded. It can also remove lips from the gage corners of a frog running surface when welding is not required.

The flexible shaft type grinder shown in Figure 11 can also be used for grinding incident to the repair of engine burns and to finish welded rail ends. It is useful for work incident to the welding of switch points. This type of machine can remove excess metal around thermit welds or butt welds.

CUTTING BACK SWITCH POINTS

Some railroads employ another procedure to repair switch points in addition to or instead of, welding. A thin, chipped, cracked or broken switch point can have the head portion of the tip removed by grinding. A new tip is formed at the location where the removal of the head stops. The gage side of the switch point head must be retapered beyond this point by grinding, to avoid a blunt point. Much cutting back of switch points is done to the extent of a 6 inch to 12 inch range. In addition to determining whether this procedure is recommended on your railroad, you should find out the allowable limits, should this practice be used.

CARE OF GRINDING WHEELS

If misused, a grinding wheel can be a hazardous tool. Grinding wheels rotate at high speeds. Should one disintegrate while in use, fragments may fly off in unpredictable directions. It is necessary to observe certain precautions in handling grinding wheels, to maintain them in a sound condition.

Grinders should always be operated with the hood or shield designed for the type of wheel being used in place. The operator should be aware of the speed at which his grinder is operated. Grinder speeds are rated in revolutions per minute. This can be checked with a tachometer. Grinding wheels must never be operated at speeds greater than that for which they are rated.

A grinding wheel with a crack must never be used. Cracks may not be visible to inspection. Avoid bumping a grinding wheel. A wheel may be bumped from moving the machine with the wheel attached. Placing a grinding wheel in a vehicle or storage compartment where other tools or material may be thrown against it, can cause a crack. Suspend a wheel and listen to the sound which is made when it is tapped lightly with a tool such as a screwdriver. Once you learn to recognize the sound of a good grinding wheel, you can use this test on any wheel suspected of being defective.

Grinding wheels should not be used if they are vibrating. Determine whether it is improperly mounted. If the vibration cannot be corrected, do not use the grinding wheel. Grinding wheels tend to absorb moisture. Should a portion of a wheel absorb some moisture, it may be off-balance, causing it to shatter when used. Store in a dry place where it won't be exposed to the elements. If necessary to leave the machine outdoors when not being used, remove the grinding wheel and store it where it will be protected. Never lay a grinding wheel on the ground.

CONCLUSION

The welding and grinding procedures which have been discussed in this lesson are the principal ones encountered in track work. You may have occasion to become acquainted with some less frequently used procedures, but the principles are similar to those contained in this lesson.

This lesson has not covered all details which welders and grinder operators should know concerning the operation of their equipment. What has been covered, is that which a Track Foreman should know, so that he can properly direct such work to be done, and know whether it is done in a safe and proper manner.

LESSON 14

EXERCISE QUESTIONS

1. What welding process would be used to repair a solid manganese self-guarded frog?

2. What is the approximate weight of an acetylene cylinder when full?

3. What is the name of the device which is used to reduce the pressure in an oxygen or acetylene tank to a suitable working pressure?

4. How can leaks in oxygen or acetylene hose be detected?

5. How do the fittings on oxygen and acetylene regulators, hoses and blowpipes differ from each other?

6. When a battered rail end is welded, when should surface grinding and cross grinding be carried out?

7. What is the recommended maximum depth of weld to repair an engine driver burn?

8. When building up a switch point by welding, what position should the point be in?

9. What tools may be used to remove excess filler metal from a thermit weld?

Answer the following questions TRUE or FALSE

10. The flexible shaft type grinder is used to remove defective metal in preparation for welding a frog.

11. Where oxy-acetylene cutting of rail ends is permitted, bolt holes may be cut in the same manner.

12. The joints at the ends of strings of CWR do not have to be end hardened, if it is intended to thermit weld them.

13. Prior to thermit welding relay rail, any lip on the field side of the rail head must be removed.

(Exercise questions continued on next page)

14. After welding a switch point, any lip on the gage side of the stock rail should be removed by grinding.

15. A major consideration in welding engine burns is to avoid overheating the rail.

16. When welding rail ends, the joints should be surfaced upon completion of the welding.

17. Working pressure for acetylene should not exceed 15 pounds per square inch.

18. Oxygen cylinders should always be kept in a vertical position.

Submit your answers to these questions to The Railway Educational Bureau in the prescribed manner. Be sure to include your name, file number, address, company's name, and lesson number in the upper right hand corner of your paper.

10. TRACKWORK

10.1 Tie and Ballast Track

Ballasted track will be located throughout the mid-corridor segment, except in intermittent at-grade street crossings. This type of trackwork will consist of 115 lb/yard tee-rail welded in continuous lengths, concrete ties, a minimum of 8-inch deep sub-ballast and 12-inch deep ballast (Figure 10-1). Rail fasteners for both tie and ballast and embedded tracks will consist of spring clips fastened to the tie. A resilient pad will provide a cushion between the rail and tie. The track gauge on all tangent track sections will be a standard 4 feet, 8½ inches.

10.2 Embedded Track

Embedded or paved track will be used in downtown city streets and in some mid-corridor grade crossings. The recommended design for on-street alignments in downtown Los Angeles and Long Beach consists of 128 lb/yard girder rail on concrete ties, with asphalt surfacing (Figure 10-2). Several segments in Long Beach call for surfacing with architectural treatment, and the recommendation is to use paving block surfacing with tee-rail, concrete ties, and ballast. Rubber filler around the rails will be used to provide good electrical resistance between the track and ground.

The recommended design for paved tracks embedded in some of the mid-corridor grade crossings calls for tee-rail, with asphalt paving and concrete ties. The use of girder rail is not recommended since it would involve cutting continuously welded strings of tee-rail.

10.3 Special Trackwork

The term "special trackwork" refers to all of the track elements required to divert a train from one track to another. It includes turnouts, crossovers, rail crossings, and pocket tracks, which are necessary for permitting flexible operation of the system during different periods of the day or during emergencies or failures (see Chapter 4).

The mainline route schematic (Figure 10-3) shows the proposed locations of seven crossovers and one set of pocket tracks, the latter of which provides for temporary train storage between the double tracks. All special trackwork will use tee-rails, wooden instead of concrete ties, steel tie plates with spring clip fasteners, and special assemblies involving switches, frogs, crossing angles, and guardrails.

10.4 Direct Fixation

This technique will be used in the subway segment of downtown Los Angeles and on all grade-separated or aerial sections. Tee-rails will be connected directly to concrete slabs by resilient fasteners (spring clips), and no ties will be required. Either one continuous concrete slab will be poured, or two separate blocks will be provided in a second pour to support the rails. If required to meet noise limitations, the use of floating slabs or other vibration-damping measures will be considered.

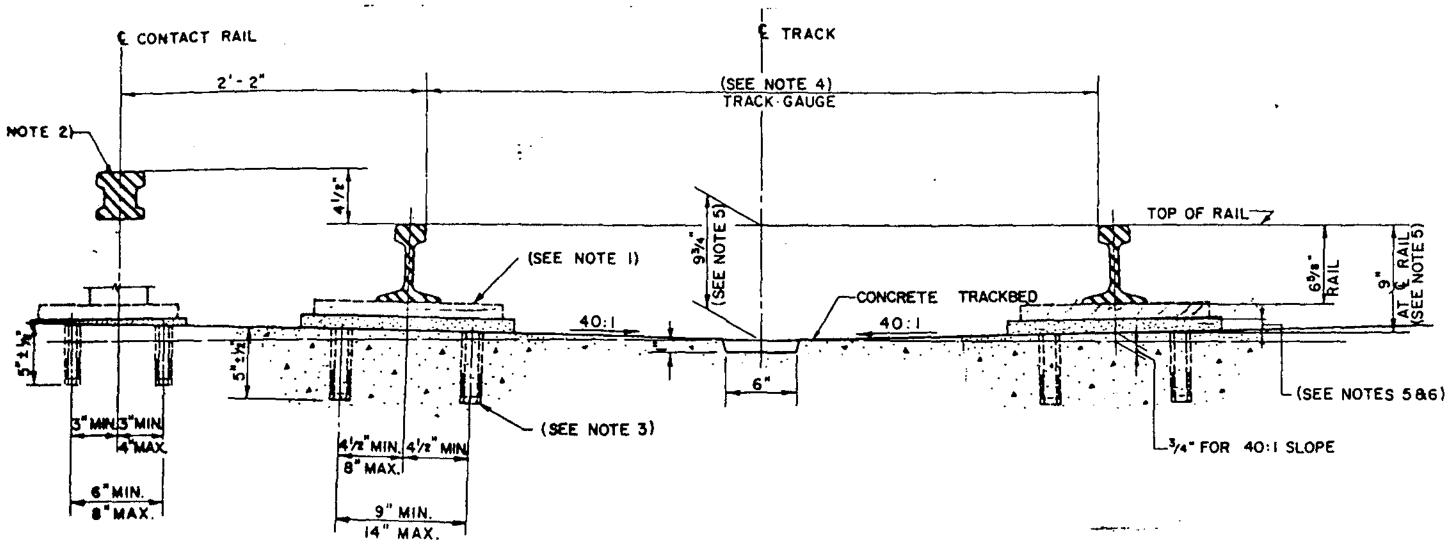
11. STATIONS/STOPS

Station/stop locations have been shown on the mainline route schematic (Figure 10-3). A shelter stop is distinguished from a station on the basis of unrestricted passenger access onto a safe area (e.g., city sidewalks). The downtown Los Angeles stops (except 7th/Flower) and the Long Beach stops are therefore considered to be shelter stops. Some of the at-grade mid-corridor stops may also be so designated. Seventh/Flower, elevated mid-corridor stations, and the remainder of the mid-corridor stops will be classed as stations.

Stations/stops are listed in Table 11-1 with information such as vertical alignment -- at-grade, aerial or subway -- placement in the right-of-way, platform configuration, and availability of parking. In general, these locations have been selected because they 1) provide reasonable station spacing for maximizing service coverage and operating speed, 2) provide cross-corridor bus connections, 3) serve major sources of ridership, and 4) are highly visible. A typical station concept design is shown on Figure 11-1.

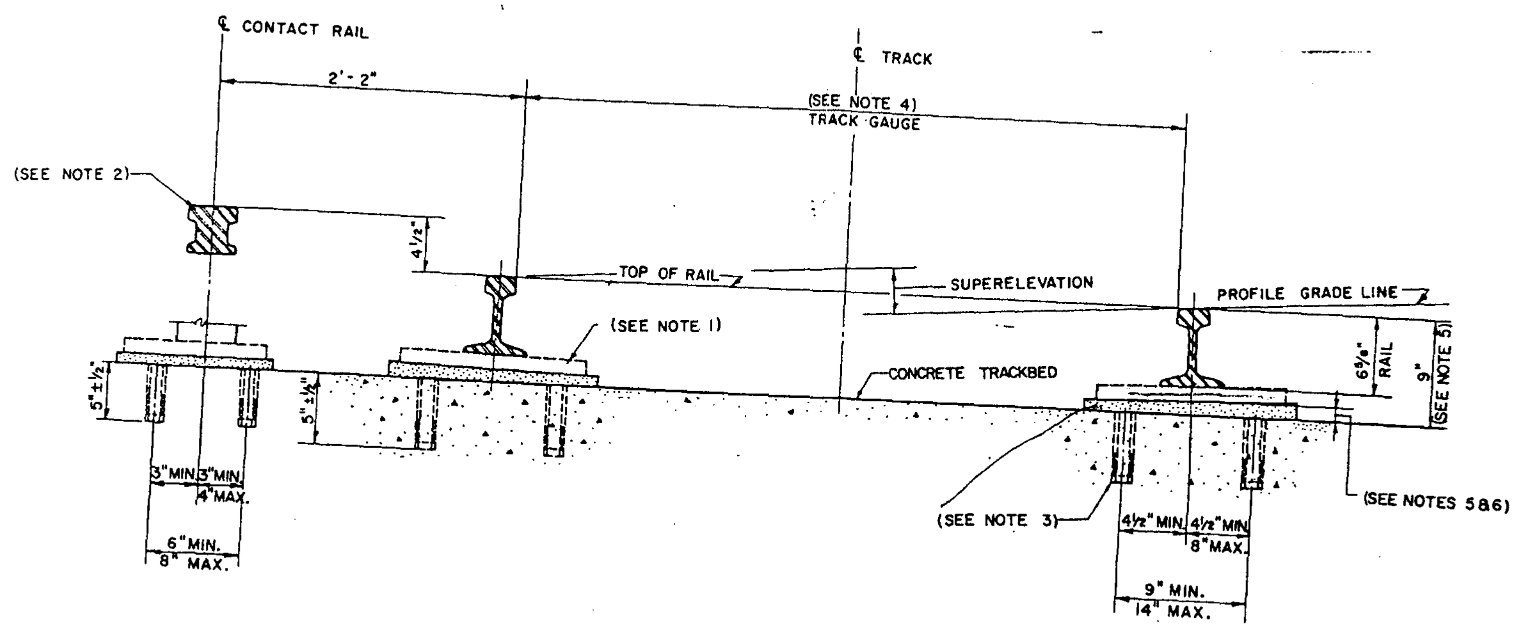
11.1 Platforms

Platforms will be designed to accommodate 2-car trains (210 feet), unless they are located in special -- aerial or subway -- structures. The latter structures will have the potential to accommodate 3-car trains (280 feet). High-level platforms, which are at the same level as the light rail vehicle floor (39 inches above the top of rail), will be used at all station locations. At-grade and aerial stations will have center platforms, where passengers will wait for trains arriving from either direction. The 7th/Flower Station will have side platforms. | 2



STANDARD SECTION

TANGENT OR SUPERELEVATED TRACK
0" ≤ S.E. ≤ 3/4"
FASTENED TO CONCRETE TRACKBED



STANDARD SECTION

SUPERELEVATED TRACK
3/4" < S.E. ≤ 6"
FASTENED TO CONCRETE TRACKBED

NOTES:

1. DETAILS OF DIRECT FIXATION RAIL FASTENERS SHALL BE IN ACCORDANCE WITH TWI TRACKWORK SPECIFICATIONS, SECTION 6.3, "DIRECT FIXATION RAIL FASTENERS."
2. FOR CONTACT RAIL DETAILS SEE CONTRACT DRAWING TWI-CR-4.
3. HOLES FOR RAIL FASTENER ANCHOR BOLTS TO BE DRILLED, 1¾" MAX. Ø, AND 90°±1° TO THE BASE OF RAIL FASTENER.
4. GAUGE LINES SHOWN ARE METRO STANDARD GAUGE, REFER TO CONTRACT DRWG. NO. TWI-T-48 FOR TRACK GAUGE CRITERIA.
5. ON FLOATING SLABS THIS DIMENSION IS 1/4" GREATER THAN SHOWN HERE.
6. THIS DIMENSION IS 5/8" TO 1" NOMINAL FROM BASE OF RAIL FASTENER TO TOP OF UNROUGHENED INVERT SURFACE AT ℄ RAIL.

(DES)IGNED	DUNN, SMITH	9-16-69 DATE
(DRA)WN	WESTRA	9-16-69 DATE
(CHE)CKED	A.J. Kiffler	4-28-70 DATE
(APP)ROVED	R.H. Dunn	4-28-70 DATE

REFERENCE DRAWINGS	
NUMBER	DESCRIPTION
TWI-T-48	TRACK DETAILS - TRACK GAUGE, SPIKING AND RAIL ANCHORING

REVISIONS		
DATE	BY	DESCRIPTION

WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY

DE LEUW, CATHER & COMPANY
SECTION DESIGNER

SUBMITTED

DE LEUW, CATHER & COMPANY
GENERAL ENGINEERING CONSULTANT

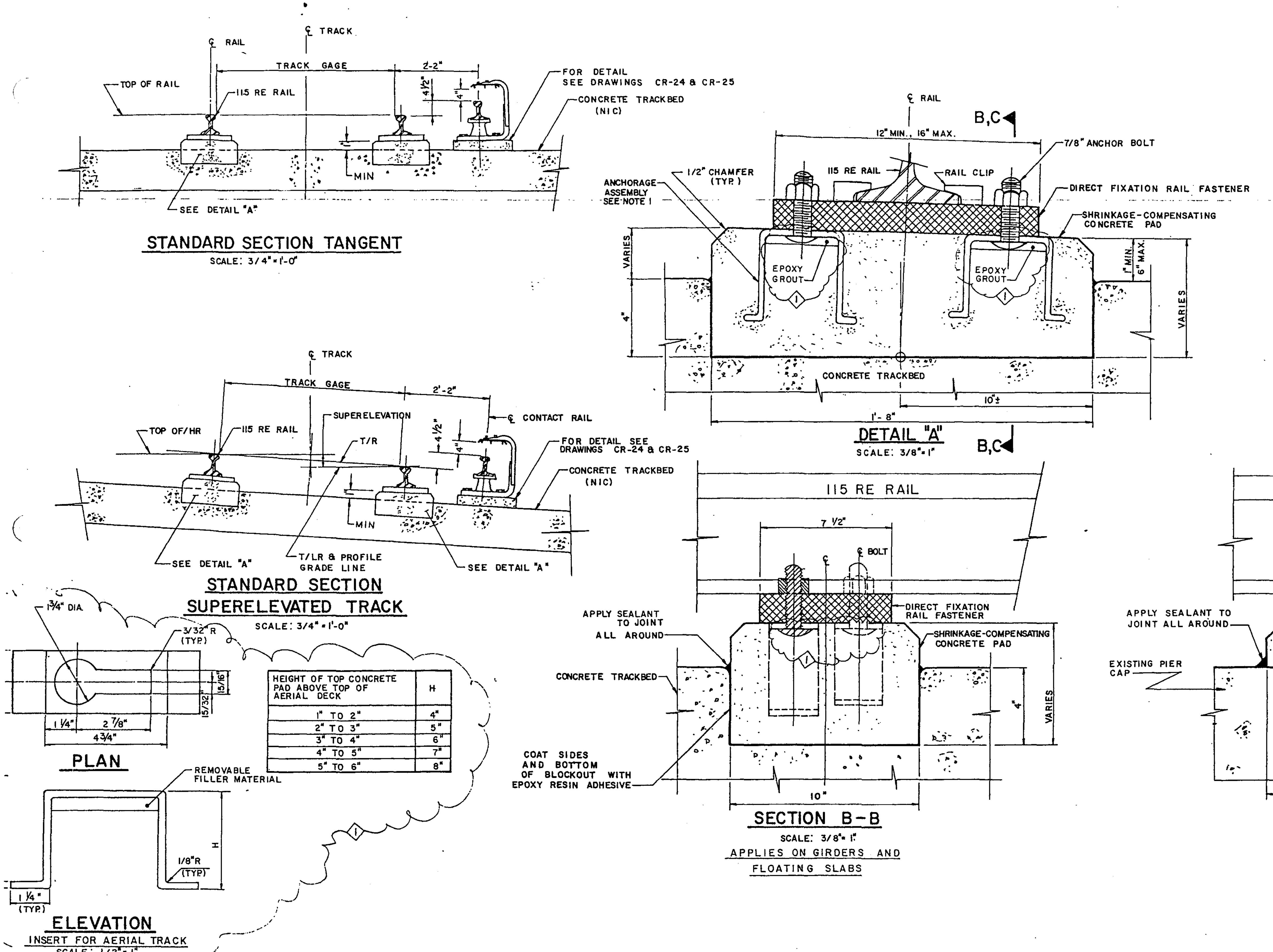
HARRY WEESE & ASSOCIATES
GENERAL ARCHITECTURAL CONSULTANT

APPROVED

TRACKWORK- PHASE I
STANDARD TRACKBED SECTION
METRO ON DIRECT FIXATION

SCALE 1½" = 1'-0"

DRAWING NO. TWI-T-46 M23-48



HEIGHT OF TOP CONCRETE PAD ABOVE TOP OF AERIAL DECK	H
1" TO 2"	4"
2" TO 3"	5"
3" TO 4"	6"
4" TO 5"	7"
5" TO 6"	8"

NOTES:

1. THE HEIGHT "H" OF EACH INSERT SHALL BE STAMPED ON TOP OF THE INSERT.
2. ON AERIAL STRUCTURES, INSTALL DIRECT FIXATION FASTENERS IN ALL BLOCKOUTS. BLOCKOUT SPACING VARIES UP TO A MAXIMUM OF 36". FOR EXACT BLOCKOUT SPACINGS, SEE REFERENCE DRAWINGS AND SHOP DRAWINGS OF AERIAL STRUCTURES.
3. PROVIDE A 1:40 RAIL CANT BY SLOPING THE TOP OF THE SHRINKAGE-COMPENSATING CONCRETE PAD.

STATE OF MARYLAND DEPARTMENT OF TRANSPORTATION
MASS TRANSIT ADMINISTRATION
LTIMORE REGION RAPID TRANSIT SYSTEM
PHASE I

DANIEL, MANN, JOHNSON, & MENDENHALL / KAISER ENGINEERS
GENERAL CONSULTANT
DANIEL, MANN, JOHNSON, & MENDENHALL / KAISER ENGINEERS
FINAL DESIGNER

NO.	DESCRIPTION	BY	DATE
1	GENERAL REVISIONS MADE	C.G.	7-16-79

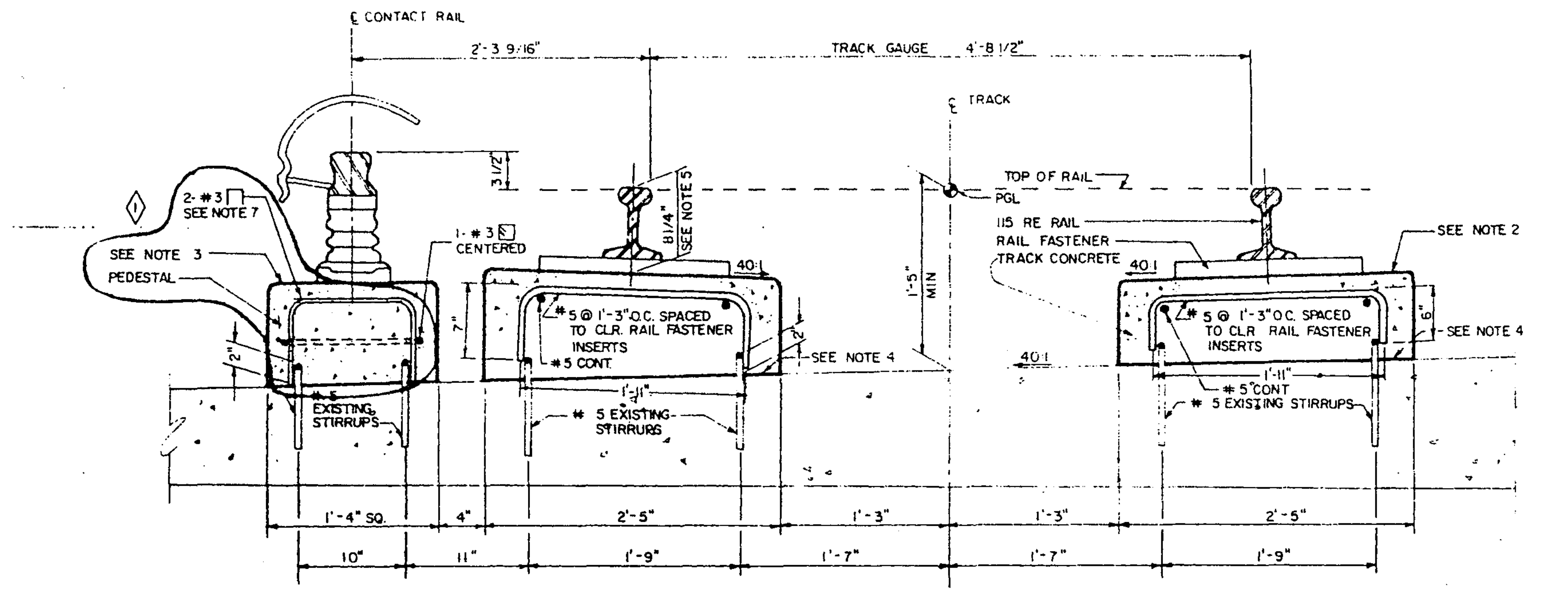
REVISIONS

DESIGNED C. GUILES — DATE 6-11-79
DRAWN C. VARGAS — APPROVED
CHECKED D. SHOFF — APPROVED

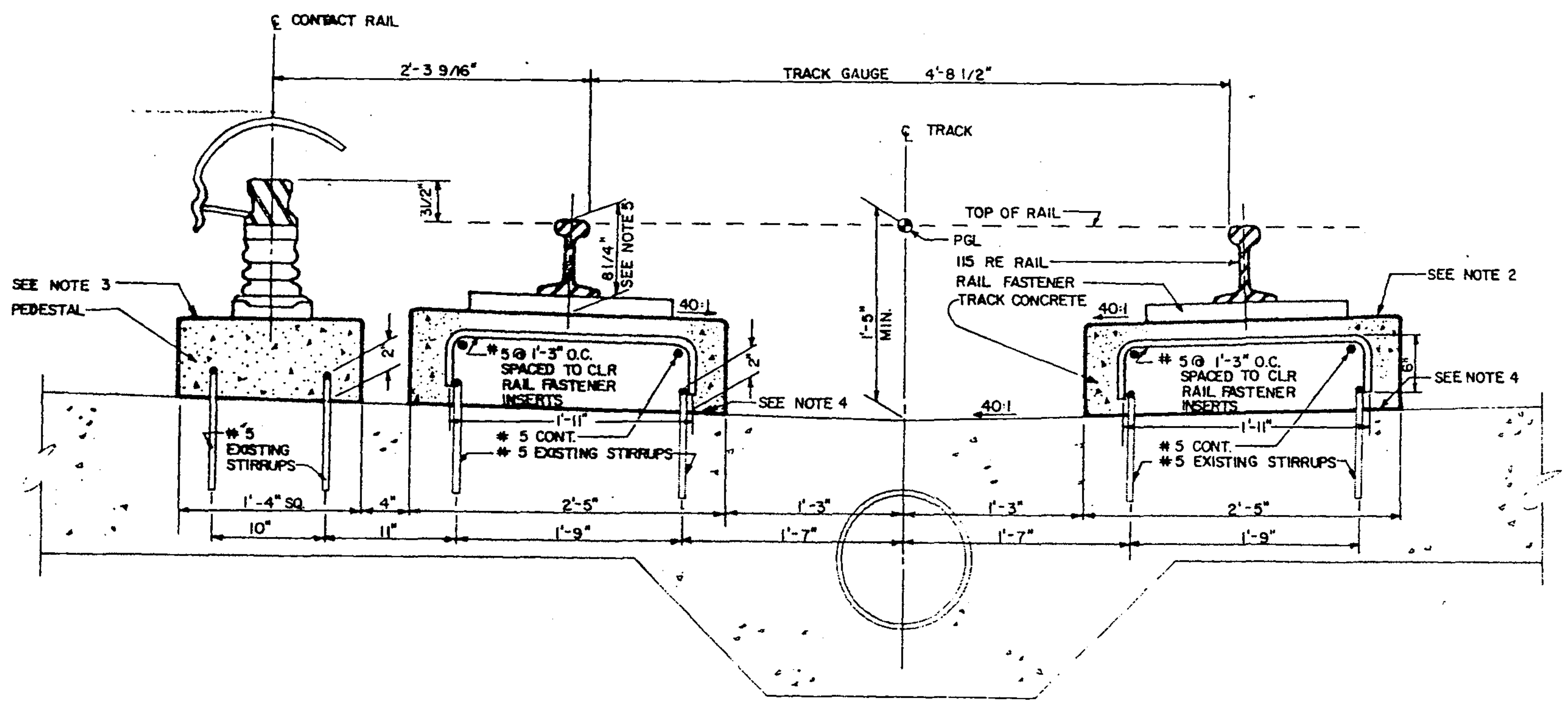
TRACKWORK INSTALLATION
DIRECT FIXATION TRACK
AERIAL AND FLOATING SLAB TYPE

SCALE AS NOTED

DRAWING NO. X0-04-09
T-53-1
SHEET NO. 58



SIDE OF TRACK DRAINAGE INVERT



CENTER OF TRACK DRAINAGE INVERT

NOTES:

1. VARIATIONS IN THE INVERT PROFILE SHALL BE COMPENSATED FOR IN THE TRACK CONCRETE.
2. THE CANT OF THE TRACK CONCRETE SHALL BE A 40:1 INWARD SLOPE TO THE TOP OF RAIL PLANE.
3. TOP OF CONTACT RAIL PEDESTAL SHALL BE PARALLEL TO THE TOP OF RAIL PLANE.
4. A 12" WIDE DRAINAGE CHASE AT 75'± SHALL BE LOCATED MIDWAY BETWEEN ADJACENT RAIL-FASTENERS AND OPPOSITE INVERT CATCH-BASINS AS DETAILED ON STANDARD DRAWING NO. TS051.
5. DIMENSION BASED ON 6 5/8" RAIL AND 1 5/8" THICK RAIL FASTENER WHICH MAY VARY IN THICKNESS FROM 1 1/8" TO 1 3/4".
6. PROVIDE 1 1/2" MIN. COVER ON ALL REINFORCING STEEL.
7. PROVIDE REINFORCEMENT FOR CONTACT RAIL PEDESTALS OVER 8" HIGH.

THIS PRINT REDUCED HALF SCALE

REV	DATE	BY	SUB.	APP.	DESCRIPTION
1	17NOV76	RGS			REINFORCING ADDED TO CONTACT RAIL PEDESTAL
0	27AUG76				INITIAL ISSUE

THE PREPARATION OF THIS DRAWING HAS BEEN FINANCED IN PART THROUGH A GRANT FROM THE U. S. DEPARTMENT OF TRANSPORTATION, URBAN MASS TRANSPORTATION ADMINISTRATION, UNDER THE URBAN MASS TRANSPORTATION ACT OF 1964, AS AMENDED, AND IN PART BY THE TAXES OF THE CITIZENS OF FULTON AND DEKALB COUNTIES OF THE STATE OF GEORGIA.

DESIGNED R.G. SKOOG
DRAWN E. M. SIDDIQUI
CHECKED T.D. Shum
IN CHARGE T.D. Shum
DATE 27 AUG 1976

METROPOLITAN ATLANTA RAPID TRANSIT AUTHORITY

DELEUW, CATHER & COMPANY, ATLANTA — CONSULTING ENGINEERS

PARSONS BRINCKERHOFF-TUDOR — GENERAL ENGINEERING CONSULTANTS

SUBMITTED ______ APPROVED ______

TRACKWORK STANDARD

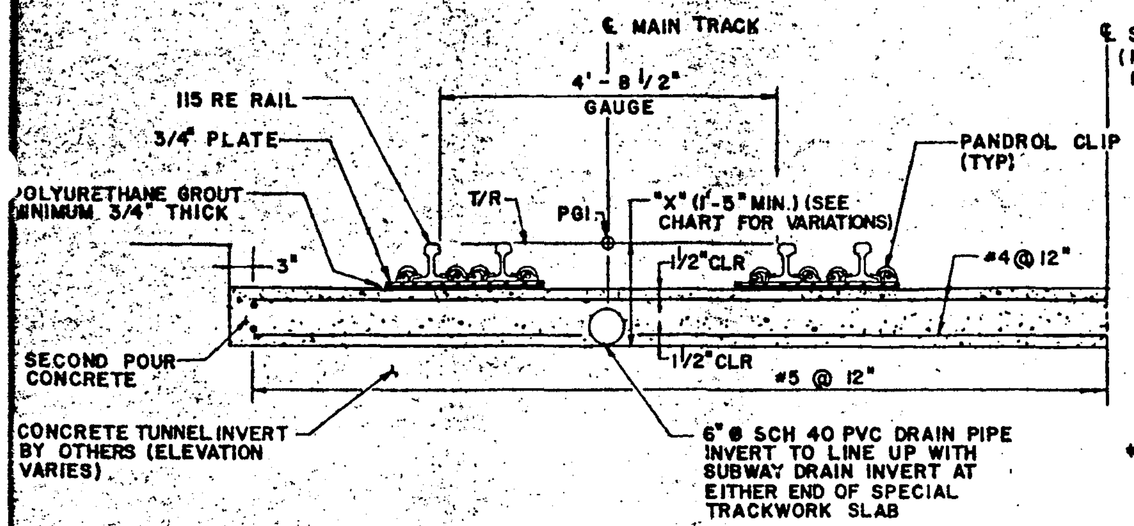
AT-GRADE STATION DIRECT FIXATION DETAILS

SCALE 1 1/2" = 1'-0"

CONTRACT NUMBER CY110

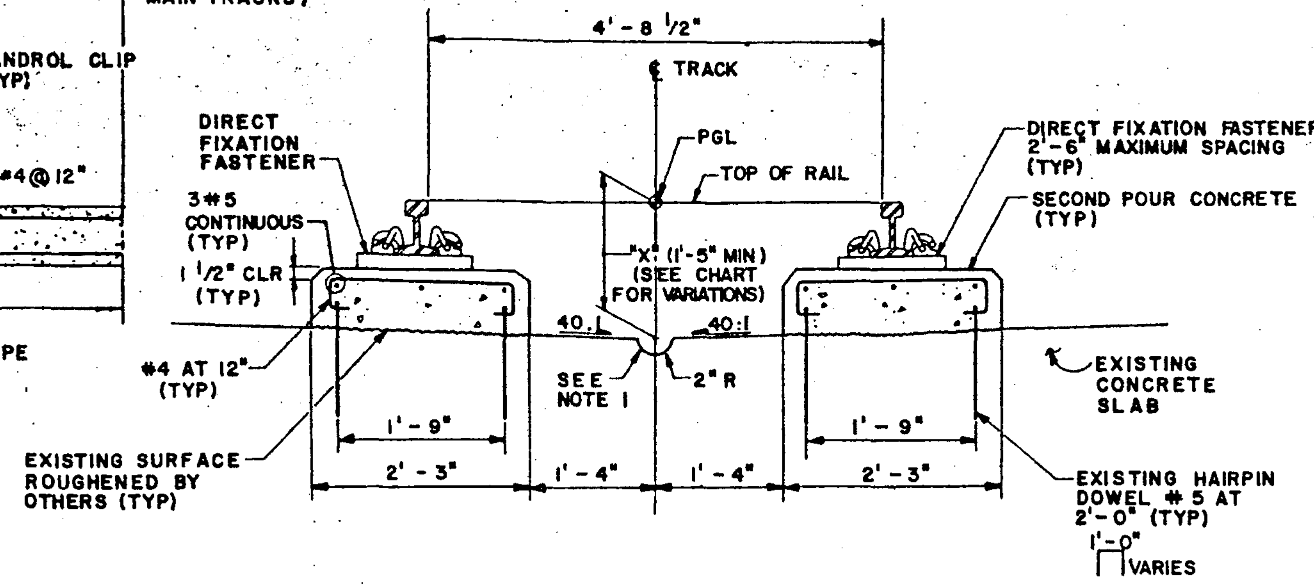
DRAWING NO. - REV. TS053A-1

PAGE NO. 29



TYPICAL SUBWAY SPECIAL TRACKWORK

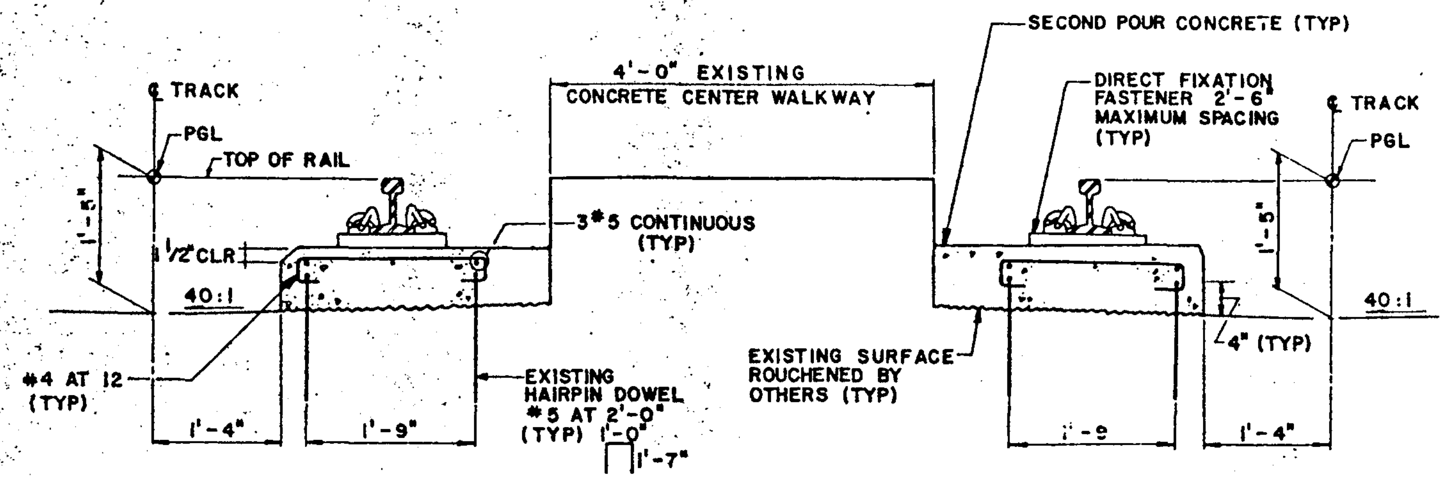
SCALE : 3/4" = 1'-0"



TYPICAL DIRECT FIXATION TRACK SUBWAY AND RETAINED CUT

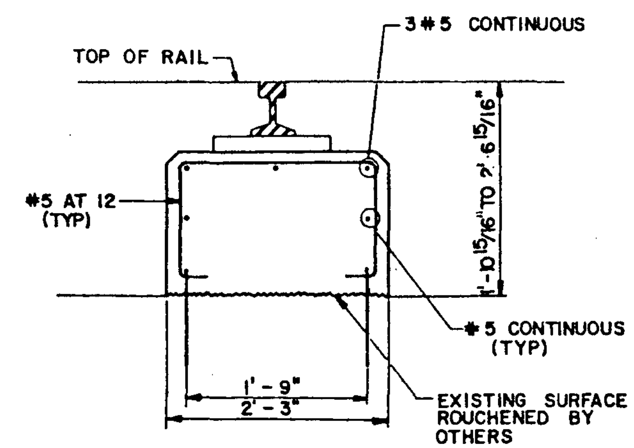
SCALE : 1" = 1'-0"

STATIONING	"X" DIMENSION		REMARKS
	NB TK	SB TK	
4+61 TO 6+65	1'-5"	1'-5"	
6+65 TO 8+04	N/A	N/A	CROSSOVER SEE DWG NO TK
8+04 TO 11+47	1'-5"	1'-5"	
11+47 TO 13+83	N/A	N/A	CROSSOVER SEE DWG NO TK
13+83 TO 29+00	1'-5"	1'-5"	
29+00 TO 34+00	1'-9"	1'-9"	A PORTION SHALL BE CONSTRUCTED TO ALLOW FUTURE TURNOUTS PER DWG NO TK-1340
34+00	1'-5"	1'-5"	STATIONING IS ALONG SOUTHBOUND TRACK
34+36	1'-5"	1'-6 9/16"	
34+72	1'-5"	1'-10 5/16"	
35+20	1'-5"	2'-6 15/16"	
35+20 TO 42+47	1'-5"	1'-5"	SEE DETAIL FOR PORTION WITH EXISTING CONCRETE CENTER WALKWAY



DIRECT FIXATION EXISTING TRACK SPECIAL DETAIL AT RAISED CENTER WALKWAY IN SUBWAY

STA 35+26± TO STA 37+45±
SCALE : 1" = 1'-0"



DIRECT FIXATION SB TRACK SPECIAL DETAIL

STA 34+72 TO 35+20
SCALE : 1" = 1'-0"

NOTES:

1. EXISTING SEMICIRCULAR DRAINAGE SLOT IS FROM STA 4+61 TO 6+65, 8+04 TO 11+47 AND 13+83 TO 14+21 ONLY.

1" = 1'-0" GRAPHIC SCALE
3/4" = 1'-0" GRAPHIC SCALE

DATE	DESCRIPTION	BY	APP.
5/87	ISSUED FOR BID		

Information confidential: all plans, drawings, specifications, and/or information furnished herewith shall remain the property of the Los Angeles County Transportation Commission; shall be held confidential; and shall not be used for any purpose not provided for in agreements with the Los Angeles County Transportation Commission.

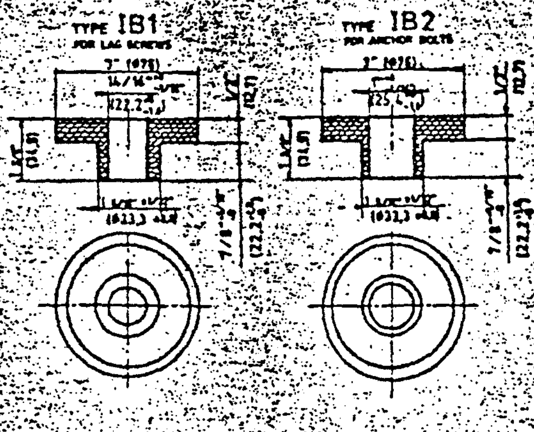
DESIGNED BY / DRAWN BY / CHECKED BY / APPROVED BY
DATE 5/28/87

REGISTERED PROFESSIONAL ENGINEER WAYNE R. SAN FILIPPO No. 19837 EXP. 9/30/89 CIVIL STATE OF CALIFORNIA

LOS ANGELES COUNTY TRANSPORTATION COMMISSION
The Long Beach-Los Angeles Rail Transit Project
LACTC
DMJM
SUBMITTED:
Southern California Rail Consultants
A Joint Venture of
Parsons Brinckerhoff Quade & Douglas, Inc.
Kaiser Engineers (California) Corporation
Daniel, Mann, Johnson, & Mendenhall
APPROVED:

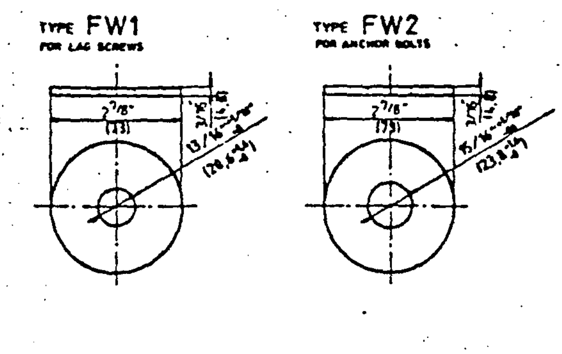
LRT TRACKWORK INSTALLATION
TYPICAL PLAN AND SECTION - SUBWAY

CONTRACT NO. R01-T08-C258
DRAWING NO. SE-1245
REV.
SHEET NO. 192
SCALE AS NOTED



INSULATING BUSHINGS

SCALE: 1" = 2"

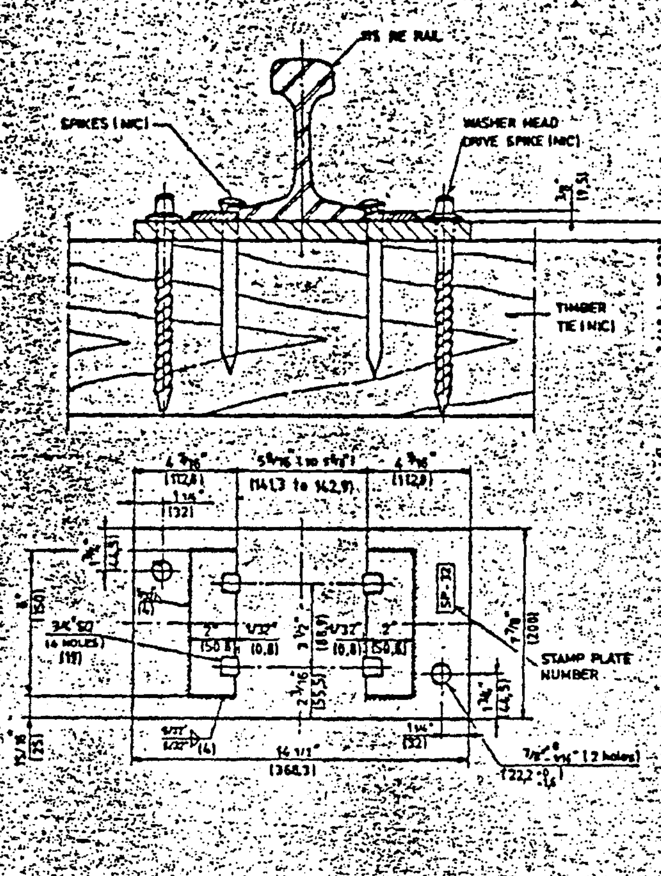


STEEL FLAT WASHERS

SCALE: 1" = 2"

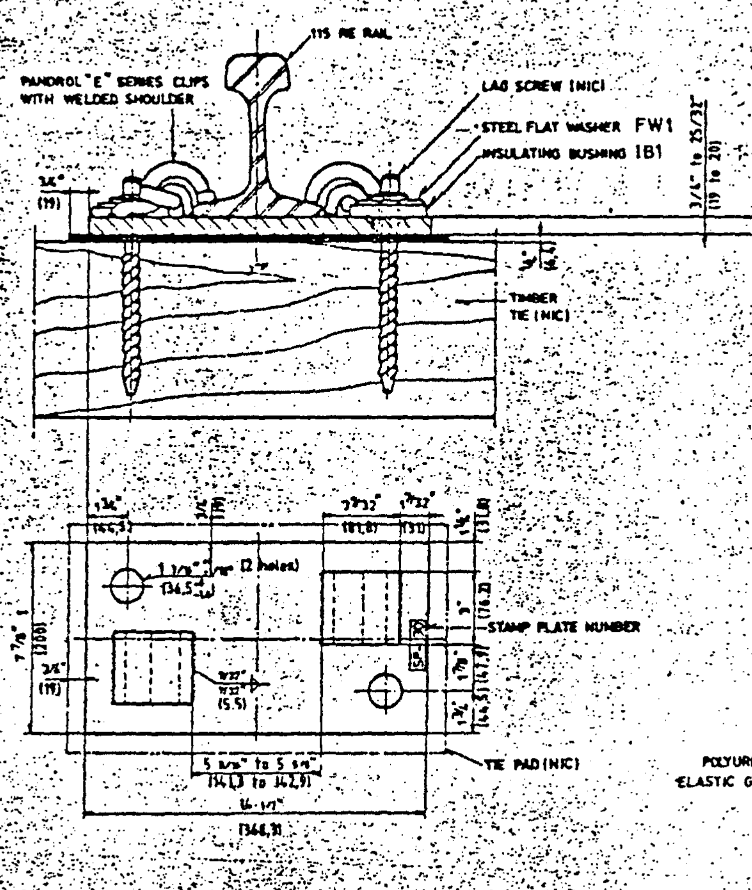
MATERIALS:

- INSULATING BUSHING AS PER NEMA Standard Publication LI 1-1971, Grade 10
- WASHERS FW1 & FW2 (St. 37.2 DIN 17100) ASTM A283 Gr. C
- PLATES (St 44.2 DIN 17100) ASTM A663 Gr. 60



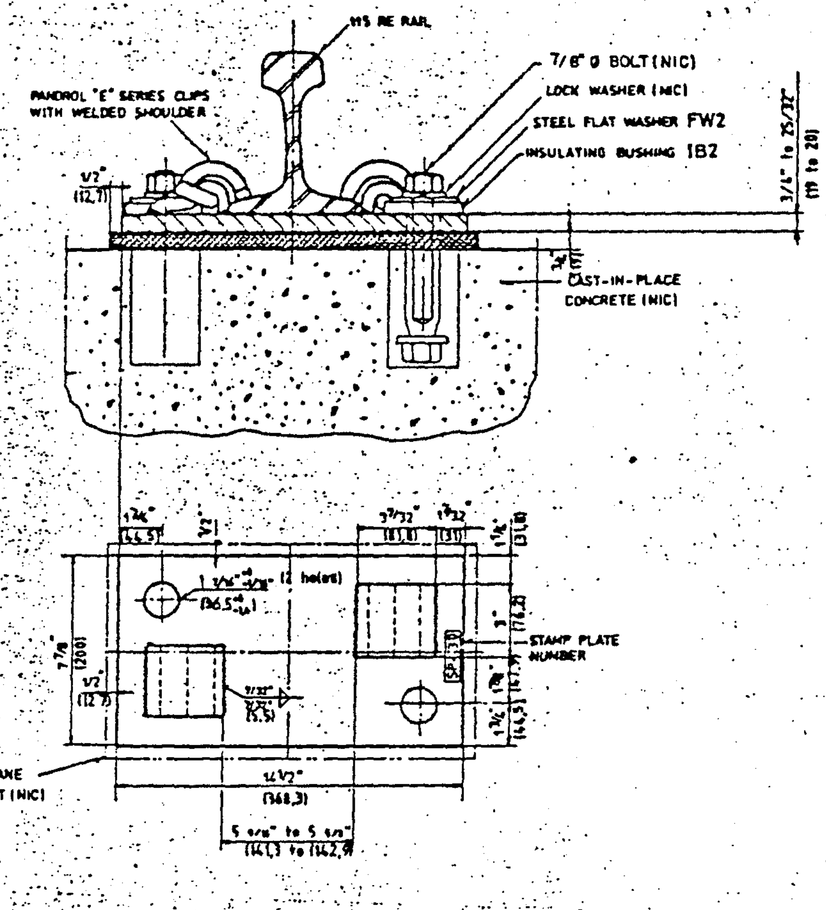
BALLASTED TRACK-YARD

SCALE: 3" = 1'-0"



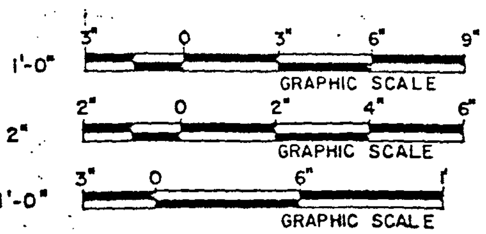
BALLASTED TRACK-MAINLINE

SCALE: 3" = 1'-0"



DIRECT FIXATION TRACK

SCALE: 3" = 1'-0"



0	2/2/89 ADDENDUM 1: NEW DRAWINGS

DESIGNED BY / DRAWN BY / CHECKED BY / APPROVED BY

DATE 06/30/87

REGISTERED ENGINEER WAYNE ... No. 19837 Exp. 9/30/89

LOS ANGELES COUNTY TRANSPORTATION COMMISSION
The Long Beach-Los Angeles Rail Transit Project

DMJM

SUBMITTED:

Southern California Rail Consultants
A Joint Venture of
Parsons Brinckerhoff Quade & Douglas, Inc
Kaiser Engineers (California) Corporation
Daniel Mann Johnson & Mendenhall

APPROVED:

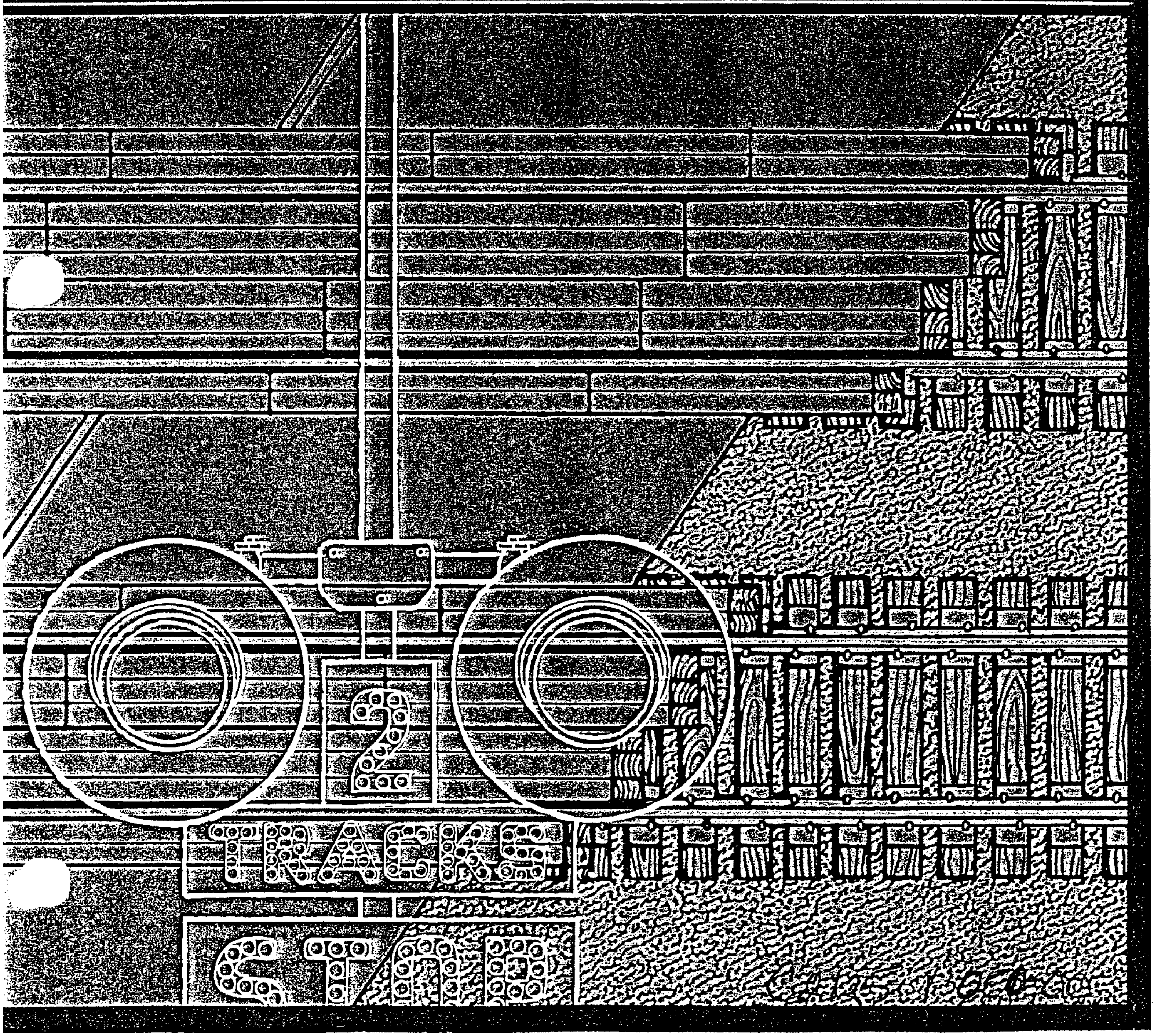
LRT TRACKWORK INSTALLATION

MISCELLANEOUS DETAILS
SHEET 2

CONTRACT NO. R01-T08-C25b
DRAWING NO. TK-1342
REV. 0
SHEET NO. 144B
SCALE AS NOTED

Koppers Grade Crossings combine long life with low maintenance

KOPPERS
Engineered Products



Koppers Crossings
Designed for Safety, Smoothness, Endurance

CONTRACT NAME: MID CORRIDOR SITE WORK & RAILROAD ~~RECONSTRUCTION~~

CONTRACT NO: R01-T01-C2125

[ ] Accepted
[X] Accepted, As Noted
[ ] Revise and Resubmit
[ ] Not Accepted

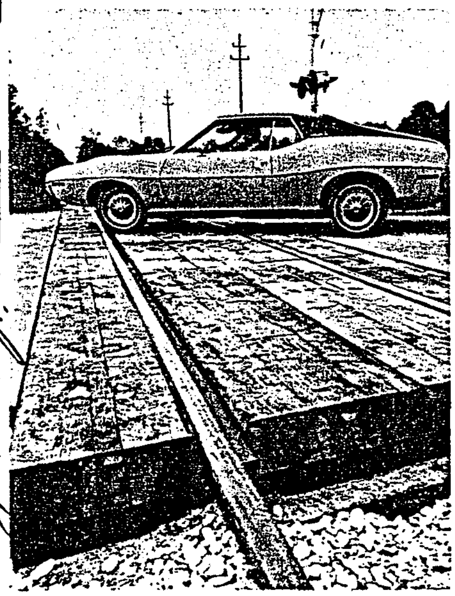
Acceptance is only for conformance with the design concept of the project and compliance with the information given in the Contract Documents. Contractor is responsible for dimensions to be confirmed and correlated at the job site; for information that pertains solely to the fabrication processes or to the techniques of contruction; and for coordination of the work of all trades.

SOUTHERN CALIFORNIA RAIL CONSULTANTS

By: ____ Date: 7/22/87

Subject to separate approval by SPTC

HERZOG CONTRACTING CORP.
SUBMITTAL
REVIEWED & APPROVED
DATE: July 3, 1987 Rev #1



Timber crossing panels from Koppers have provided years of maintenance-free service in countless installations on public highways, railroad yards and industrial plants. Over the years, the Koppers brand has become synonymous with durable crossing panels throughout the railroad industry. Now Koppers offers two types of prefabricated panels, plus optional features which will make for an even smoother crossing.

Select your model

Koppers can provide Premium Grade or Industrial Grade crossings, each with its own features and advantages. Optional features such as engineering fabric, crossties, spring-loaded drive spikes and rubber cushions are available with either one. These options help to insure a tight, smooth, long-lasting crossing.

Common features

All Koppers prefabricated timber panel crossings are made from selected mixed hardwood or gum timbers, machined to your specifications. Wood is pressure-creosoted for lasting protection against the ravages of weather, decay and attack by termites. Panels are preassembled with drive dowels, four ¾" steel dowels to each panel. Individual panels are shipped completely assembled with full installation instructions, match-marked so that they can be identified and installed easily by work crews.

In the completed installation, traffic loads are spread over the entire panel, reducing the stress and flexing of individual panel members. When installed properly, Koppers grade crossings won't sag or spall.

Before crossings are installed, care should be taken to assure that new ties and ballast are used and that good drainage is provided. If repairing the track becomes necessary after installation, the panels can be easily removed and replaced with no damage or loss.

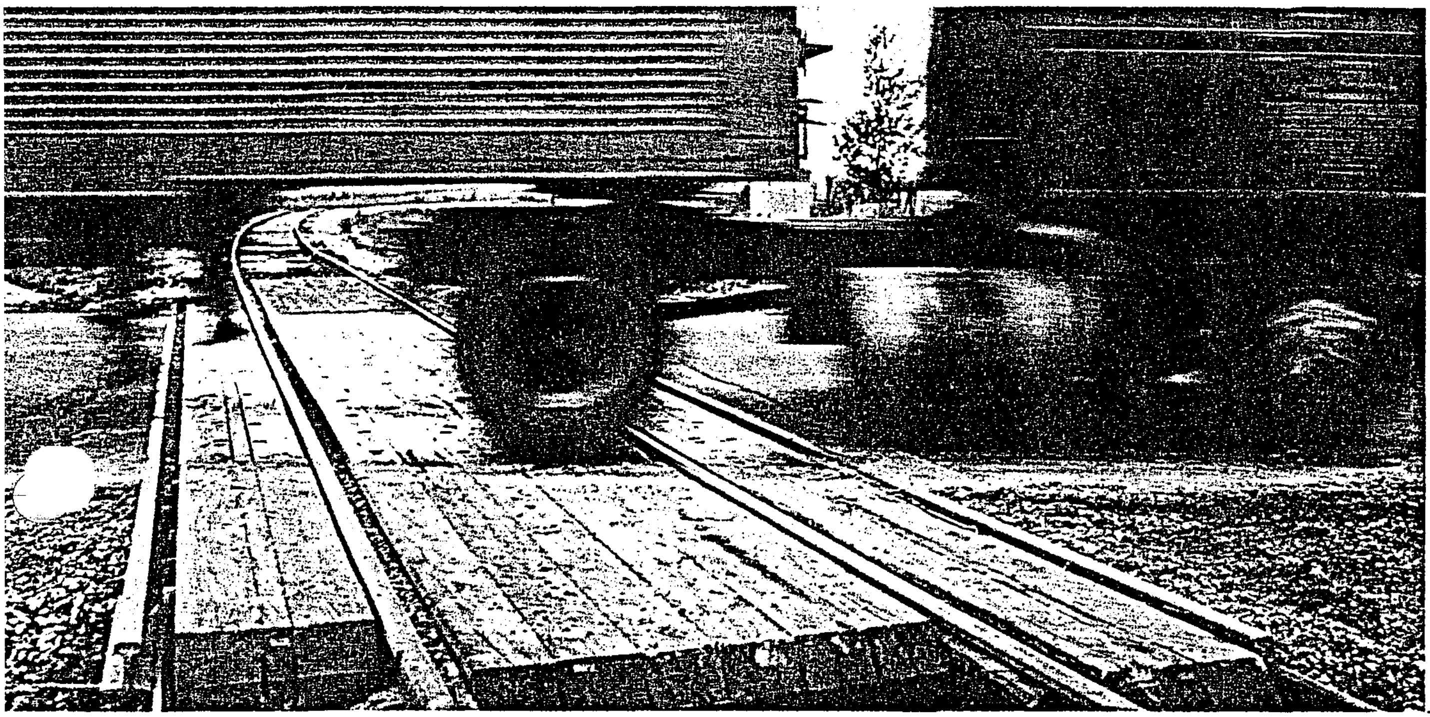
Preassembled timber grade crossing panels from Koppers ...

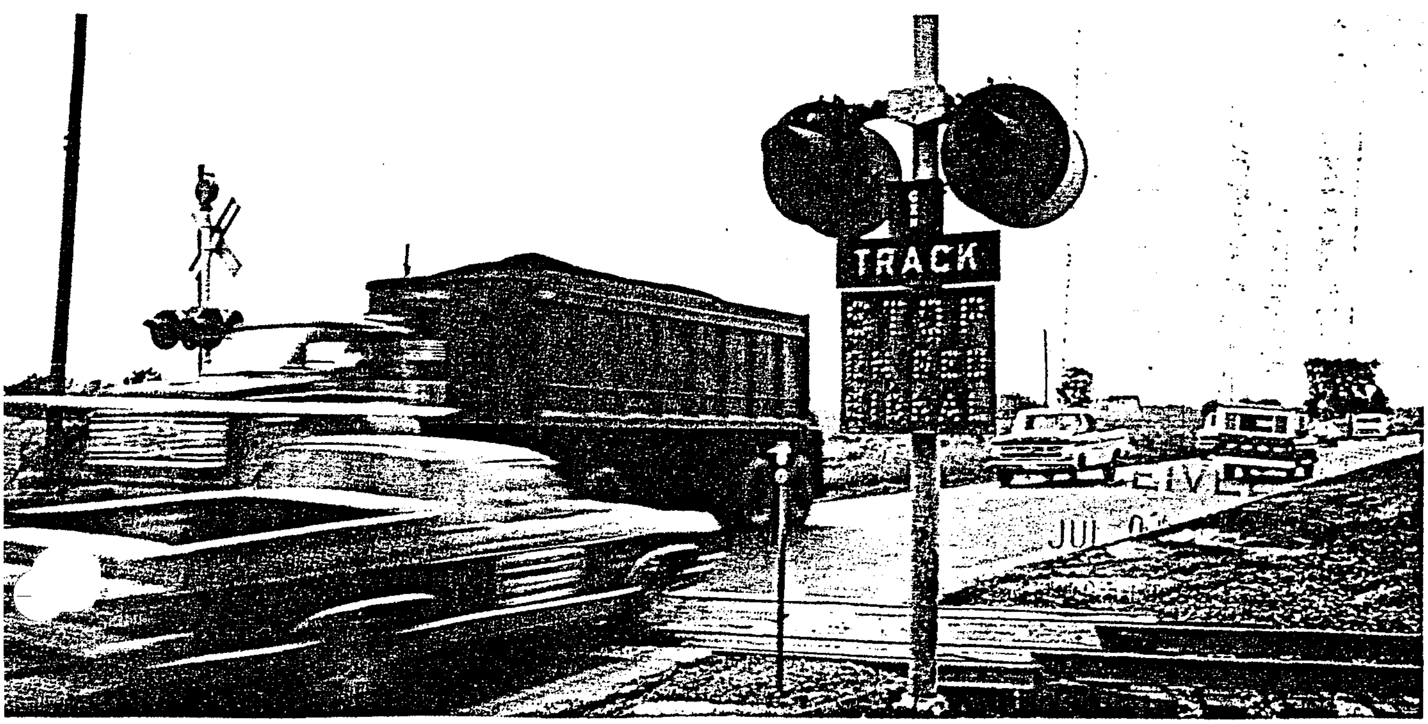
- *are prefabricated for maximum economy*
- *are pressure-creosoted for protection against weathering, decay and termites*
- *minimize your installation costs*
- *minimize your maintenance expenses*
- *withstand heavy loads*
- *stay level with a stable roadbed*
- *ride smoothly*
- *don't sag or spall*
- *are easy to remove and replace*

he importance of grade crossing foundations nd roadway-to-crossing transitions

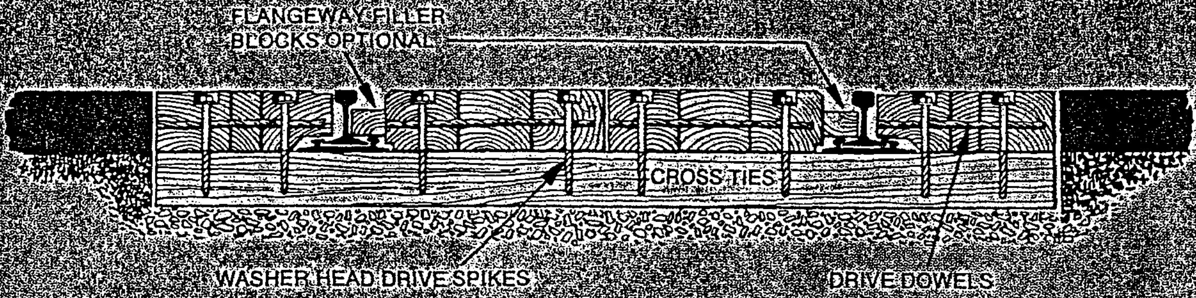
Whatever type of crossing is ordered, regardless of its producer, a proper foundation and good road-to-crossing transitions are vital to a smooth and long-lasting crossing. If the foundation is unstable or if a transition surface adjacent to the crossing is too high or too low, bumpiness and reduced service life are certain.

Properly installed over an adequate foundation with appropriate transitions, Koppers grade crossings can provide years of low-maintenance service. They are, however, no better than the system around them. See the installation procedure described on Page 8.

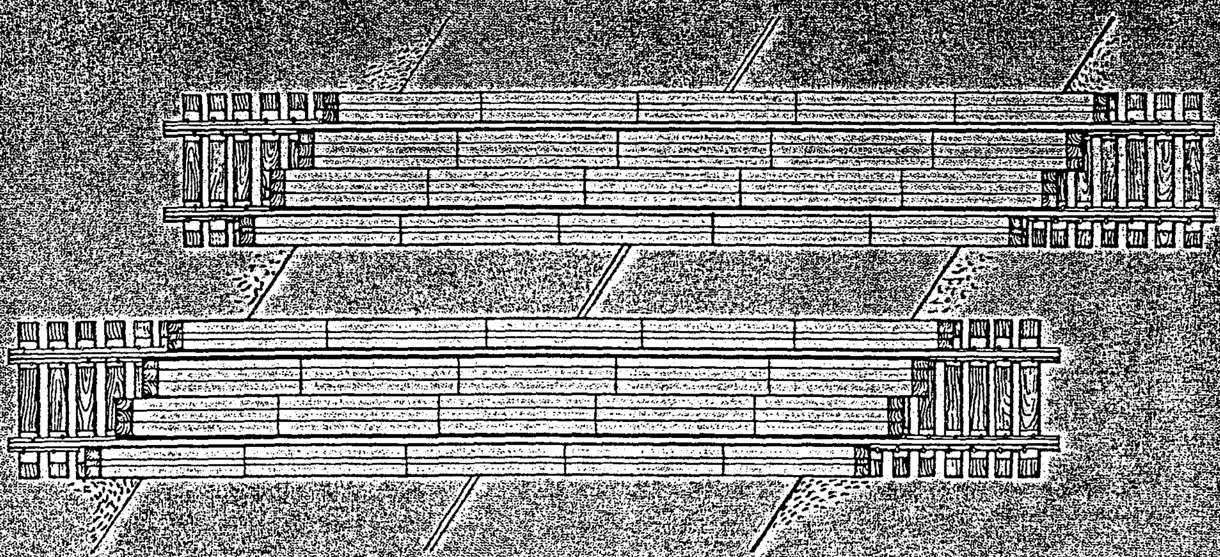




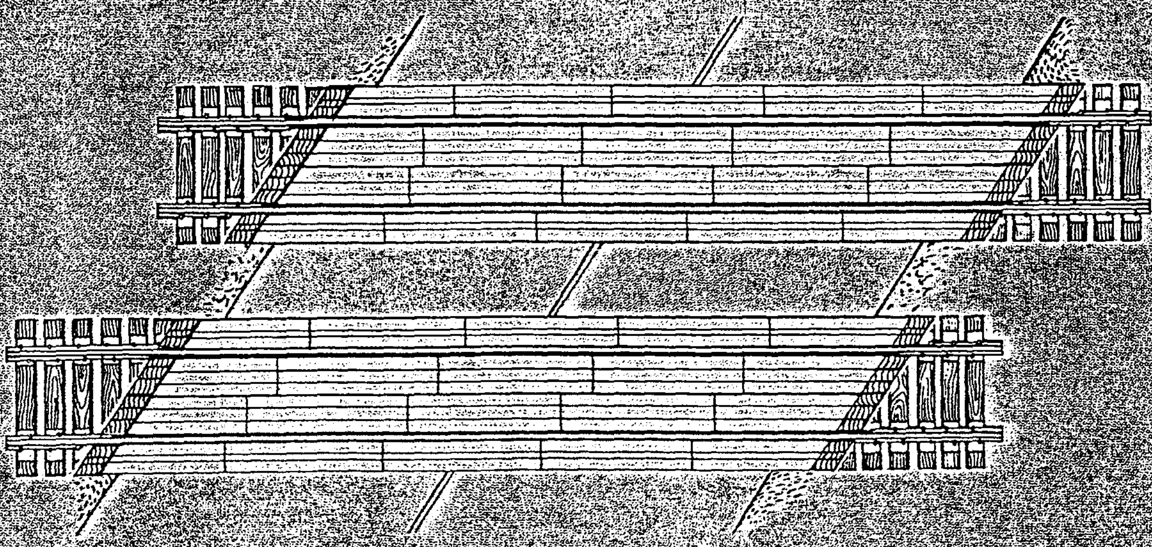
SECTION THROUGH A TYPICAL PREMIUM GRADE CROSSING



TWO TRACK STAGGERED CROSSING (Standard)



TWO TRACK SKEWED CROSSING (Special)



Koppers Industrial Grade Crossings combine economy and practicality

Panel sizes and types

Koppers Industrial Grade Crossings are recommended for side tracks of industrial plants, farm crossings and other low density traffic areas.

Panels are made from selected crosstie stock. Standard thickness is 6″ or 7″. Outside panel width is 17″ ± one inch. Inside panel width is 25″ ± one inch. Either four or eight hold-down spikes are used for each panel. Panels can be pre-bored if desired, providing ties are spaced on 19 3/16″ centers.

Standard panel lengths are 8′ and 6′4¾″. Additional crossing lengths are obtained by using multiples of these basic units.

Panels may contain two or three members. They can be placed directly on the crossties and held by washers, dome-head drive spikes or lag screws.

Industrial Grade Crossings are not prefabricated for curves or with skewed ends.

Shipping and installation

Koppers panels arrive at the crossing site ready for immediate installation.

Koppers supplies

- *a diagram of the complete crossing. Location of each panel is shown in detail, including site preparation and installation instructions.*
- *completely assembled panels, match-marked for easy installation.*
- *¾″ washer head drive spikes or lag screws of suitable length or dome-head drive spikes for fastening panels to the crossties, if requested.*

Quotations and delivery

To obtain quotations and delivery information, fill out the enclosed Form FP-718 and mail to your nearest Koppers Sales Office as listed on the back page of this catalog.

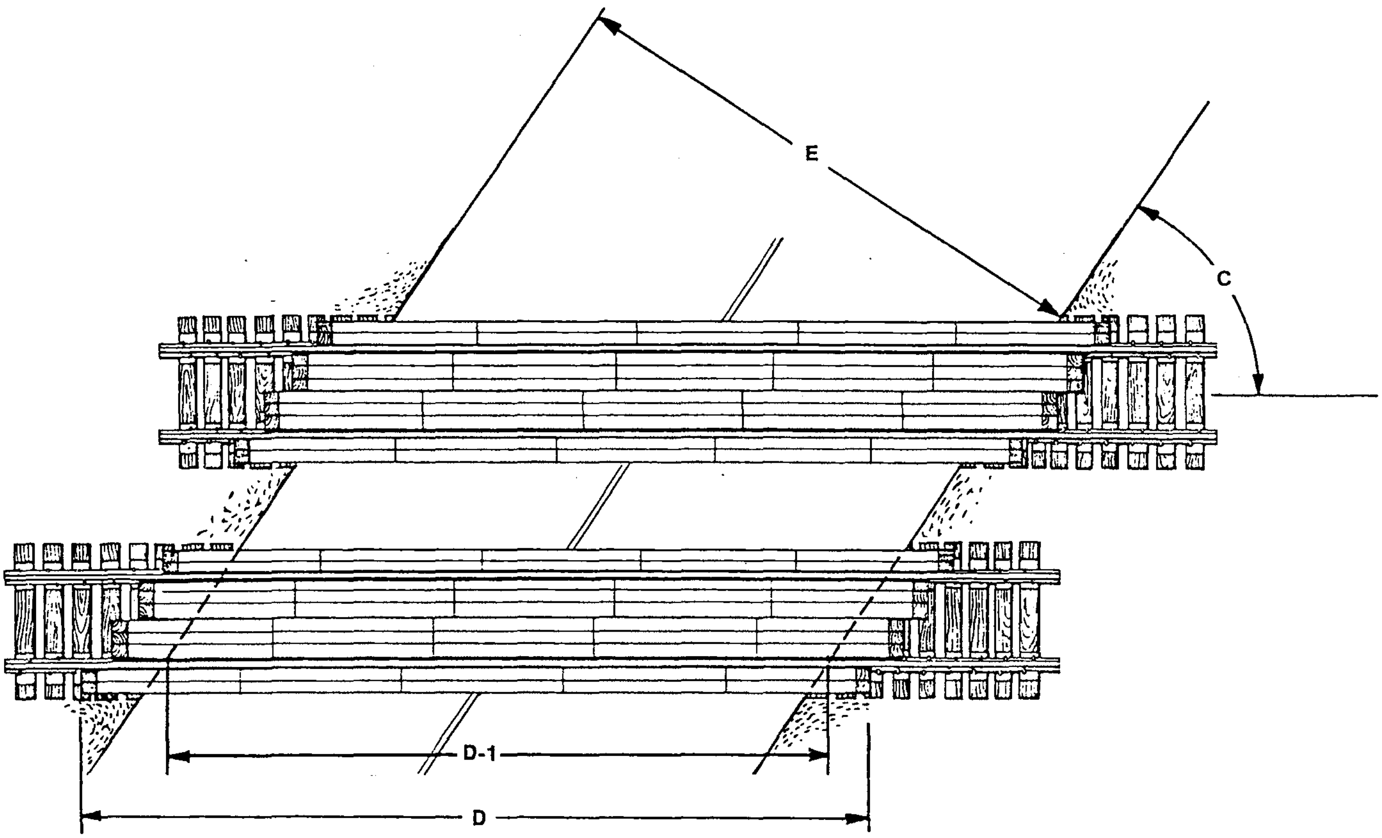
Data required for fabrication of INDUSTRIAL grade crossings

(Not recommended for heavy traffic patterns and/or where small wheeled vehicles are used.)

DATE____________________

A—Crossing Location____________________

B—Number of Tracks____________________



C—Angle of Roadway to track, if skewed____________________Degrees.

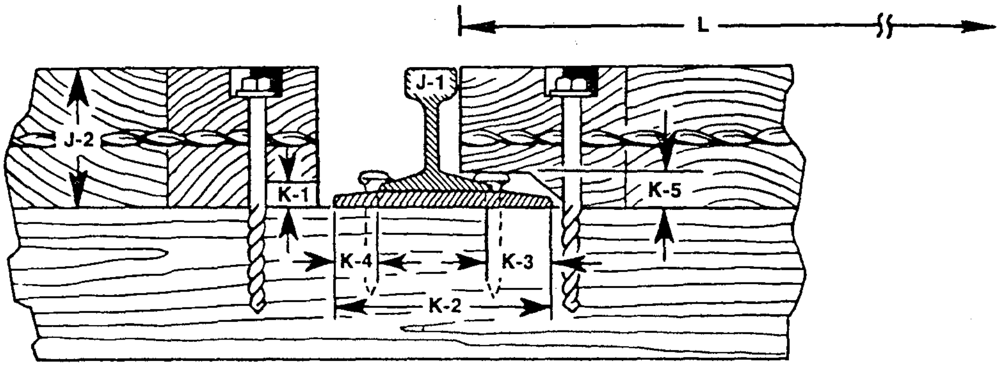
C-1 Skew is to right (as shown) ☐ To Left ☐

D—Length of Crossing____________________
(8' and 6'-4¾" are standard panel lengths)

1 Width of Crossing Along Track____________________
(Measure from one edge of the roadway to the other along rail.)

E—Width of Usable Roadway____________________

(Please complete other side)



J—Weight and Section of rail_____ **J-1**____________________ **J-2** Panel Thickness Desired____________________

K—Tie Plate_____ **K-1** Thickness____________________ **K-2** Length____________________

K-3 Outside Projection ____________________ **K-4** Inside Projection ____________________
(outside edge of rail base to outside edge of tie plate)

K-5 Depth of Dap to clear spikes ____________________

L — Width of outside panels in inches 17″ standard width

O—Prebore panels for ties to be spaced on 19$\frac{3}{16}$ inches (1.6 ft centers) ☐ YES ☐ NO

O-1 Prebore for ☐ Four ☐ Eight Spikes per panel (see note)

-Do not prebore panels for drive spikes to avoid respacing ties ☐

Q—Koppers is to supply installation hardware ☐ YES ☐ NO

Q-1 Type of installation hardware—check one.

☐ Dome-head drive spikes ☐ Washer-head drive spikes

☐ Washer-head lag screws

NOTE: *Eight drive spikes per panel are recommended where rail traffic is heavy or where heavy vehicles will use the crossing.*

R—Double coil spring washers ☐ YES ☐ NO

S—Rubber cushion desired ☐ YES ☐ NO

T — Crossties ☐ YES ☐ NO

U — Engineered fabric ☐ YES ☐ NO

Preferred Shipping Instructions ____________________

____

NAME ____________________

COMPANY ____________________

RESS ____________________

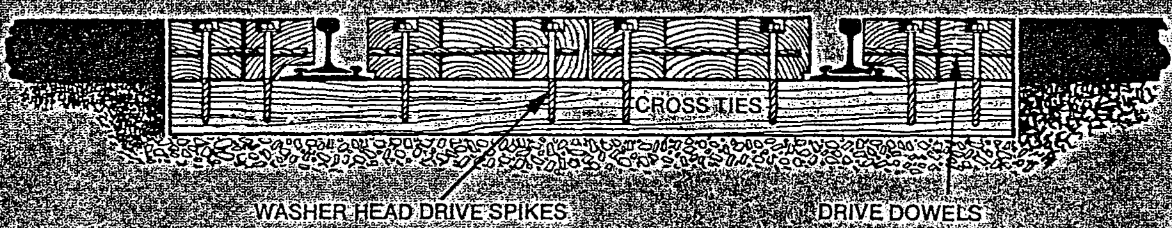
CITY____________________ STATE__________ ZIP__________

FP-718

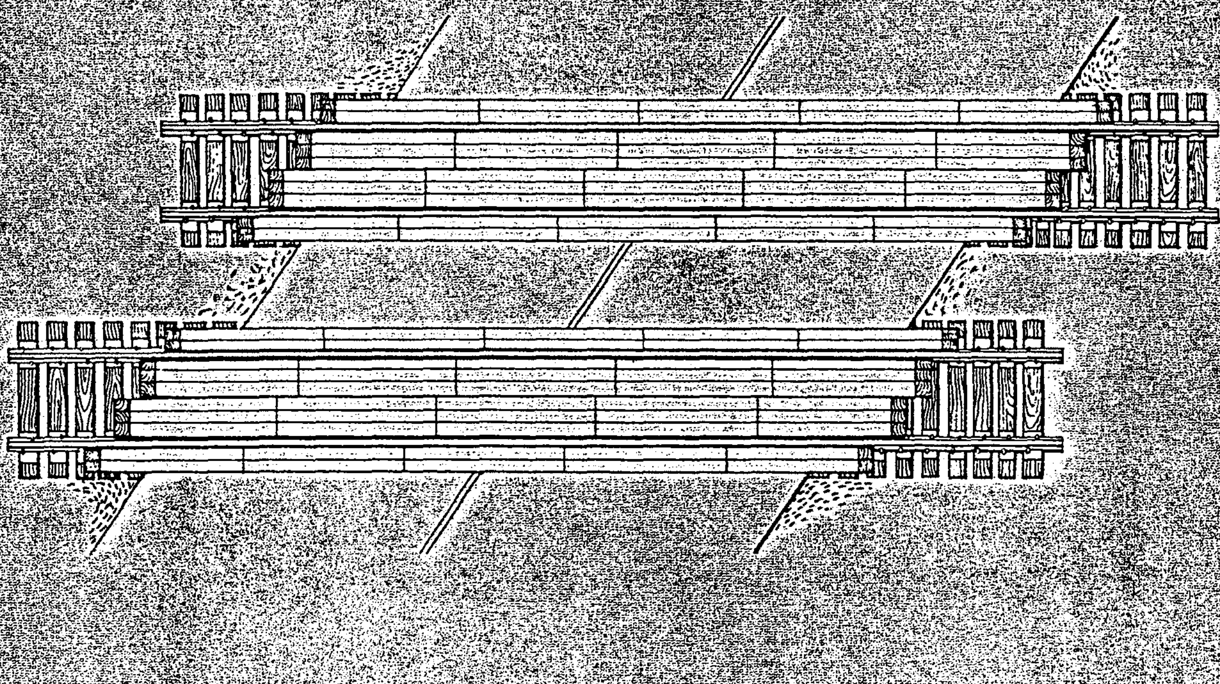
Mail to your local Koppers Sales Office or to:
Koppers Company, Inc., Forest Products Group
900 Koppers Building, Pittsburgh, Pa. 15219

KOPPERS
Engineered Products

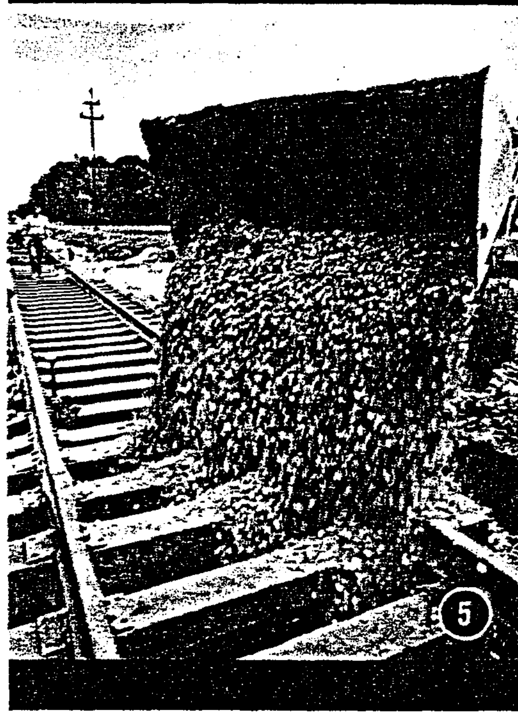
SECTION THROUGH A TYPICAL INDUSTRIAL GRADE CROSSING

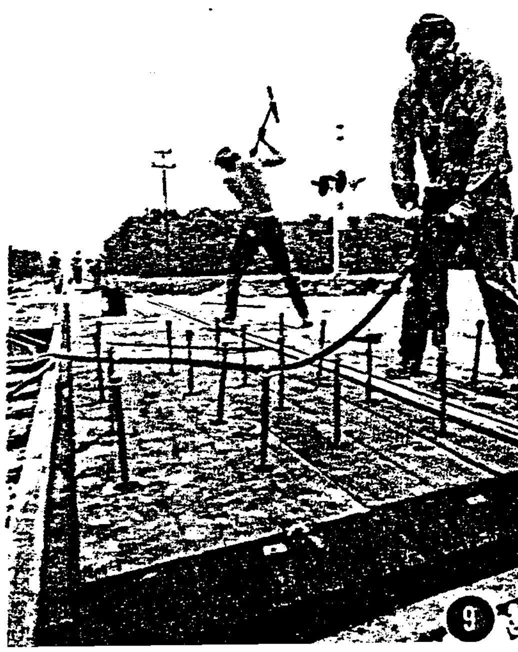


TWO TRACK STAGGERED CROSSING



Installation procedure for Koppers Grade Crossing





1, 2, 3. Before installing panel type grade crossings, the roadbed at the site should be completely reconditioned. The ballast and sub-ballast should be dug out a sufficient distance below the bottom of the ties, beyond the ends of the ties, beyond the crossing and then reballasted with prepared stone, slag or gravel ballast meeting AREA specifications. Provision should be made to intercept surface and subsurface drainage and discharge it away from the crossing area.

4. New rails and crossties are then positioned. All crossties under the panels should be treated, sawn ties.

5. After ties are spaced to suit the crossing (five tie spaces equal exactly eight feet), ballast is poured to bring the ties up to grade.

6. [illegible]llast and ties are then properly [illegible]d.

7. Crossing panels and flange filler are placed in position according to the assembly plan. Flangeway fillers should be installed before adjacent panels are secured to ties.

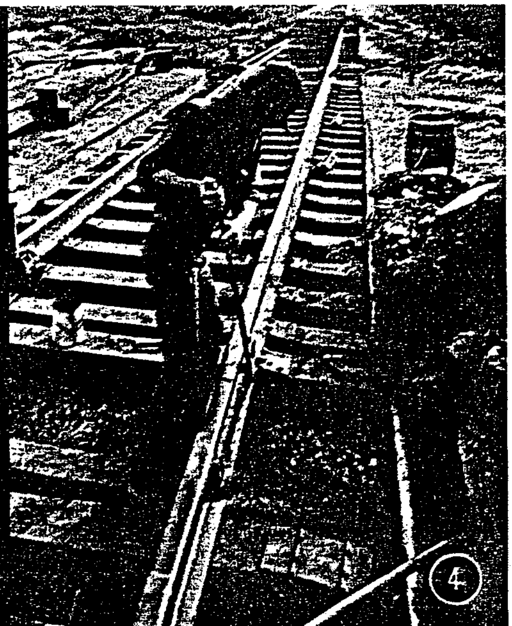
8. If panels are not pre-drilled for drive spikes (to avoid re-spacing of existing ties), $^{13}/_{16}$″ diameter holes are drilled through the panels and counterbored 2½″ diameter x 1¼″ deep. Field drilled holes and counterbores should be flushed with creosote before installing drive spikes.

9. Lead holes should be drilled in the ties for ¾″ diameter drive spikes, spaced to suit the holes in the panels. $^{11}/_{16}$″ diameter bit should be used in hardwoods or ⅝″ diameter bit in softwoods. Holes in ties should be flushed with creosote before drive spikes are installed.

10. After drive spikes are installed, counterbored holes should be filled with a bitumastic material to keep water out.

11, 12. Crossing is then ready for service.


2

3

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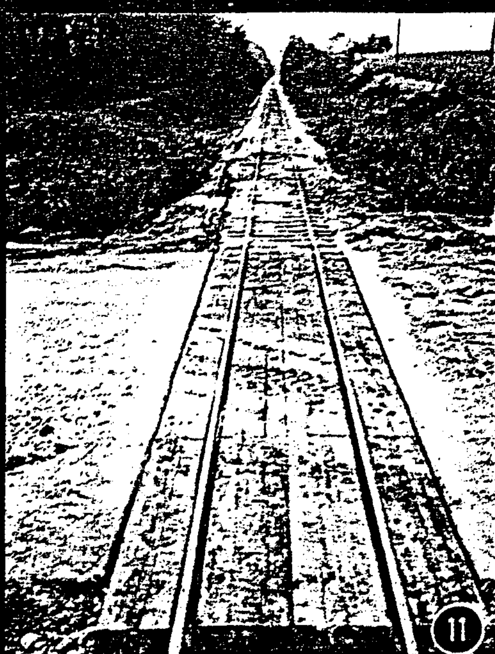
6

7

8

10

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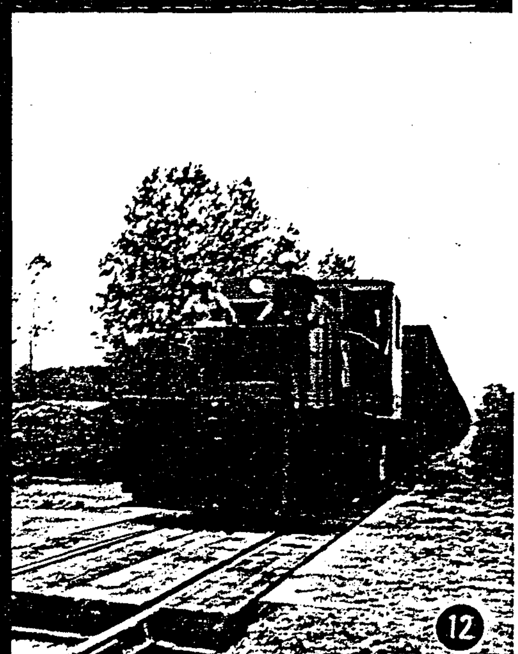
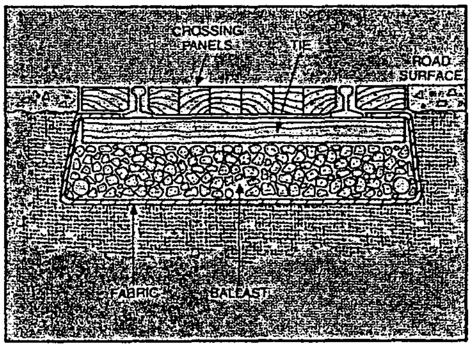
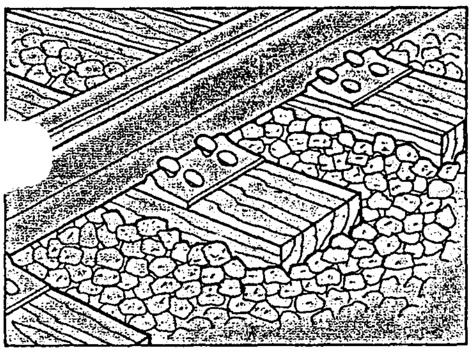

12

Optional features



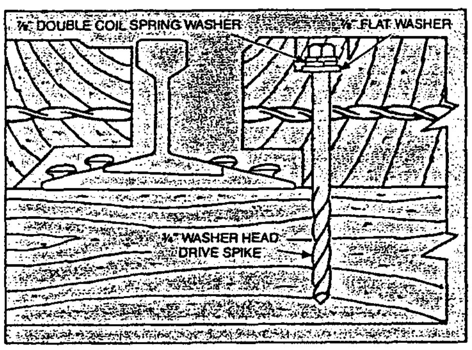
Engineering fabric

The use of engineering fabric will help maintain the loadbearing capacity of the track bed. It acts as a barrier, preventing nearly all fine silt particles from fouling the ballast and preventing ballast loss to the subsoil, while providing roadbed drainage. A stabilized roadbed means a smoother, longer-lasting crossing.



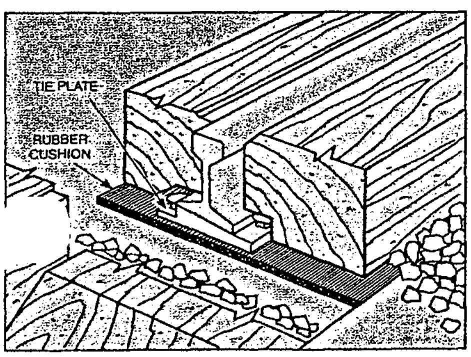
Crossties

In installing a new panel crossing, it is advisable to replace the crossties. Koppers, a leading producer of dependable pressure-creosoted crossties, can supply your tie needs with every crossing ordered.



Spring-loaded drive spike

This double coil spring-loaded drive spike absorbs shock from the traffic and is designed to keep tension between the drive spike and timber. Hard grease lubricates and seals the hole to keep water out.



Rubber cushion

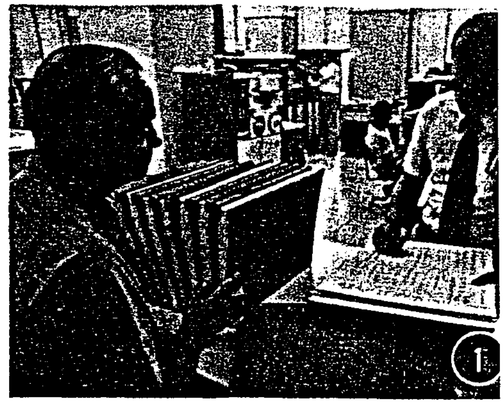
This special rubber strip reduces vibration and keeps pressure on the hold-down spikes. Measuring $3/16''$ thick x 8″ wide x 8′6″ long, the cushion can be laid over the full length of the tie underneath the plate, or full length except for the area underneath the tie plate. Wear to the tie is reduced and panels are kept tight.

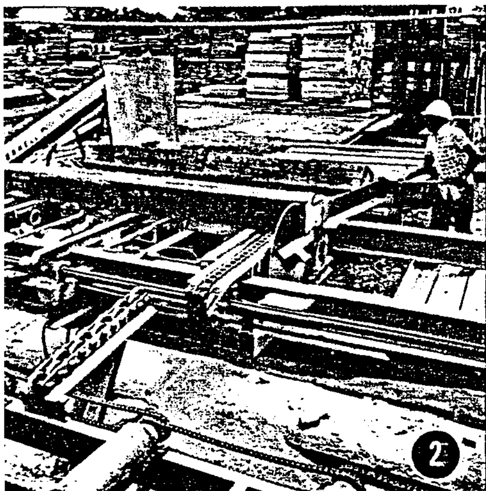
The spring-loaded drive spike and the rubber cushion can be installed separately or both features can be installed in the same grade crossing.

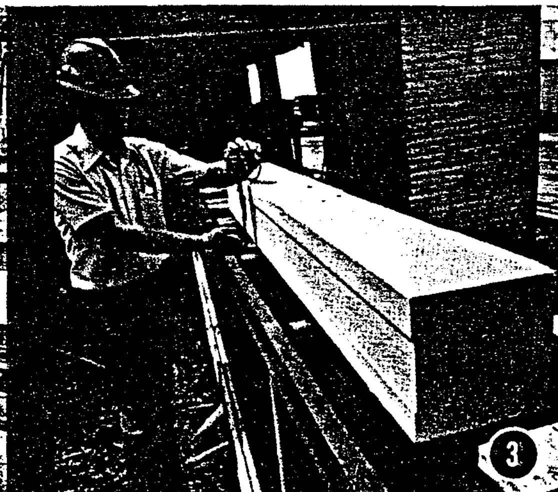
Crossings produced to last

mputer-generated designs, quality ntrol checks and years of experience help assure that a Koppers grade crossing will be produced efficiently and correctly and that it will perform as expected.

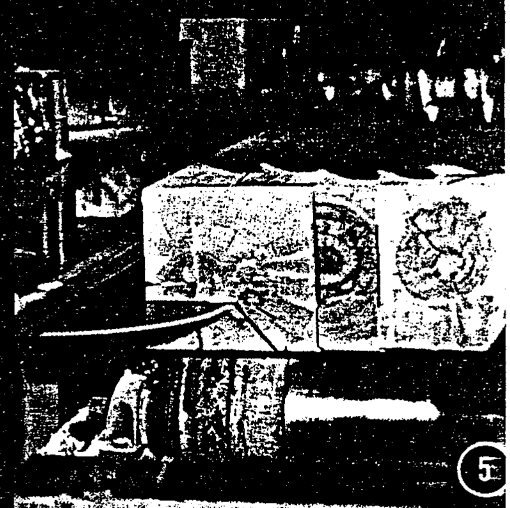
Koppers is a world leader in the pressure treatment of wood and a long-time supplier to the transportation industry. The expertise developed over decades of production involving various products — for common, standard units as well as unique ones — contributes to the reliability of every crossing shipped from a Koppers facility.

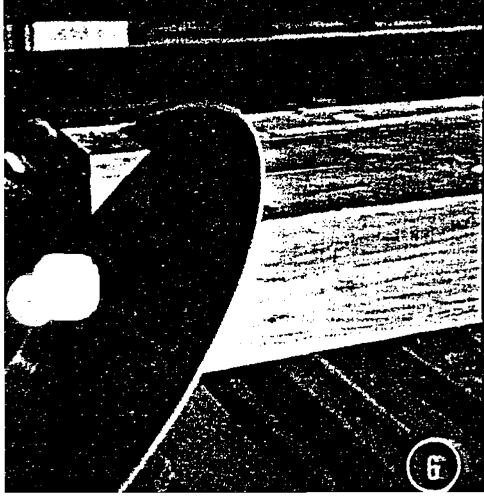


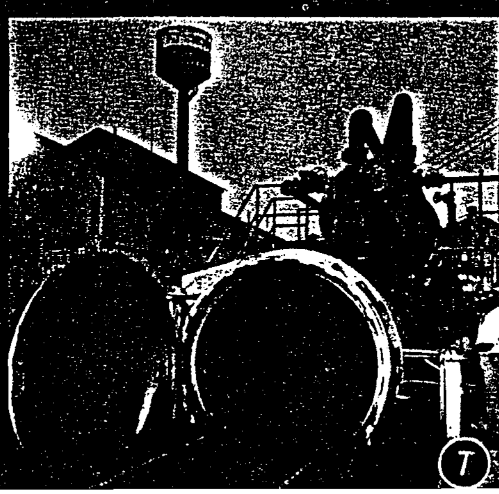


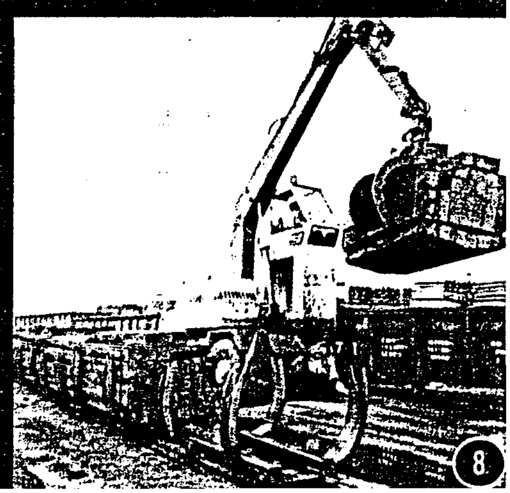


1. *Computer printouts have been generated for 97,000 design variations. Panel production is thus speeded and the possibility of a design error reduced.*
2. *Square-sawn blanks (stacked in background) are cut to eight-foot lengths on a double-end trim saw.*
3. *Blank is examined after passing through a planer where it is surfaced to the proper width and depth.*
4. *Holes are drilled for hold-down spikes while steel dowels are driven in from the side to securely fasten panel timbers together.*
5. *Dap depth is checked after bottom cut is made to allow tie plate clearance.*
6. *End panels are given a bevel cut.*
7. *Panels are pressure-treated with creosote preservative in a treating cylinder.*
8. *After treatment, panels are loaded into railroad cars for shipment.*

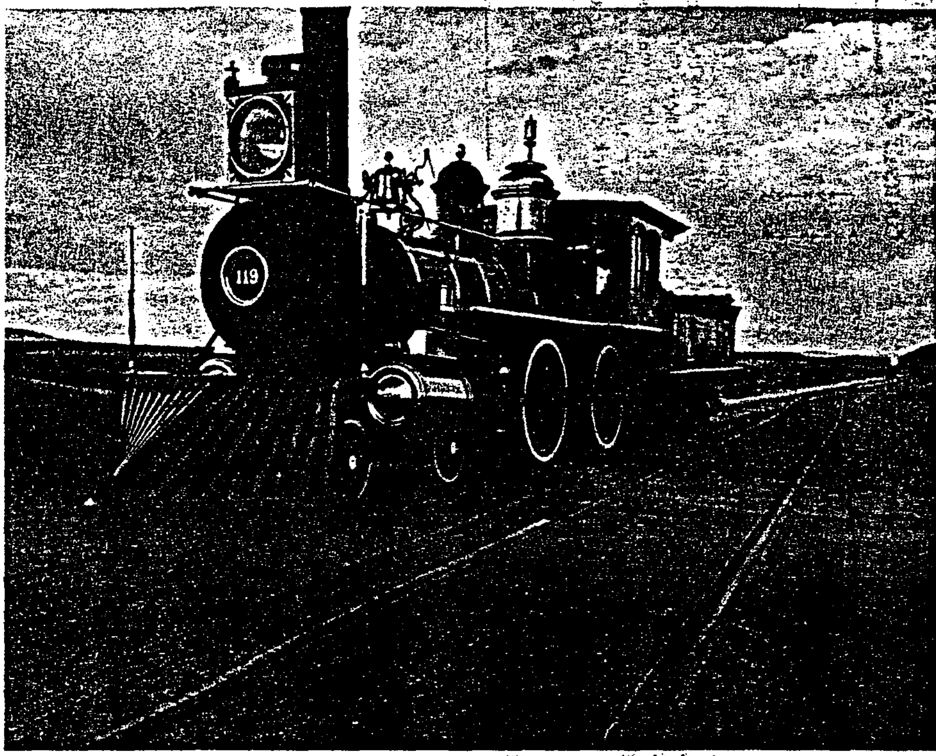








Forest Products Group Sales Offices



The full size replica of Union Pacific locomotive "119" passes over a Koppers grade crossing at Golden Spike National Historic Site, Brigham City, Utah. Each summer, thousands of visiting motorists use the crossing to watch the daily reenactment of the completion of the first transcontinental railroad.

Transportation Department

Suite 2051
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2830 Koppers Building
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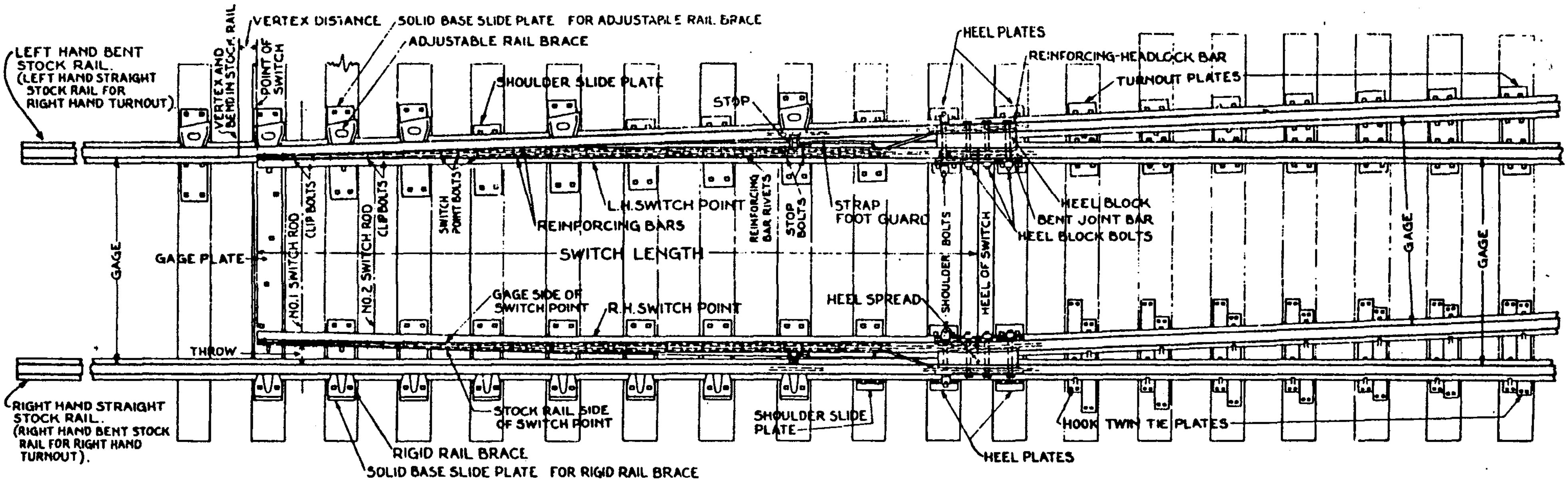
Koppers Company, Inc.
Pittsburgh, Pa. 15219

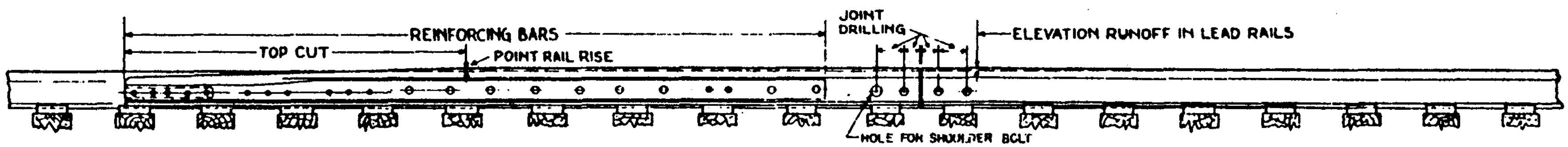
KOPPERS

FP-716R

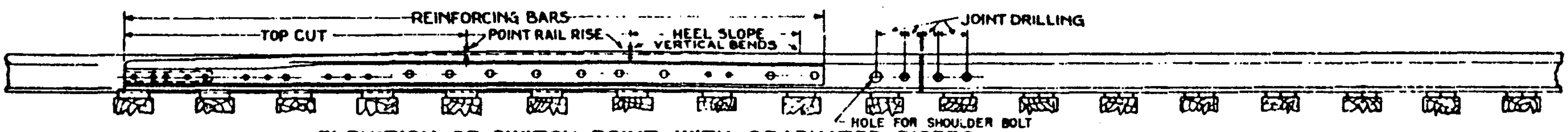
Printed in U.S.A.



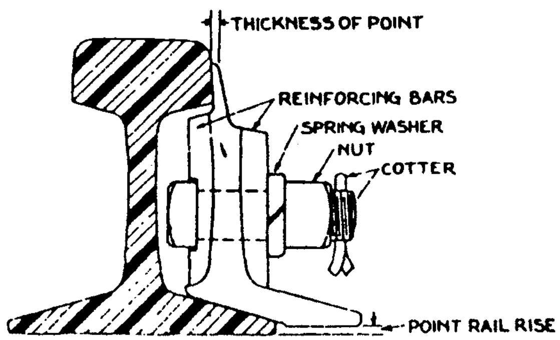
PLAN VIEW INDICATING (FOR ILLUSTRATION ONLY) VARIOUS PARTS OF SWITCH LAYOUTS
DRAWN FOR LEFT HAND TURNOUT



ELEVATION OF SWITCH POINT WITH UNIFORM RISERS



ELEVATION OF SWITCH POINT WITH GRADUATED RISERS

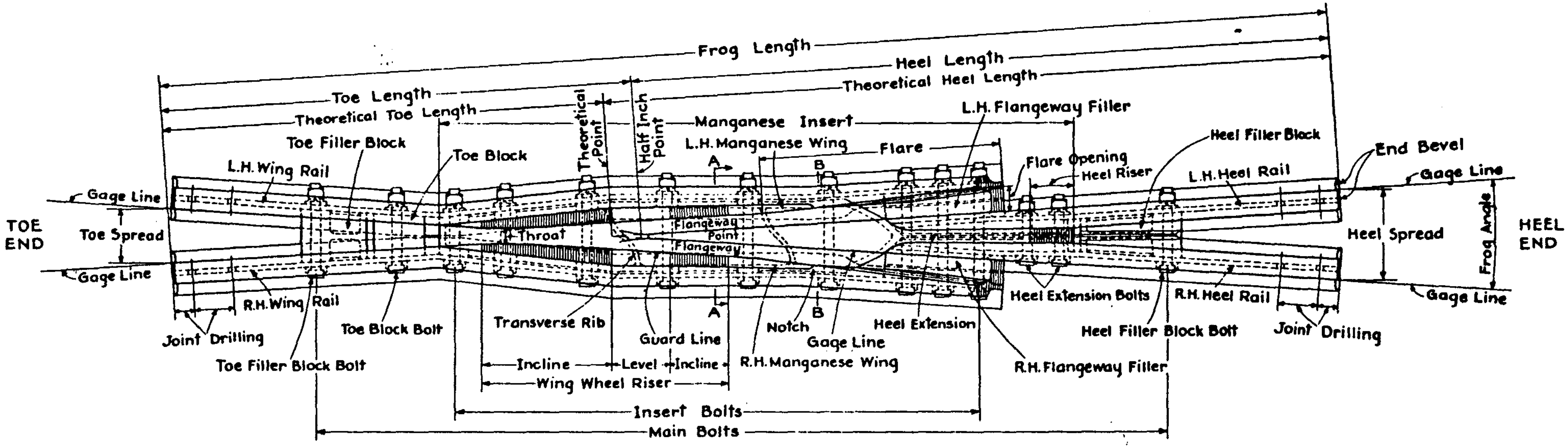


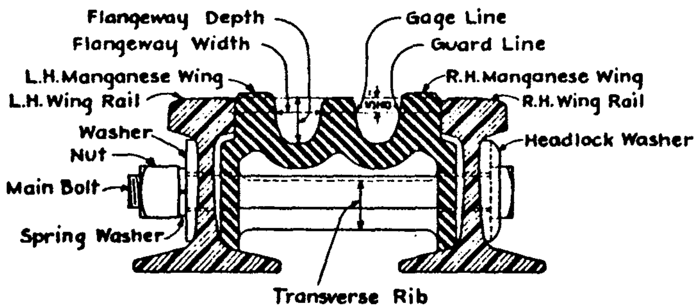
NOTE

FOR NAMES OF ADDITIONAL PARTS SEE PLANS BASIC NO. 181, 220, 221, 222, 223, 224, 241, AND THE PLANS FOR THE VARIOUS LENGTHS OF SPLIT SWITCHES. SEE ALSO APPENDIX "B".

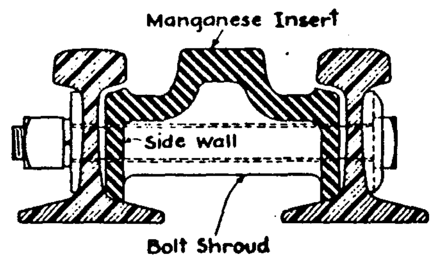
American Railway Engineering Association

DIAGRAM ILLUSTRATING PREFERRED NAMES OF PARTS FOR SPLIT SWITCHES

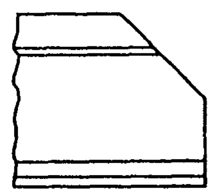




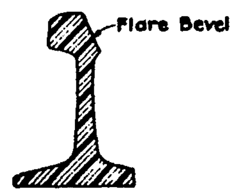
SECTION A-A



SECTION B-B



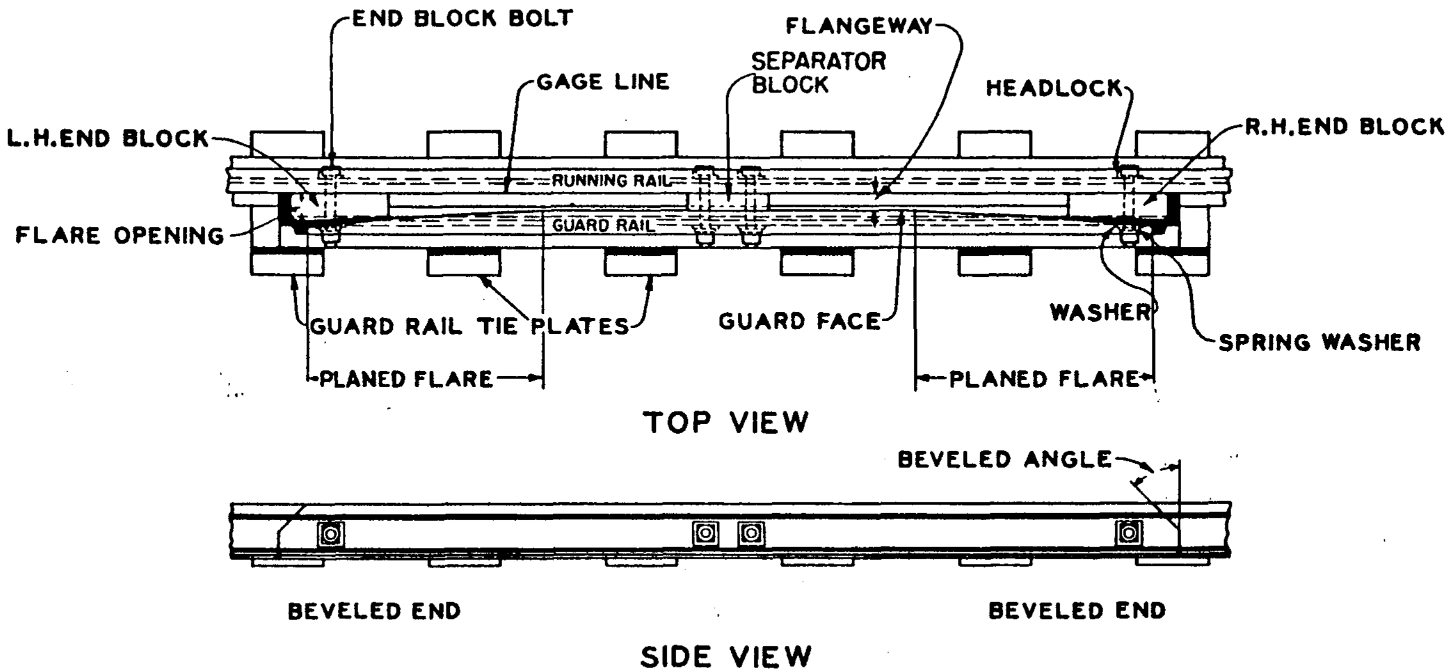
BEVELED WING RAIL END



SECTION AT WING RAIL END

American Railway Engineering Association

DIAGRAM ILLUSTRATING PREFERRED NAMES OF PARTS FOR RAIL BOUND MANGANESE STEEL FROGS



American Railway Engineering Association

DIAGRAM ILLUSTRATING PREFERRED NAMES OF PARTS FOR GUARD RAILS

PLAN NO. 590-55

Frog Spring

The spring is either of the double pattern recommended by the A.R.E.A., when it is placed ahead of the point of the frog and operates on a spring bolt passing through both wing rails, or is of the single pattern, connected to the spring wing rail over the second tie behind the point of the frog and backed upon the bearing plate attached thereto. The spring is generally double coil; the larger spring is called the outer coil and the other, the inner coil. The pressure of the coil springs is received on a metal cylinder called the spring follower and metal housings are provided for the springs.

The hold-down consists of a horn projecting at right angles from a reinforcing strap bolted in the A.R.E.A. design to the wing of the spring wing rail, which moves back and forth inside an inverted-U housing with little play, to prevent the movable wing rail from rising, especially when ice forms under it. Usually two hold-downs are considered sufficient.

Manganese Frogs

Manganese steel has been in use as a frog material since about 1900. Its marked resistance to abrasion and impact has led to its adoption in the construction of frogs for installation at points of heavy service, where it usually outwears two to three frogs of plain carbon-steel construction. Due to the relatively high cost of manganese steel, present practice favors its limitation in tracks carrying moderately heavy traffic, to the wearing parts in carbon-steel rail frogs. It is used in the form of a single manganese casting for the point wings and throat of the frog and is surrounded by rails of carbon steel. These frogs are known as manganese-insert or rail-bound manganese frogs. The construction offers the advantage of the longer life of the manganese steel, without an excessive increase in cost over that of the carbon-steel rail frog.

Manganese steel, in its cast condition, has a Brinell hardness of only about 190, but is unique in its reaction to impact and rolling loads. The grain becomes denser in proportion to the work-hardening applied, with a corresponding increase in Brinell hardness. During this change, the surface metal "flows," but once this flow has stopped, the surface keeps its shape and will withstand the severest impact.

This work-hardening will occur under traffic, after which the flowed metal must be removed by grinding to restore the original contours of the casting. In the process, the point and wings will be depressed as the metal becomes denser. To maintain a smooth surface, it may be necessary to build up the casting by welding.

It is possible, however, to provide the initial work-hardening before a frog is installed in track. This may be done by the hammer, press or explosion hardening methods. The cost of the hardening process will be offset by eliminating the need for initial grinding and welding after the frog has been placed in service.

The solid manganese steel frog is favored for use in freight yards; where curves are sharp, axle loads are heavy and switching movements are numerous. The single manganese casting functions as a unit; there are no fastenings to maintain and the service life is extended. The solid manganese steel frog is not regarded as economical for Nos. above 12, for which the railbound manganese steel frog is usually substituted. The latter is economical for all Nos. and is preferred for installation in main tracks.

Railbound Manganese Frogs

The railbound manganese-steel frog is the most desirable type for long turnouts, since manganese steel is especially suited to the long thin points and such frogs require comparatively little maintenance. This type is also desirable for main-line turnouts and crossovers, where a considerable protion of the track is diverted through the turnout, and is also adapted for locations involving high-speed movements in yards and station layouts. Proper blocking is essential at the toe and heel to insure the accurate alinement of the rails with the casting and, heavy tie plates, frequently equipped with shoulders or hook clamps, should be used to protect the switch ties and also to hold the frog in accurate alinement.

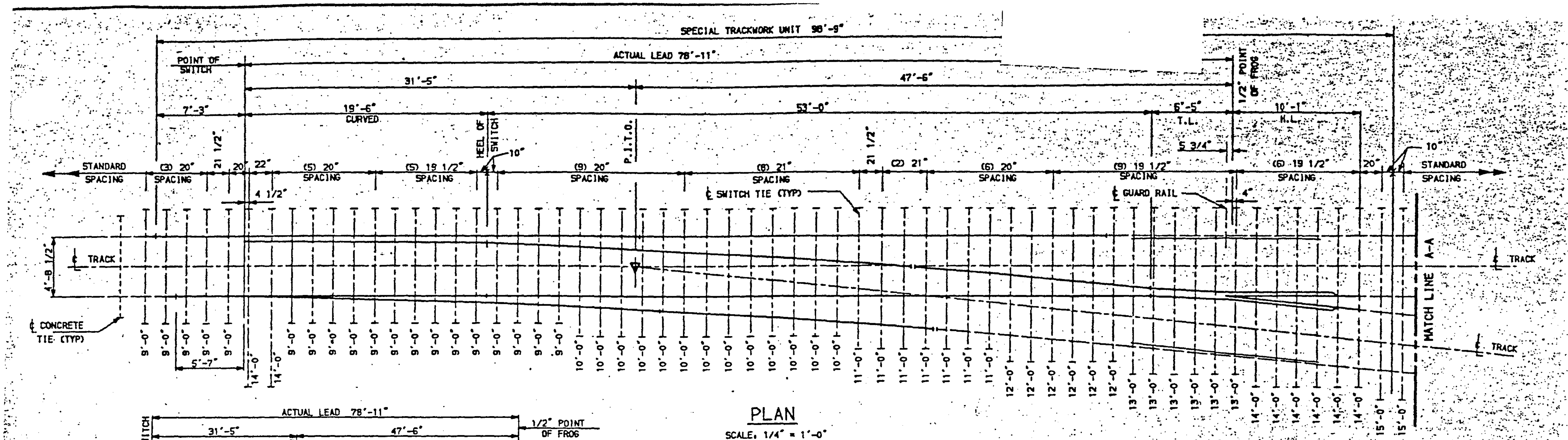
The A.R.E.A. plans for railbound manganese-steel frogs include Nos. 4, 5, 6, 7, 8, 9, 10, 11, 12, 14, 15, 16, 18 and 20. The designs specify a manganese steel center casting supported on the flanges of carbon steel reinforcing rails and secured to them through bolting. The entire casting is known as the manganese body, the two sides at the right and left hand as manganese wings and the center portion as the point; the other parts have the same names as those in the ordinary bolted rigid frog.

In A.R.E.A. designs for railbound manganese frogs, the manganese body is extended well behind the throat of the frog and has a heel extension which fills the space between the heel rails and joins them to it, serving also as a heel riser. Opposite the point of the frog, the wing rails are of full section.

The actual point of the frog for all types of manganese frogs, except those intersecting at an angle of 25 degrees or more, is established where the distance between gage lines is 5/8 inch instead of the customary 1/2 inch. The real theoretical 1/2-inch frog point is marked on the frog by a notch for working purposes. For manganese frogs of 25 degrees or more, the point of the frog is at the 1/2-inch point. Both the width and depth of the flangeways are 1 7/8 inches and the bottom is formed with a 27/32-inch radius.

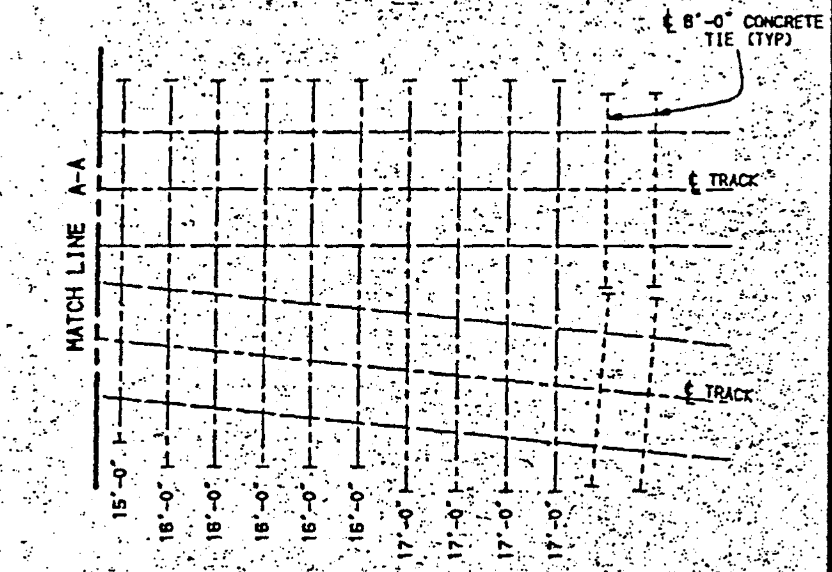
Solid Manganese Frogs

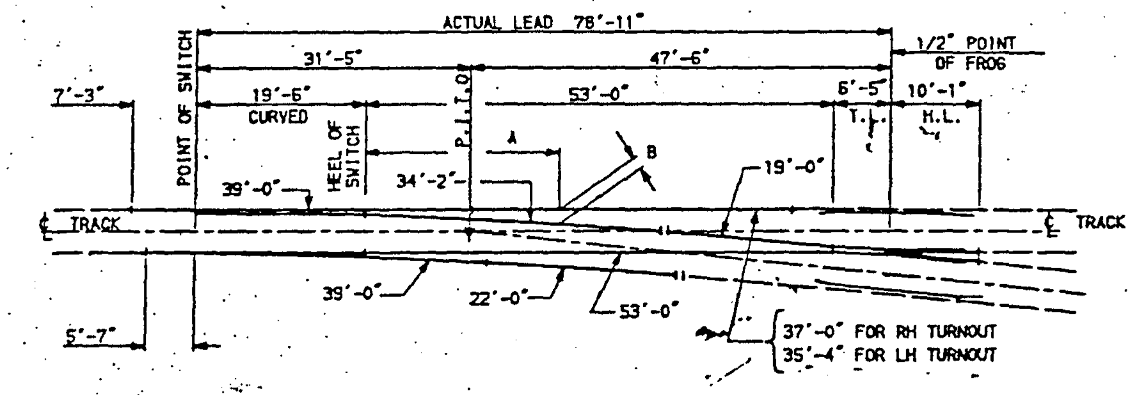
This type is designed especially for use in busy yards and station layouts. Those designed with flat surfaces are used in locations where speed is unrestricted, while solid manganese frogs with flange guards, commonly referred to as "self-guarded," are suited to locations with speed restrictions. The detail of the design is relatively simple; the frog consists of a single casting with bars and bolts to fasten to the connecting rails. Twin hook plates are used with these frogs.



PLAN

SCALE: 1/4" = 1'-0"





RAIL LAYOUT DIAGRAM

SCALE: 3/32" = 1'-0"

TURNOUT DATA		
FROG	NUMBER	10
	ANGLE	5°-43'-29"
	TOE LENGTH	6'-5"
	HEEL LENGTH	10'-1"
	TOTAL LENGTH	16'-6"
	TOE SPREAD	7 3/16"
	HEEL SPREAD	12 5/8"
SWITCH	LENGTH OF SWITCH RAIL	19'-6"
	THICKNESS OF POINT	0"
	RADIUS	1222.17'
	HEEL ANGLE	1°-59'-15"
	HEEL SPREAD	6 1/4"
	ANGLE AT POINT	1°-04'-24"
ACTUAL LEAD		78'-11"
STRAIGHT CLOSURE LENGTH		53'-0"
CURVED CLOSURE LENGTH		53'-2"
CENTERLINE RADIUS		806.28'
DEGREE OF CURVE		7°06'22"
TANGENT AT HEEL OF SWITCH		0"
TANGENT AT TOE OF FROG		5 1/8"

TURNOUT OFFSETS	
A	B
10'-0"	0'-11 3/16"
20'-0"	1'-5 9/16"
30'-0"	2'-1 7/16"
40'-0"	2'-10 13/16"

A - DISTANCE FROM HEEL OF SWITCH MEASURED ALONG LEFT THRU RAIL.

B - OFFSET FROM GAUGE LINE TO GAUGE LINE.

SWITCH TIES	
LENGTH	QTY
9'-0"	19
10'-0"	13
11'-0"	7
12'-0"	6
13'-0"	6
14'-0"	8
15'-0"	3
16'-0"	5
17'-0"	4
TOTAL	71

BILL OF MATERIAL (FURNISHED BY LACTC)	
QTY	DESCRIPTION
1	NO. 10 LATERAL TURNOUT BALLASTED, COMPLETE PER REFERENCE DWG TK-0197, CONTRACT NO. R01-T06-P830.
1 SET	7" x 9" TIMBER SWITCH TIES
A/R	115 RE RAIL

BILL OF MATERIAL (FURNISHED BY CONTRACTOR)	
QTY	DESCRIPTION
9	BONDED STANDARD JOINTS
2	BONDED INSULATED JOINTS
A/R	LAG SCREWS
A/R	ELASTOMER PADS
A/R	SEALANT

BID DOCUMENTS

NOTES:

1. FOR ADDITIONAL DETAILS, SEE DWG NO. (5) TK-1281 & TK-1282 & TK-1332.
2. FOR GENERAL NOTES SEE DWG NO. GI-1224.
3. REFER TO TRACK CHARTS FOR LOCATIONS OF INSULATED JOINTS AT PS END OF STOCK RAILS.

8 4 0 16 32 — 3/32" = 1'-0" GRAPHIC SCALE

2 0 5 10 — 1/4" = 1'-0" GRAPHIC SCALE

ISSUED FOR BID — DESCRIPTION

DESIGNED BY J.L. Patterson — DRAWN BY CADD — CHECKED BY — APPROVED BY — DATE 3/27/87

REGISTERED PROFESSIONAL ENGINEER WAYNE K. SAN FILIPPO No. 19637 EXP. 9/30/89 CIVIL STATE OF CALIFORNIA

LOS ANGELES COUNTY TRANSPORTATION COMMISSION — The Long Beach-Los Angeles Rail Transit Project

DMJM

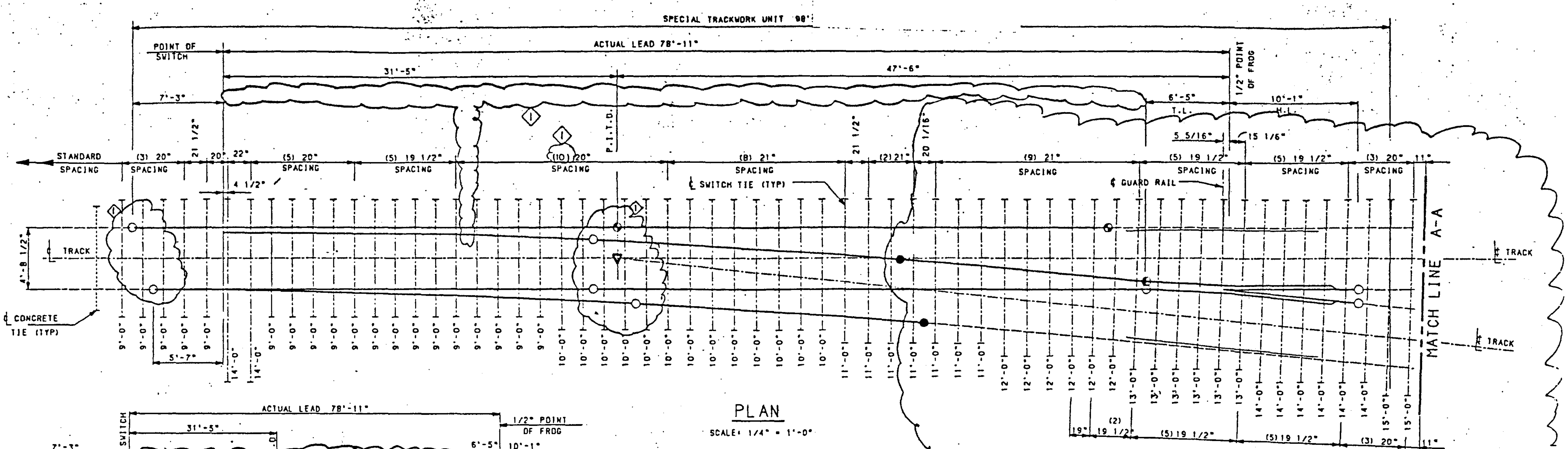
Southern California Rail Consultants

SUBMITTED: — APPROVED:

LRT TRACKWORK INSTALLATION

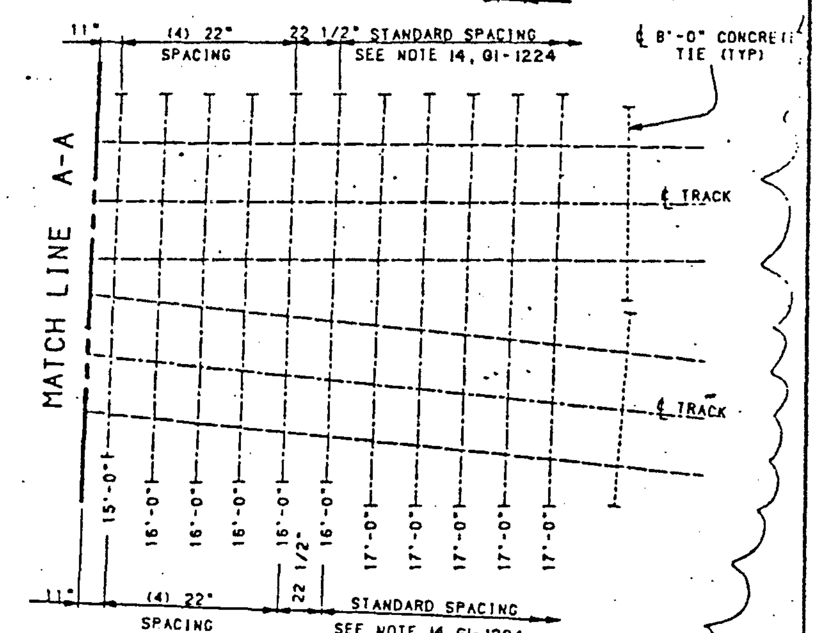
NO. 10 LATERAL TURNOUT BALLASTED

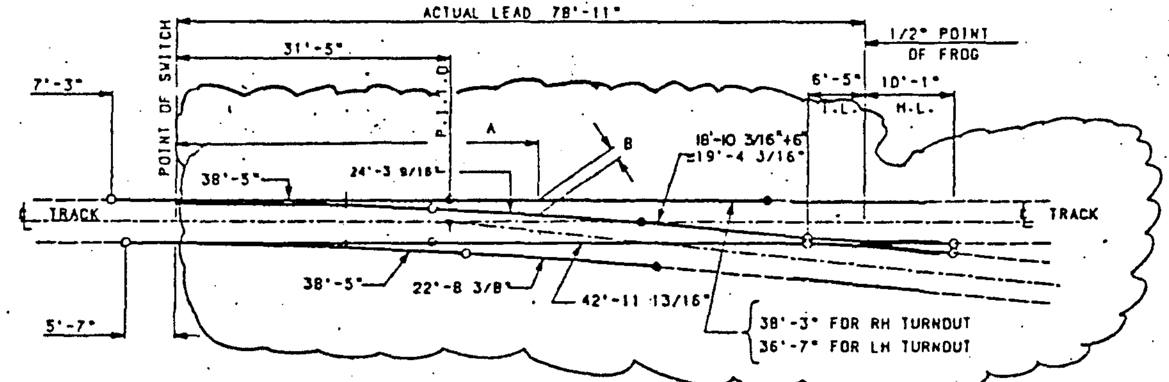
CONTRACT NO. R01-T06-C258 — DRAWING NO. TK-1280 — REV. — SHEET NO. 96 — SCALE AS NOTED



PLAN

SCALE: 1/4" = 1'-0"





RAIL LAYOUT DIAGRAM

SCALE: 3/32" = 1'-0"

TURNOUT DATA

FROG	NUMBER	10
	ANGLE	5°43'-29"
	TOE LENGTH	6'-5"
	HEEL LENGTH	10'-1"
	TOTAL LENGTH	16'-6"
	TOE SPREAD	7 3/16"
	HEEL SPREAD	12 5/8"
SWITCH	LENGTH OF SWITCH RAIL	25'-6 3/16"
	THICKNESS OF POINT	1/8"
	RADIUS	839.52'
	HEEL ANGLE	2°46'46"
	HEEL SPREAD	10 29/32"
	ANGLE AT POINT	1°00'00"
ACTUAL LEAD		78'-11"
STRAIGHT CLOSURE LENGTH		42'-11 13/16"
CURVED CLOSURE LENGTH		43'-1 15/16"
CENTERLINE RADIUS		837.17
DEGREE OF CURVE		6°50'38"
TANGENT AT HEEL OF SWITCH		0"
TANGENT AT TOE OF FROG		0"

TURNOUT OFFSETS

A	B
30'-0"	0'-11 3/16"
40'-0"	1'-5 13/16"
50'-0"	2'-1 7/8"
60'-0"	2'-11 3/8"

A - DISTANCE FROM POINT OF SWITCH MEASURED ALONG LEFT THRU RAIL.

B - OFFSET FROM GAUGE LINE TO GAUGE LINE.

SWITCH TIES

LENGTH	QTY
9'-0"	19
10'-0"	13
11'-0"	7
12'-0"	6
13'-0"	6
14'-0"	8
15'-0"	3
16'-0"	5
17'-0"	5
TOTAL	72

BILL OF MATERIAL (FURNISHED BY LACTC)

QTY	DESCRIPTION
1	NO. 10 LATERAL TURNOUT BALLASTED, COMPLETE PER SHOP DWG NO. 6-200-6016, CONTRACT NO. R01-T08-PB30.
1 SET	7" x 9" TIMBER SWITCH TIES
A/R	115 RE RAIL

BILL OF MATERIAL (FURNISHED BY CONTRACTOR)

QTY	DESCRIPTION
9	BONDED STANDARD JOINTS
4	BONDED INSULATED JOINTS
A/R	LAG SCREWS
A/R	ELASTOMER PADS
A/R	SEALANT
2	4 HOLE BONDED STANDARD JOINTS

ADDENDUM NO 1

NOTES:

1. FOR ADDITIONAL DETAILS, SEE DWG NOS. TK-1281, TK1-1282 &TK-1332.
2. FOR GENERAL NOTES, SEE DWG GI-1224.
3. REFER TO TRACK CHARTS FOR LOCATIONS OF INSULATED JOINTS AT PS END OF STOCK RAILS.

3/32" = 1'-0" GRAPHIC SCALE (8 4 0 16 32)

1/4" = 1'-0" GRAPHIC SCALE (2 0 5 10)

REV.	DATE	DESCRIPTION	BY	APP
1	7/1/87	ADDENDUM NO. 1-GENERAL REVISIONS AS PER SHOP DWG		
	6/5/87	ISSUED FOR BID		

DESIGNED BY J.L. Patterson
DRAWN BY CADD
CHECKED BY C. Jules
APPROVED BY
DATE 03/27/87

LOS ANGELES COUNTY TRANSPORTATION COMMISSION
The Long Beach-Los Angeles Rail Transit Project

DMJM

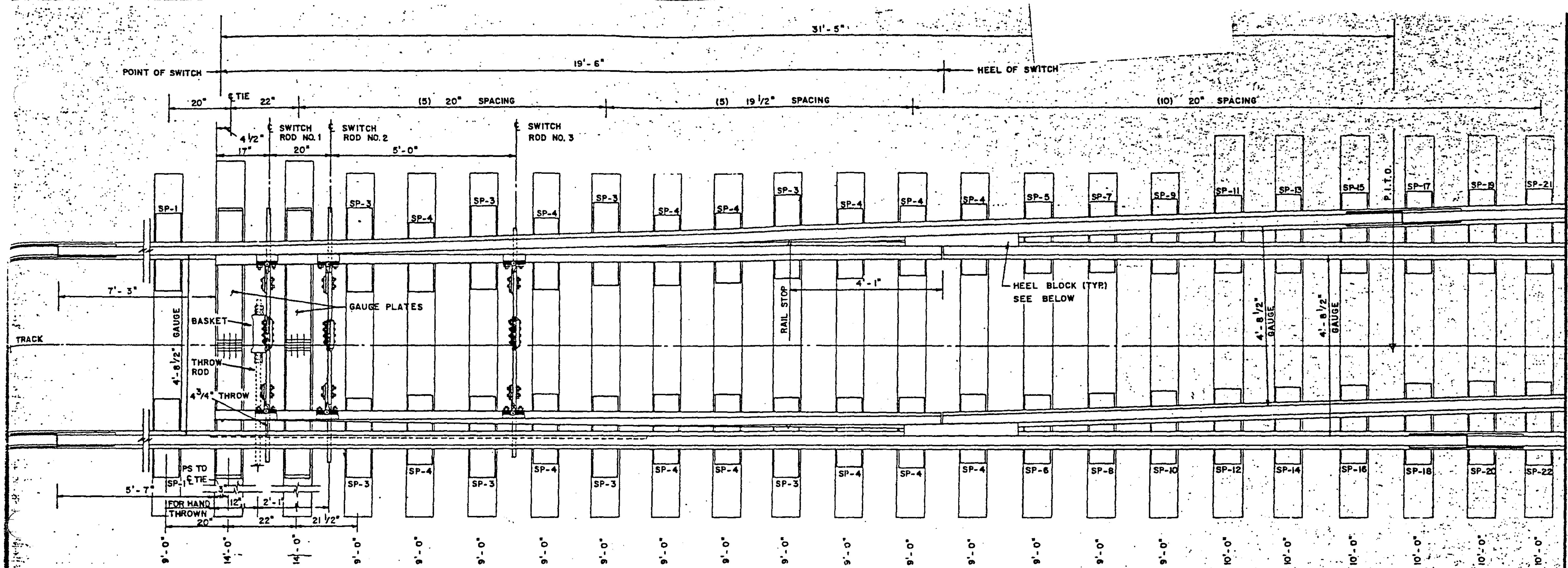
Southern California Rail Consultants

SUBMITTED: Noel L. San Filippo
APPROVED:

LRT TRACKWORK INSTALLATION
NO. 10 LATERAL TURNOUT BALLASTED

CONTRACT NO. R01-T08-C258
DRAWING NO. TK-1280
REV. 1
SHEET NO. 96
SCALE AS NOTED

47

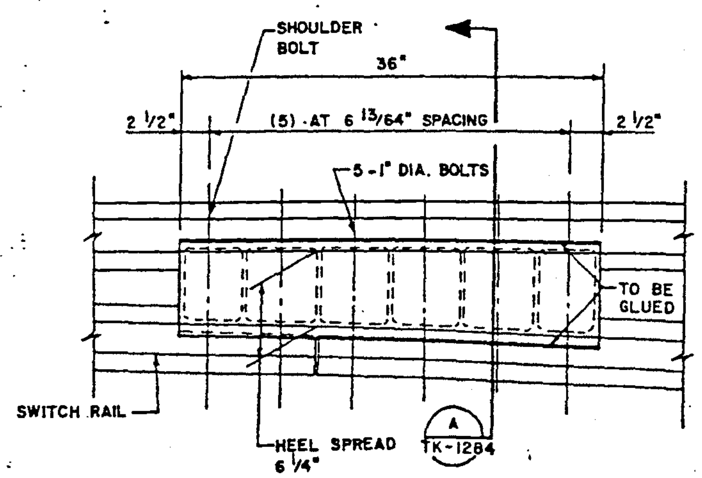


PLAN

SCALE: 3/4" = 1'-0"

BILL OF MATERIAL
(FURNISHED BY LACTC)

QTY	DESCRIPTION
1	NO. 10 LATERAL SWITCH - BALLASTED, COMPLETE AS PER ATTACHED REFENCE DWG NO. TK-0199, CONTRACT NO. R01-T08-P830.



HEEL BLOCK ASSEMBLY (MAINLINE)

SCALE: 1 1/2" = 1'-0"

NOTES:

1. FOR ADDITIONAL DETAILS, SEE DWG. NO.(S) TK-1280, TK-1332 AND TK-1282.
2. JOINTS AT ENDS OF STOCK RAILS ARE BONDED JOINTS UNLESS BONDED INSULATED JOINTS ARE SHOWN ON SPECIFIC LOCATIONS ON TRACK CHARTS.

BID DOCUMENTS

0 1 2 3
3/4" = 1'-0" GRAPHIC SCALE

0
1 1/2" = 1'-0" GRAPHIC SCALE

ISSUED FOR BID

DESCRIPTION | BY | SUP. | APP.

Information confidential: all plans, drawings, specifications, and/or information furnished herewith shall remain the property of the Los Angeles County Transportation Commission shall be held confidential; and shall not be used for any purpose not provided for in agreements with the Los Angeles County Transportation Commission.

DESIGNED BY J. L. Patterson
DRAWN BY Raymond Ley
CHECKED BY D. Diules
APPROVED BY
DATE 03/27/87

REGISTERED PROFESSIONAL ENGINEER WAYNE K. SAN FILIPPO No. 19837 EXP. 3/31/89 CIVIL STATE OF CALIFORNIA

LOS ANGELES COUNTY TRANSPORTATION COMMISSION
The Long Beach-Los Angeles Rail Transit Project

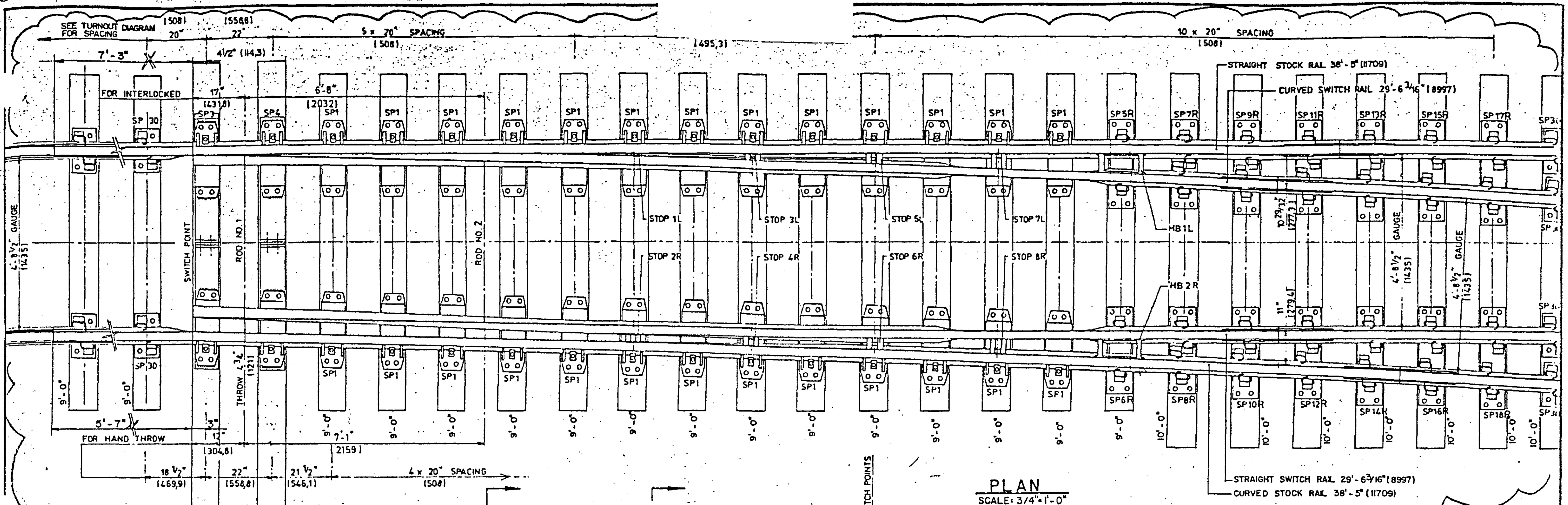
DMJM

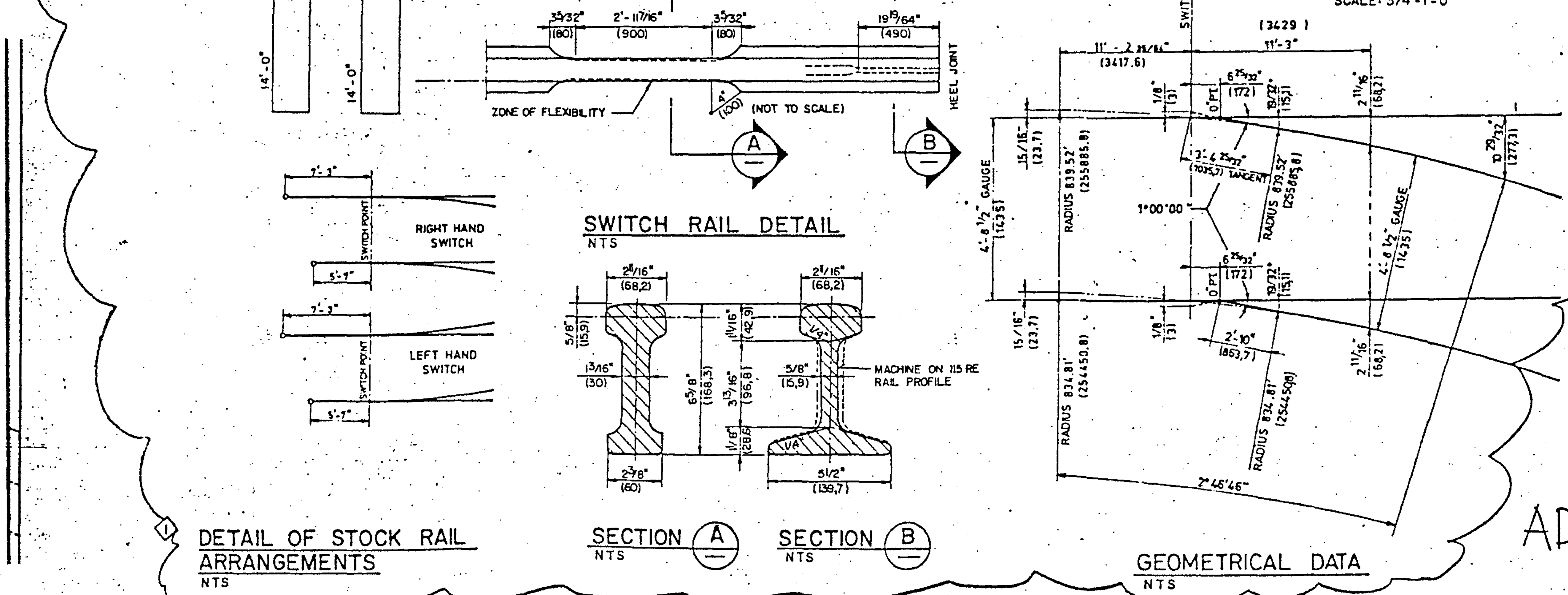
SUBMITTED: Wayne K. San Filippo

Southern California Rail Consultants
A Joint Venture of
Parsons Brinckerhoff Quade & Douglas, Inc.
Kaiser Engineers (California) Corporation
Daniel, Mann, Johnson & Mendenhall
APPROVED:

LRT TRACKWORK INSTALLATION
NO. 10 LATERAL SWITCH
BALLASTED

CONTRACT NO. R01-T08-C258
DRAWING NO. TK-1281
REV.
SHEET NO. 97
SCALE AS NOTED





NOTES:

1. FOR ADDITIONAL DETAILS, SEE DWG. NO.(S) TK-1280, TK-1332 AND TK-1282
2. JOINTS AT ENDS OF STOCK RAILS ARE BONDED JOINTS UNLESS BONDED INSULATED JOINTS ARE SHOWN ON SPECIFIC LOCATIONS ON TRACK CHARTS

BILL OF MATERIAL
(FURNISHED BY LACTC)

QTY	DESCRIPTION
1 EA	410' RADIUS EQUILATERAL SWITCH BALLASTED, COMPLETE AS PER SHOP DWG NO 6-132-6001, CONTRACT NO R01-T08-P830.

3/4" = 1'-0" GRAPHIC SCALE

ADDENDUM NO. 1

7/1/87 ADDENDUM 1 GENERAL REVISIONS AS PER SHOP DWG.
ISSUED FOR BID

DESIGNED BY J. L. Patterson
DRAWN BY
CHECKED BY
APPROVED BY
DATE

No. 19837 Exp. 3/30/89

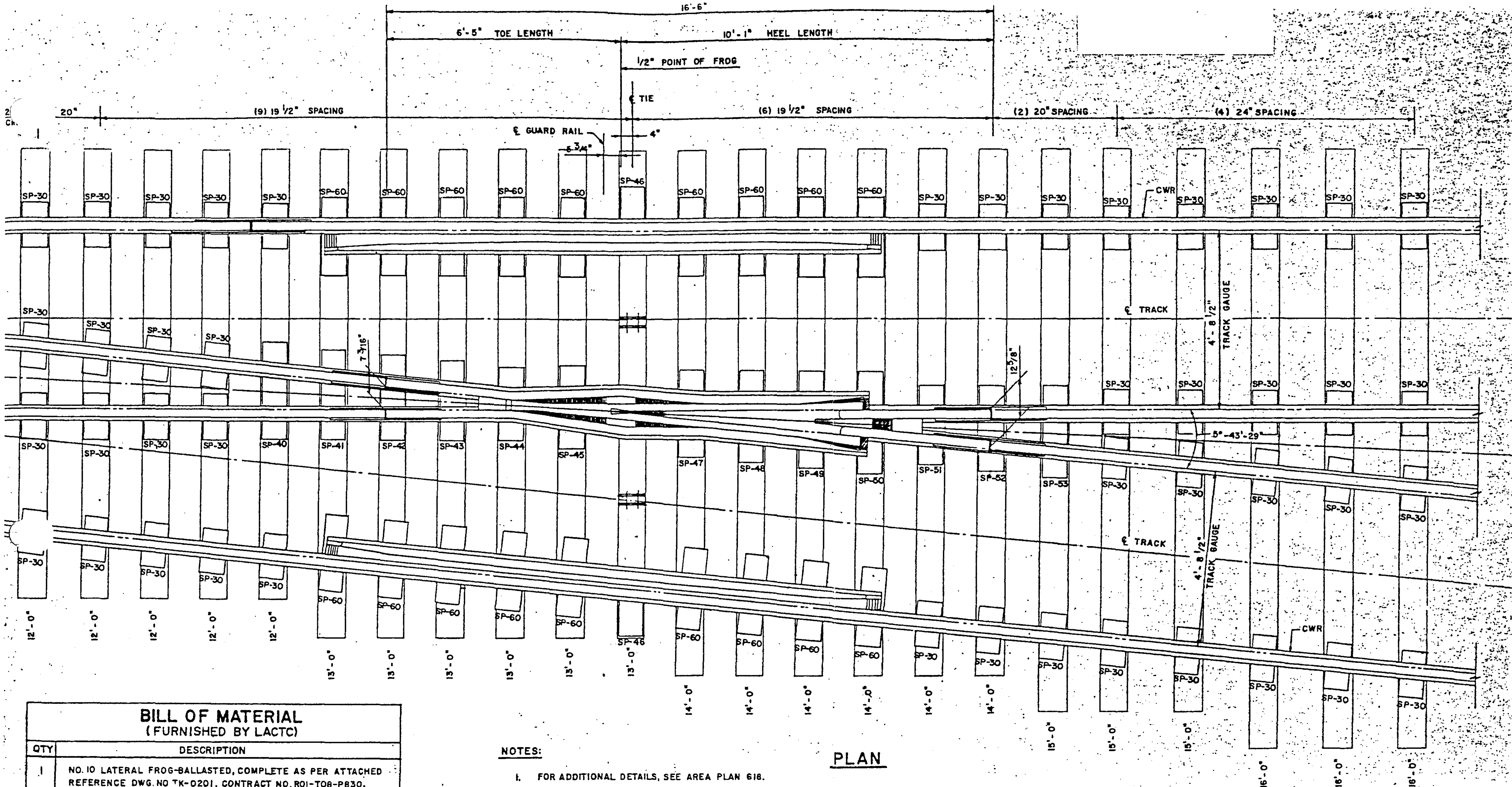
LOS ANGELES COUNTY TRANSPORTATION COMMISSION
The Long Beach-Los Angeles Rail Transit Project

DMJM

Southern California Rail Consultants
A Joint Venture of
Parsons Brinckerhoff Quade & Douglas Inc
Kaiser Engineers (California) Corporation
Daniel Mann Johnson & Mendenhall

LRT TRACKWORK INSTALLATION
NO. 10 LATERAL SWITCH
BALLASTED

CONTRACT NO. R01-T08-C25
DRAWING NO. TK-1281
REV. 1
SHEET NO. 97
SCALE AS NOTED



BILL OF MATERIAL
(FURNISHED BY LACTC)

QTY	DESCRIPTION
1	NO. 10 LATERAL FROG-BALLASTED, COMPLETE AS PER ATTACHED REFERENCE DWG. NO TK-0201, CONTRACT NO. R01-T08-P830.

PLAN

NOTES:

1. FOR ADDITIONAL DETAILS, SEE AREA PLAN 618.
2. FOR GUARD RAIL DETAILS, SEE DWG. NO. TK-1332
3. DETAIL SHOWN IS FOR RIGHT HAND TURNOUT. A LEFT HAND FROG IS OF OPPOSITE CONSTRUCTION.
4. TIE SPACINGS AND LENGTHS VARY AT CROSSOVERS.
5. FOR GENERAL NOTES SEE DWG NO. G1-1224.

BID DOCUMENT

1 0 1 2 3
3/4" = 1'-0" GRAPHIC SCALE

SUED FOR BID

DESCRIPTION | BY | APP.

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DESIGNED BY J. L. Patterson
DRAWN BY
CHECKED BY
APPROVED BY
DATE 03/27/87

REGISTERED PROFESSIONAL ENGINEER WAYNE K. SAN FILIPPO No. 19837 EXP. 3/30/89 CIVIL STATE OF CALIFORNIA

LOS ANGELES COUNTY TRANSPORTATION COMMISSION
The Long Beach-Los Angeles Rail Transit Project
LACTC

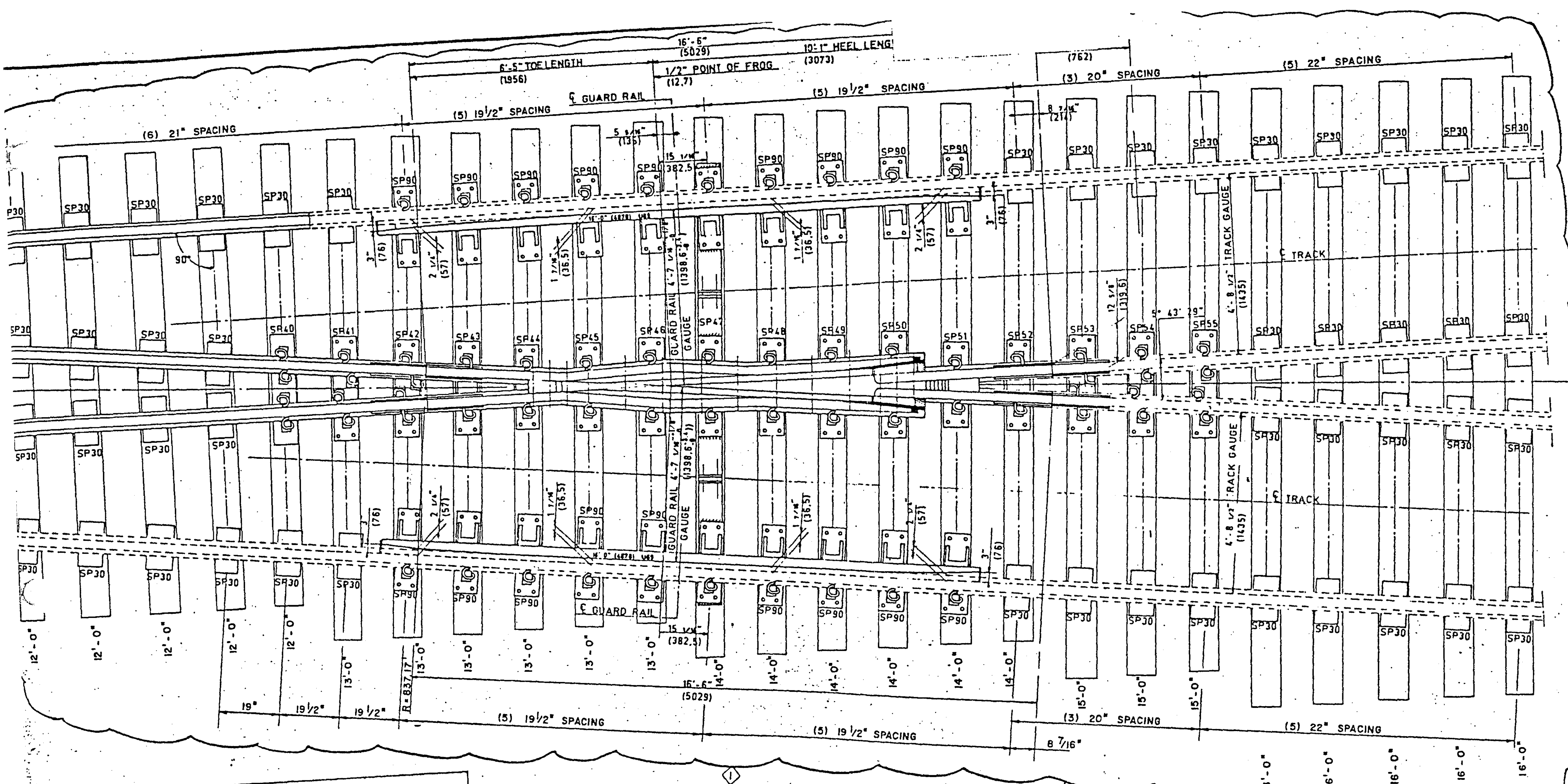
DMJM

SUBMITTED: Wayne K. San Filippo

Southern California Rail Consultants
A Joint Venture of
■ Parsons Brinckerhoff Quade & Douglas, Inc.
■ Kaiser Engineers (California) Corporation
■ Daniel, Mann, Johnson, & Mendenhall
APPROVED:

LRT TRACKWORK INSTALLATION
NO. 10 LATERAL FROG
BALLASTED

CONTRACT NO. R01-T08-C258
DRAWING NO. TK-1282
REV.
SHEET NO. 98
SCALE 3/4" = 1'-0"



PLAN

BILL OF MATERIAL (FURNISHED BY LACTC)	
QTY	DESCRIPTION
1	NO 10 LATERAL FROG-BALLASTED, COMPLETE AS PER SHOP DWG. NO 6-170-6013 CONTRACT NO. R01-T08-P830.

NOTES:

1. FOR ADDITIONAL DETAILS, SEE AREA PLAN 618.
2. FOR GUARD RAIL DETAILS, SEE SHOP DWG NO 6-378-6004
3. DETAIL SHOWN IS FOR RIGHT HAND TURNOUT. A LEFT HAND FROG IS OF OPPOSITE CONSTRUCTION.
4. TIE SPACINGS AND LENGTHS VARY AT CROSSOVERS.
5. FOR GENERAL NOTES SEE DWG NO. G1-1224.

ADDENDUM NO. 1

GRAPHIC SCALE 3/4" = 1'-0"

LOS ANGELES COUNTY TRANSPORTATION COMMISSION
The Long Beach-Los Angeles Rail Transit Project

Southern California Rail Consultants

DMJM

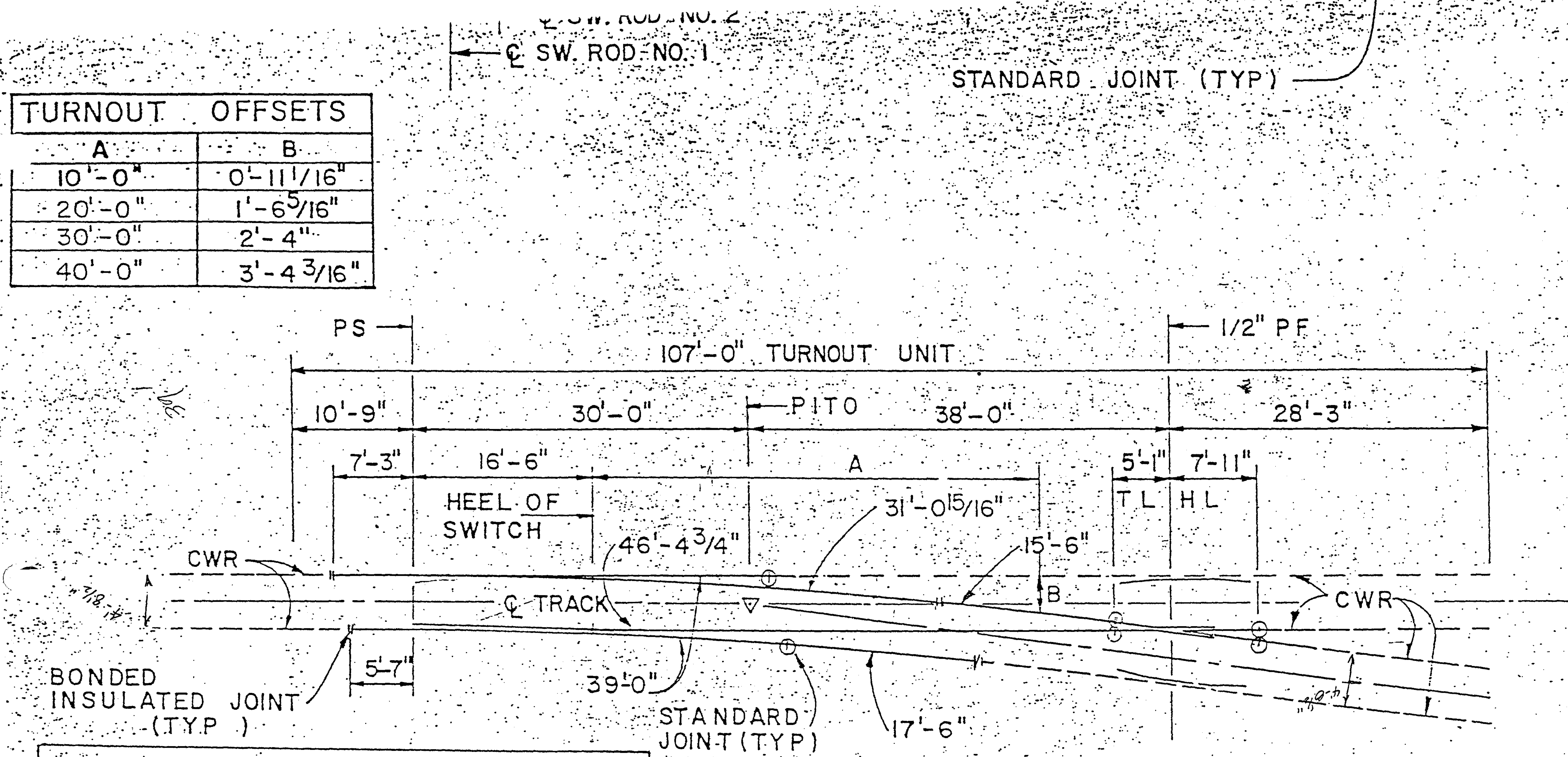
LRT TRACKWORK INSTALLATION
NO. 10 LATERAL FROG
BALLASTED

CONTRACT NO R01-T08-C256
DRAWING NO. TK-1282
REV. 1
SHEET NO. 98
SCALE 3/4" = 1'-0"

DESIGNED BY J.L. Patterson
DRAWN BY
CHECKED BY
APPROVED BY
DATE 3/27/87

1 ADDENDUM 1 REVISED AS PER SHOP DWG
0 ISSUED FOR BID

TURNOUT	OFFSETS
A	B
10'-0"	0'-11 1/16"
20'-0"	1'-6 5/16"
30'-0"	2'-4"
40'-0"	3'-4 3/16"



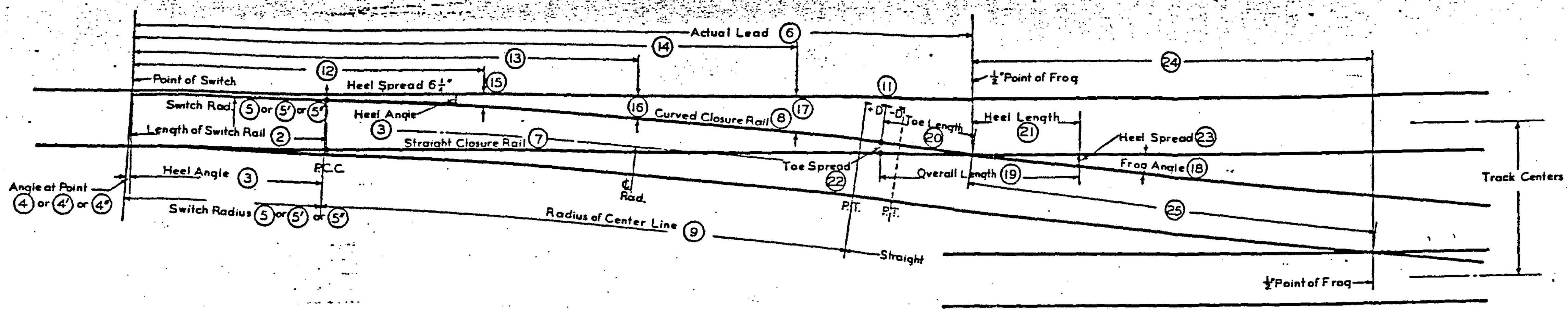
TURNOUT DATA		
FROG	NUMBER	8
	ANGLE	7°-09'-10"
	TOE LENGTH	5'-1"
	HEEL LENGTH	7'-11"
	TOTAL LENGTH	13'-0"
	TOE SPREAD	7 1/8"
	HEEL SPREAD	12 3/8"
[SWI]TCH	LENGTH OF SWITCH RAIL	16'-6"
	THICKNESS OF POINT	0"
	HEEL ANGLE	[illegible]

RAIL LAYOUT DIAGRAM

SCALE: 3/32"=1'-0"

SC.

SEE



NOTES

1. TURNOUTS AND CROSSOVERS RECOMMENDED

   For main line high speed movements, No. 16 or No. 20. For main line slow speed movements, No. 12 or No. 10. For yards and sidings, to meet general conditions, No. 8.

2. The data shown are computed for turnouts out of straight standard 4'8½" gage track. If the wheel base of the equipment used requires wider gage for the switch alinement or curvatures shown, the lead and the alinement of curved closure rail shall be maintained, and inside stock and curved rails shall be moved out the necessary amount. The gage of straight track through switch will then be increased, and the straight closure rail shall be bent to true alinement in advance of toe of frog.

3. FROG DESIGNS

   For short spring rail type frogs, the straight closure, and for solid manganese frogs, the straight and curved closures, shall be lengthened to conform.

4. MODIFICATION OF ALINEMENT

   The alinement shown in columns (4") and (5") is for use with ¼" switch points alternate Detail 4000.

5. For length of closure rails, see Plan Basic No. 921.

6. For bills of timber for various turnouts and crossovers see Plan Basic No. 912.

7. For permissible speeds see A.R.E.A. Manual Chapter 5.

TURNOUT AND CROSSOVER DATA

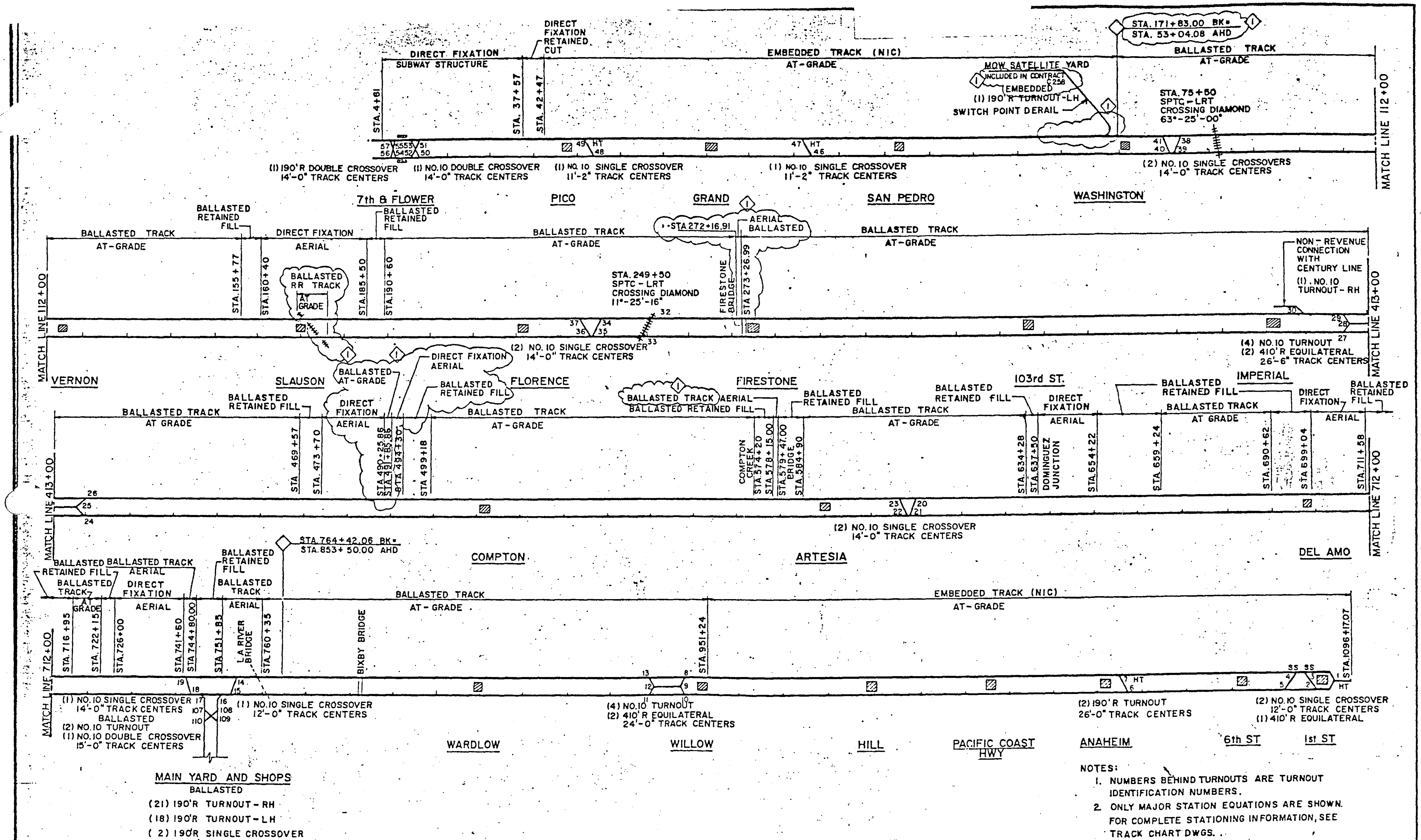
Col. 1 Frog No.	Properties of Curved Switches: Col. 2 Length of Switch Rail (Ft. In.)	Col. 3 Heel Angle (DegMinSec)	Col. 4 Point 0" Thick Angle at Point Pt. Detail No. 5100 (DgMnSc)	Col. 5 Switch Radius Pt. Detail No. 5100 (Feet)	Col. 4' Point ⅛" Thick Angle at Point Pt. Detail No. 5100 (DegMinSec)	Col. 5' Switch Radius Pt. Detail No. 8000 (Feet)	Col. 4" Point ¼" Thick Angle at Point Pt. Detail No. 4000 (DegMinSec)	Col. 5" Switch Radius Pt. Detail No. 4000 (Feet)	Col. 6 Actual Lead (Ft. In.)	Closure Distance: Col. 7 Straight Closure Rail (Ft. In.)	Closure Distance: Col. 8 Curved Closure Rail (Ft. In.)	Lead Curve: Col. 9 Radius of Center Line (Feet)	Lead Curve: Col. 10 Degree of Curve (DegMinSec)	Col. 11 Distance D (Feet)	Gage Line Offsets: Col. 12 (Ft. In.)	Gage Line Offsets: Col. 13 (Ft. In.)	Gage Line Offsets: Col. 14 (Ft. In.)	Gage Line Offsets: Col. 15 (Inches)	Gage Line Offsets: Col. 16 (Inches)	Gage Line Offsets: Col. 17 (Ft. In.)	Col. 1 Frog Number	Properties of Frogs: Col. 18 Frog Angle (DegMinSec)	Properties of Frogs: Col. 19 Overall Length (Ft. In.)	Properties of Frogs: Col. 20 Toe Length (Ft. In.)	Properties of Frogs: Col. 21 Heel Length (Ft. In.)	Properties of Frogs: Col. 22 Toe Spread (Inches)	Properties of Frogs: Col. 23 Heel Spread (Inches)	Data for Crossover, 13'-0" Track Centers: Col. 24 Straight Track (Ft. In.)	Data for Crossover, 13'-0" Track Centers: Col. 25 Crossover Track (Ft. In.)	For change of 1'-0" in Track Centers: Straight Track (Ft. In.)	For change of 1'-0" in Track Centers: Crossover Track (Ft. In.)
5	13-0	2-54-00	1-41-31	616.55	1-36-00	572.96	1-30-30	535.22	44-6 1/2	28-0	28-3 1/8	188.10	30-49-49	0.00	20-0	27-0	34-0	12 1/16	21	2-9 1/8	5	11-25-16	9-0	3-6 1/2	5-5 1/2	7 15/16	13 9/16	16-10 5/16	18-1 7/8	4-11 7/16	5-0 5/8
6	13-0	2-54-00	1-41-31	616.55	1-36-00	572.96	1-30-30	535.22	49-9	33-0	33-3 1/4	283.88	20-17-20	+0.17	21-3	29-6	37-9	12 11/16	22 1/16	2-10 1/4	6	9-31-38	10-0	3-9	6-3	7	13	20-5 1/2	21-6 1/2	5-11 1/2	6-0 1/2
7	13-0	2-54-00	1-41-31	616.55	1-36-00	572.96	1-30-30	535.22	54-8 1/2	37-0	37-2 5/8	409.77	14-01-02	-0.68	22-0	31-0	40-0	12 15/16	21 15/16	2-9 3/4	7	8-10-16	12-0	4-8 1/2	7-3 1/2	7 9/16	13	24-0 3/8	24-11 5/8	6-11 9/16	7-0 7/16
8	13-0	2-54-00	1-41-31	616.55	1-36-00	572.96	1-30-30	535.22	58-11 5/8	40-10 5/8	41-0 5/8	550.75	10-25-03	0.00	23-3	33-6	43-9	13 1/4	23 5/16	2-11 5/16	8	7-09-10	13-0	5-1	7-11	7 1/8	12 3/8	27-7 1/8	28-4 7/8	7-11 5/8	8-0 3/8
9	19-6	1-59-15	1-04-24	1222.17	1-00-45	1145.92	0-57-04	1078.04	74-1 1/2	48-2 3/4	48-5	632.15	9-04-23	0.00	31-6	43-6	55-6	12 3/8	21 3/16	2-9 3/16	9	6-21-35	16-0	6-4 1/2	9-7 1/2	8	13 5/16	31-1 5/8	31-10 3/8	8-11 11/16	9-0 5/16
10	19-6	1-59-15	1-04-24	1222.17	1-00-45	1145.92	0-57-04	1078.04	78-11	53-0	53-2	806.09	7-06-45	+0.44	32-9	46-0	59-3	13 1/16	22 1/2	2-10 3/16	10	5-43-29	16-6	6-5	10-1	7 3/16	12 5/8	34-8 1/8	35-3 7/8	9-11 11/16	10-0 5/16
11	19-6	1-59-15	1-04-24	1222.17	1-00-45	1145.92	0-57-04	1078.04	83-6	57-0	57-1 7/8	1009.34	5-40-44	+0.34	33-9	48-0	62-3	13 3/8	22 13/16	2-10 15/16	11	5-12-18	18-8 1/2	7-0	11-8 1/2	7 1/8	13 1/4	38-2 1/2	38-9 1/2	10-11 3/4	11-0 1/4
12	19-6	1-59-15	1-04-24	1222.17	1-00-45	1145.92	0-57-04	1078.04	87-3 1/2	60-0	60-1 1/4	1205.02	4-45-22	+1.47	34-6	49-6	64-6	13 3/8	23 1/4	2-11 1/8	12	4-46-19	20-4	7-9 1/2	12-6 1/2	7 5/16	13 1/16	41-8 3/4	42-3 1/4	11-11 3/4	12-0 1/4
14	26-0	1-27-00	0-50-44	2464.55	0-48-00	2291.83	0-45-14	2140.01	108-7 1/2	74-0	74-1 1/2	1576.40	3-38-07	+1.36	44-6	63-0	81-6	13 1/8	22 1/8	2-10 1/4	14	4-05-27	23-7	8-7 1/2	14-11 1/2	6 7/8	13 5/16	48-9 1/4	49-2 13/16	13-11 13/16	14-0 1/4
15	26-0	-1-27-00	0-50-44	2464.55	0-48-00	2291.83	0-45-14	2140.01	113-5	78-0	78-1 3/4	1872.90	3-03-34	+0.60	45-6	65-0	84-6	13 3/8	23	2-11	15	3-49-06	24-4 1/2	9-5	14-11 1/2	7	12 7/16	52-3 7/16	52-8 5/8	14-11 13/16	15-0 3/16
16	26-0	1-27-00	0-50-44	2464.55	0-48-00	2291.83	0-45-14	2140.01	118-5	83-0	83-1 1/4	2240.84	2-33-26	-0.27	46-9	67-6	88-3	13 11/16	23 1/2	2-11 3/16	16	3-34-47	26-0	9-5	16-7	6 9/16	12 15/16	55-9 5/8	56-2 1/2	15-11 13/16	16-0 3/16
18	39-0	1-04-30	0-27-19	3605.70	0-25-30	3437.74	0-23-39	3282.02	147-0 1/2	97-0	97-1 7/8	2622.45	2-11-06	+0.56	63-3	87-6	111-9	13 1/16	22 3/4	2-10 3/4	18	3-10-56	29-3	11-0 1/2	18-2 1/2	6 7/8	12 5/8	62-9 7/8	63-2 3/16	17-11 13/16	18-0 3/16
20	39-0	1-04-30	0-27-19	3605.70	0-25-30	3437.74	0-23-39	3282.02	156-0 1/2	106-0	106-1	3329.91	1-43-15	+2.03	65-6	92-0	118-6	13 1/2	23 1/4	2-11 3/16	20	2-51-51	30-10 1/2	11-0 1/2	19-10	6 1/8	12 3/8	69-10	70-2	19-11 7/8	20-0 1/8

American Railway Engineering Association

TURNOUT AND CROSSOVER DATA FOR CURVED SPLIT SWITCHES

PLAN NO. **920-51**

opted March 1951. Revision of Plan No. 920-41.



NOTES:

1. NUMBERS BEHIND TURNOUTS ARE TURNOUT IDENTIFICATION NUMBERS.
2. ONLY MAJOR STATION EQUATIONS ARE SHOWN. FOR COMPLETE STATIONING INFORMATION, SEE TRACK CHART DWGS.

2	9/87	ADDENDUM NO. 1 - ADD SPTC TRACK, ELIMINATE MOW TRACK. REVISE DESCRIPTION.	32
	6/87	ISSUED FOR BID	
	DATE	DESCRIPTION	BY / APP

DESIGNED BY / DRAWN BY / CHECKED BY D. Steeley / APPROVED BY / DATE 03/27/87

REGISTERED PROFESSIONAL ENGINEER WAYNE K. SAN FILIPPO No. 19837 CIVIL STATE OF CALIFORNIA

LOS ANGELES COUNTY TRANSPORTATION COMMISSION
The Long Beach-Los Angeles Rail Transit Project

DMJM

SUBMITTED:

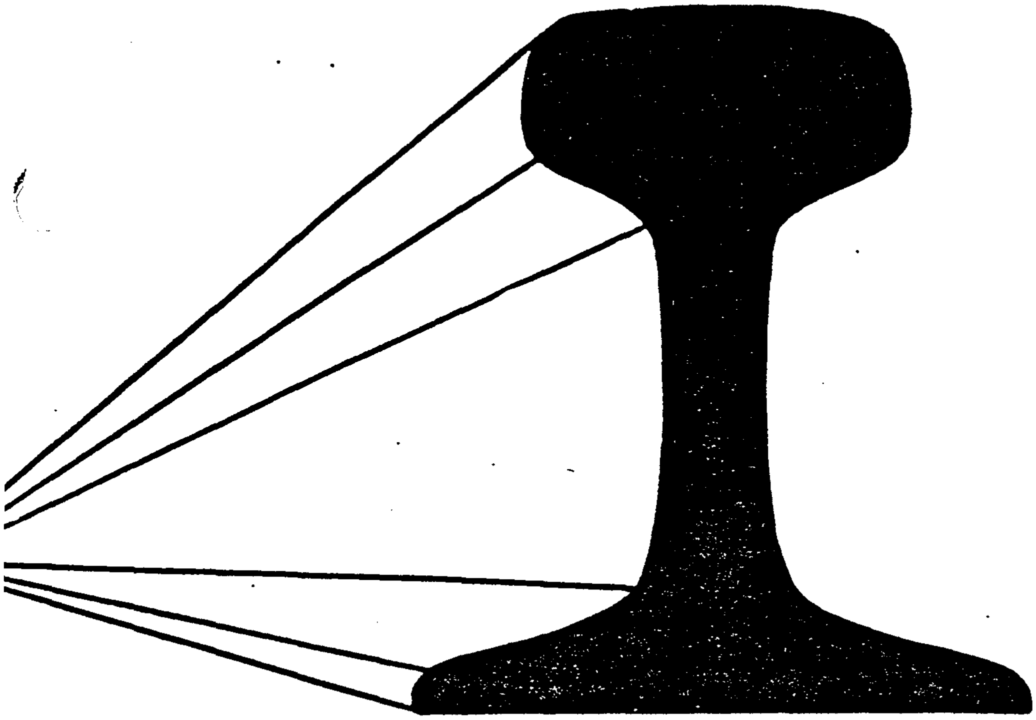
Southern California Rail Consultants

APPROVED:

LRT TRACKWORK INSTALLATION

MAINLINE SCHEMATIC

CONTRACT NO R01-T08-C258
DRAWING NO TK-1223
REV 1
SHEET NO 54
SCALE NOT TO SCALE



TRACK FOREMAN'S TRAINING PROGRAM

LESSON 15

RAILROAD-HIGHWAY GRADE CROSSINGS

The Railway Educational Bureau
1809 Capitol Ave., Omaha, Nebraska 68102

LESSON 15

RAILROAD-HIGHWAY GRADE CROSSINGS

Whenever the alinement of a railroad and a highway, street, road or other route for motorized or foot traffic intersect, one of three situations will exist. The highway may be located above the railroad on some type of bridge structure. The highway may pass under the railroad, requiring a bridge to support the track or tracks. These arrangements are known as grade separations. If no grade separation is provided, a grade crossing is necessary.

Sometimes, the natural terrain lends itself to a grade separation. At other locations, grade separations have been constructed because either rail or highway traffic conditions, or both, have made the existence of a grade crossing sufficiently undesirable to justify the cost of the grade separation.

Grade crossings are unpopular with many groups with varying interests. Maintenance of Way personnel are all too aware that they are expensive to maintain, that they are an obstruction within the basic design of a track structure interfering with the smooth flow of various maintenance operations, and a frequent cause of complaints.

Railroad operating personnel know that grade crossings represent a potential hazard. The vehicle that stalls on a crossing when there is an approaching train, or the motorist who attempts to race a train to a crossing create frightening images. When crossings exist where shifting operations are performed, the need to clear crossings for the passage of highway traffic every few minutes can seriously hamper train operations.

The traveling public is frequently annoyed by crossings which ride roughly. Delays which they encounter for the passage of trains can be another irritant. Occasionally, nearby residents are irked by such things as the blowing of whistles, traffic congestion or vibrations caused by traffic passing over a crossing.

Political and law enforcement agencies become involved in various controversies over conditions at grade crossings. Frequently, the natural tendency is to press for solutions at someone else's expense.

Track forces generally have the basic responsibility for the maintenance of grade crossings. Where there is dissatisfaction with conditions at grade crossings, much of it becomes directed towards the track maintenance organization. Where track forces succeed in doing an outstanding job of maintaining crossings, this becomes expected as the norm.

Even though crossings create various unsatisfactory situations, they are necessary. Public conveniences require access routes across railroads. The alternative of providing grade separations invariably requires large funds. Unless a grade crossing creates serious problems, such expenditures can seldom be justified.

In view of the foregoing, it should be apparent that if grade crossings are neglected, serious problems may develop. Making repairs to one or two crossings, on short notice, may not be an overwhelming project; but if there is a tendency to neglect grade crossings in general, the day may come when the size of the job which must be done will be a great burden.

There are various things which a Track Foreman can do to keep this phase of maintenance under control. One is to develop a sense of awareness of developing defects. and to correct small problems before they become large problems. Another is to perform crossing maintenance in a manner that will provide lasting results.

TRACK FORCES' RESPONSIBILITY

Although local, state and federal government monies are currently available for grade crossing work, maintenance of the road surface and track structure is generally performed by track forces. On some railroads, this responsibility is assigned exclusively to track forces. Elsewhere, bridge and building forces have partial responsibility.

If automatic crossing protection is provided, signal forces will have responsibilities, but track forces will usually maintain the insulated joints. If crossing watchmen are assigned, they will usually be under the jurisdiction of a Track Foreman. Track forces will also be charged with maintaining visibility at crossings, by controlling the growth of vegetation. With these important and varied duties, the Track Foreman is the key employee in the maintenance of his company's grade crossings.

MAINTAINING THE TRACK

Basic to the maintenance of any grade crossing, is the necessity of keeping the track in an adequate condition.

This, includes meeting the demands of the rail traffic, which operates on the track, as well as providing sufficient support for the roadway which is placed upon it. One of the greatest obstacles to maintaining track in a crossing is its inaccessibility. Most repairs to the track cannot be made until at least a portion of the roadway is removed. Surfacing track, renewing defective ties, eliminating a water pocket, replacing a defective rail, correcting gage -- all require removal of varying portions of the paving.

Crossings present a number of drainage problems. Runoff of water from the paved surfaces frequently finds its way in the track structure adjacent to the rails. A descending highway grade towards the railroad frequently includes ditches discharging drainage onto the roadbed. Water, which is directed towards a railroad from highways and their ditches usually includes sizable amounts of foreign materials, causing serious fouling of ballast. Because the ballast and sub-ballast are covered, they do not dry out readily. Much deterioration of track structures in grade crossings can be traced to lack of drainage.

The impact of highway traffic can cause deterioration of the track. This is particularly true if the rail heads are higher than the adjacent road surface and if heavy truck traffic is present.

Grade crossings are sometimes the obstacle that restrains a general tendency for rail to creep. This can create line kinks adjacent to the crossing. Occasionally, there is a creepage of the highway paving which causes the track to move laterally.

MAINTAINING THE HIGHWAY

Various types of construction are used for the highway surfaces within the limits of grade crossings. Riding quality for highway traffic is but one of the factors in the decision as to type. Economic considerations and relation to the track structure must be considered.

Regardless of the type of construction used, the track structure will serve as a foundation for the highway surface. Ballasted track is a flexible structure. Some deflection will occur under load. If the type of construction is to prove satisfactory over reasonable periods of time, it must be capable of withstanding normal flexing of the track structure under rail traffic. An alternative is to substitute a non-flexible foundation in place of the ballast. In many situations, this is not acceptable from a track standpoint.

The requirements for durability of the wearing surface are subject to wide variation. Major factors are the density and load characteristics of the highway traffic. Climatic conditions can also be important.

The impact caused by highway traffic will have a major effect on the life of a crossing. From this standpoint, traffic speeds as well as density and loads are important. A worn or rough surface increases the impact received from traffic. The amount of exposure of the rails because of flangeways or worn highway surfaces will be an important element in the severity of the impact forces.

The highway profile at a crossing can cause poor riding qualities. If the grade of the highway is level and it crosses a single level track, this is not a problem. If there are two tracks and they are not at the same elevation, there will be an irregular profile, and the ride will be adversely affected.

If there is a single track with superelevation, and the highway grade does not conform to this slope, there will be an irregular profile. Should there be multiple tracks with superelevation, not in the same plane, a sawtooth pattern will result.

From a highway standpoint, it is much more difficult to maintain a good riding condition within a grade crossing than on a conventional roadbed. The maintenance of track within a crossing also presents major problems not present in open track. Sometimes, the demands of the two modes of service are not compatible, and a compromise is made which is not completely satisfactory.

SPOT MAINTENANCE OF TRACKS

Except for the rail heads, the track structure within a crossing is normally covered. Direct observation of many kinds of track defects cannot be made unless the highway surface is removed. This is not done unless there is good cause for it.

Fortunately, that which can be determined can provide a good idea of the condition of the track materials. Rail defect detection equipment can identify most rail defects. Track surface, alinement and gage can all be determined without disturbing the crossing. These can provide important clues to the condition of ties, ballast and drainage. There may be rail joints within the crossing requiring attention. Track geometry observations or measurements can call attention to them.

There may be a suspected problem, such as the possibility of defective ties. This can usually be confirmed by removal of a small part of the crossing material such as a prefabricated panel or a timber plank to permit inspection.

The amount of difficulty that will be encountered in making spot repairs to the track structure within a crossing will depend upon the type of construction used for the road surface. If a crossing is paved with bituminous material, this must be removed and replaced with new material, in whatever area of the crossing is to be worked. If a rail is to be replaced, the paving must be dug out along the rail for the full length of the rail. If a line of timber headers is used on each side of the rails, removal of one line of timber is usually enough to permit replacement of the rail. If only one portion of a crossing requires spot surfacing, it is easier to remove and restore prefabricated panels than bituminous paving.

SPOT MAINTENANCE OF PAVING

Many crossings are paved with bituminous material the full width (from one end of the ties to the other). This results in paving being packed against the rails. If there is a good track foundation, this may work reasonably well provided there is light traffic, particularly rail traffic. Flexing of the rails under load tends to break up the paving material adjacent to it. After small pieces of paving break out close to the rail, highway traffic will tend to break out bigger chunks.

There are several factors that will determine the effectiveness of patching bituminous paving. A good bond between the new material and the old material against which it is placed is essential. Loose material should be removed from the surfaces against which the paving is to be placed. There must not be any moisture on the surfaces to be paved. Compaction is another necessity. If a roller or mechanical compactor cannot be made available, the new material should at least be compacted with truck wheels.

Even with these precautions, the effectiveness of bituminous patching will depend on the stability of the track structure, drainage and the severity of freezing conditions. All too often, the conditions which first caused deterioration of the paving will still be present to break up the paving again. This is one reason why other types of crossing surfaces are used.

SURFACING TRACK

When a general surfacing of a stretch of track is undertaken, it is usually desirable to surface the track through crossings as part of the job. There are times when crossings are skipped during such work. When this happens, it is usually because of the difficulty of opening the crossing. Poor track surface through the crossing frequently develops when it doesn't get the same routine maintenance as the rest of the track.

In order to surface track through a bituminous crossing, all of the paving must be removed from the crossing and replaced with new material. This is another limitation of the bituminous crossing. Mechanized equipment can be particularly effective in doing this work. Backhoes and Gradall type equipment are efficient in removing paving. Dump trucks can be used for disposing of the old paving and delivery of the new bituminous material. A roller is necessary for a good paving job.

A major advantage of most other types of crossings is that they can be removed readily in sections and replaced after work on the track is completed. Crossings, so constructed, are particularly desirable in important tracks that are resurfaced at regular intervals.

REPLACEMENT OF HIGHWAY SURFACE

Some crossings with severe highway traffic will require replacement of all or most of the highway surface while the track structure is still in basically good condition. If the ties, rails and drainage are good, there will be no need to rebuild the track through the crossing. While the crossing is open, care should be taken to correct any track surface irregularities and to tamp any loose ties. For a bituminous crossing, the procedure will be similar to that used in opening a crossing for resurfacing.

At times, the worn surfaces may be confined to a rather limited portion of the crossing. This can happen if there is an appreciable width for sidewalks and if the traffic tends to be restricted to well defined lanes. When this condition exists, it may only be necessary to replace the surface within the worn areas. If this happens in a bituminous crossing, with rows of timber next to the rails, replacement of only the worn timbers may be the best action. This can reduce impact against the rails. It can also provide the protection needed to restore the bituminous paving to its original surface.

If a panel type crossing has the wear restricted to limited areas, it may be good practice to reverse the positions of the worn and unworn panels. In this way, full usage of the entire set of panels can be obtained. Other crossings will have traffic wear patterns over most of the crossing width, and complete renewal of the highway surface will be needed when the surface becomes worn.

COMPLETE RENEWAL OF CROSSING

There are many instances where crossings deteriorate to the point where limited repairs are not adequate. Both the track structure and the highway surface may require complete replacement. There are various ways in which this kind of project can be progressed. The methods that should be used for a particular crossing are governed by conditions such as the extent of track usage that can be obtained, whether the road can be completely or partially closed and the types of equipment that can be made available.

Where the circumstances are such that the track must remain in service for rail traffic during the course of the crossing renewal, this will severely restrict the efficiency of the work. It is usually much more desirable to obtain exclusive use of track for several hours, even if some expense is incurred due to the detouring of trains. Should this not be practicable, the work can proceed under traffic, but productivity will be limited by this condition.

When rail traffic must be maintained, the usual procedure is to strip the crossing of the materials which form the highway surface, taking care to avoid disturbing the track structure. If panelized material is used, the fastenings are removed and the panels are lifted out. The same applies to timber planks, whether they are used only next to the rails in a bituminous crossing, or if they form the complete highway surface. Backhoe type equipment is useful for removing bituminous paving. Care must be exercised not to disturb the rails or ties when such equipment is used. It is also essential to comply with your railroad's regulations governing the fouling of tracks with construction equipment.

Once the crossing is stripped to the level of the tops of the ties (except for the rails) renewal of the track structure can begin. This discussion will be based on the complete replacement of rail, ties and ballast.

The replacement of ballast requires skeletonizing the cribs between the ties. This is usually done to a depth of a few inches below the bottom of the ties. Support must be maintained under the ties to carry the loads imposed by rail traffic. An opening should be made a sufficient distance beyond the ends of the ties, and to a greater depth, to promote drainage from the track area. These trenches should then be sloped so as to direct run-off towards the ends of the crossing. Some installations, where drainage is known to be a problem, are constructed with perforated pipe laid for the length of the crossing. These pipes are laid a few inches beyond the ends of the ties and below the bottoms of the ties. They must be sloped to carry water away from the crossing. Four inch diameter pipe is most commonly used.

The amount of track that can be skeletonized at one time will depend on the temperature, whether CWR is present and the speed of trains. It is desirable to replace ties while the adjacent cribs are empty. A decision will have to be made regarding the tie beds. If the old ties are not plate cut and if drainage is not a major problem, it may be decided to avoid disturbing the hard packed tie beds. Less settlement of the new track structure will take place if the old tie beds are preserved. On the other hand, if there is a muddy condition or if plate cut ties create a need for additional clearance to install new ties, these tie beds may be dug to the same level as the cribs before installing the new ties.

When new ties are in place, the cribs and shoulder areas that have been opened can be backfilled with new ballast. This will also permit the new ties to be tamped, as necessary. As one portion of the track within the crossing is backfilled, the process of skeletonizing and renewing ties can advance further through the crossing area. The best ballast materials available should be used within crossings. Since track within crossing is relatively inaccessible for resurfacing, the most durable materials should be used. Considerable effort is made in this kind of job to provide good drainage. Use of dirty ballast can do much to defeat this purpose.

At some point in the work, the rails will be replaced. It is desirable to do this before new ties are installed, so that the new ties will only have to be spiked once. There may be complications that make this difficult. If the tie plates are to be replaced or if the track gage must be corrected, badly plate cut or deteriorated ties may interfere with such work. When conditions such as this exist, it may be essential to renew ties before replacing the rails.

It is very desirable to avoid installing rail with rail joints within the limits of a crossing. It is also good practice to avoid all joints within a few feet of the ends of a crossing. Some railroads furnish extra length rails for crossings. 60 foot and 78 foot rails have been extensively used for this purpose. Another practice is to provide pieces of CWR of suitable length. Yet another alternative is to field weld joints within the crossing.

At crossings where automatic protection is provided, such as flashers or gates, there are insulated joints frequently located a short distance from the ends of the crossing. Your railroad may have standards for the location of such insulated joints. You should determine what your company's approved practice is. This may cover minimum and maximum distances from the crossing for these joints, as well as allowable stagger between joints in opposite rails. In many crossing installations, rails are provided of sufficient length so that the insulated joints are the first joints beyond the crossing.

The process of removing old ballast, renewing ties, and placing new ballast, together with replacement of the rails at an appropriate time, will be carried out until the entire crossing is worked. Frequently, badly fouled ballast is found in the track for a short distance beyond the ends of the crossing. This may be caused by the run-off of drainage from the highway which carries foreign materials into the ballast. It could also be due to pumping joints adjacent to the crossing. The ballast renewal process should be carried beyond the crossing to correct such conditions. Particular care should be taken to provide good ties and well-drained ballast under insulated joints.

After renewal of the track structure is completed, the track must be brought to proper surface with the rails at the desired elevation relative to the highway. This must be done before restoration of the highway surface within the crossing is begun. Once the desired track surface and alinement are obtained, it is good practice to allow rail traffic over the track so that any settlement can be corrected before restoring the highway surface.

The procedure for renewing the track structure within a crossing, which has just been described, requires a considerable amount of hand labor. Unfortunately, this general approach is necessary if track usage cannot be obtained for periods in excess of that which is required to replace the rails. One of the best labor saving systems available for this kind of project is an air compressor with appropriate tools. Pneumatic power can be used to break paving, to loosen ballast to be excavated, to drive spikes, to tamp ties and to compact ballast and paving. Excavating equipment, such as a backhoe, Speed Swing or Gradall with one or more dump trucks, is useful for disposing of paving, fouled ballast, scrap ties and crossing timbers, as well as handling new ballast, ties and paving. Either suitable hoisting equipment or adequate manpower will be needed for handling the rail.

REBUILDING TRACK BY THE PANEL METHOD

The length of time required to renew a grade crossing can usually be reduced substantially by using the panel method to renew the track structure within the crossing. The total requirement for labor can also be reduced. This approach can be used if exclusive use of track can be secured for a sufficient length of time and if adequate equipment can be made available. The track usage required will frequently amount to several hours except for small crossings.

If a panel type of highway surface is in place, this is removed prior to securing use of track. If there is a bituminous surface, the crossing is opened in advance just enough to permit removing one line of rail-holding spikes from each rail.

When track usage is secured, the first step is to remove the rails from the track through the crossing. With proper preparation this can be done quickly. Next, paving, ties and ballast are excavated. A good piece of equipment for this is a front-end loader. The type which is mounted on Caterpillar tracks will usually be more efficient for this type of work than the rubber tire type. When the crossing has been excavated to the desired depth, a well-graded subgrade surface can be provided which will promote drainage away from the crossing. This capability, together with the ability to provide a deeper bed of good ballast under the ties is another advantage of panel crossing construction.

Depending on the depth of ballast desired under the ties, some of the ballast may be placed and leveled before installing the track panel. If the track panel is laid directly on the subgrade, the ballast base is obtained by raising the track.

There are various ways in which track panels can be provided. Some crossings are short enough so that a panel constructed with standard 39 foot rails is adequate. Such a panel may be furnished from a central fabricating facility or local forces may construct it. Long crossings may require two or more panel sections. These can be set in individually and connected with joint bars. After the track has been brought to final grade, the joint bars can be removed and the rails joined by thermit welds. An alternative to this is to replace these rails with suitable lengths of CWR.

It is also possible to construct one long track panel for crossings of greater length. This is frequently done adjacent to the crossing. It can be done at the same time that the crossing is being excavated, since that job requires very little labor. A good way to do this is to set the ties across the rail heads, adjacent to one end of the crossing. This has two advantages. It provides a good surface for assembling the panel. The rail heads also make it easier to slide the panel into place. If ties are furnished with tie plates already attached at proper gage with plate-holding spikes and with holes for rail-holding spikes pre-bored, such a panel can be readily assembled. Some type of hoisting equipment will be needed for lifting the long rails onto such a panel. This equipment, together with the unit being used to excavate the crossing, serve as the means for moving the track panel into position in the crossing. If necessary, scrap rails can be laid on the bed of the crossing near the tie ends to facilitate sliding, and pulled out after the panel is in place.

Once the panel or panels are installed and connected to the track on each side of the crossing, ballast is placed and the track brought to proper surface. There is usually a greater depth of new ballast under the ties when this method is used, than when the track is reconstructed under traffic. This will provide better drainage of the track in the future, but initially more settlement of the track can be expected. It is usually desirable to allow rail traffic to consolidate the ballast at least overnight, then to correct any settlement, before working on the highway surface. Initially, a speed restriction on the track may be necessary.

The advantages of the panel method for this work are reduced labor requirements, greater productivity and improved drainage within the crossing. This approach must be well organized in advance, and proper equipment is essential. It is preferable that anyone who is inexperienced in this work undertake a shorter crossing as his first project with this method.

MAINTENANCE OF HIGHWAY TRAFFIC

At many locations, advance planning with local authorities will result in an arrangement for the detouring of highway traffic. You may have to arrange for barricades and lights at the crossing. Sometimes, railroad forces are asked to cooperate in the placement of detour signs.

Occasionally, a crossing cannot be completely closed to traffic. It might be necessary to rehabilitate half of the crossing at a time. This can be done whether the work is done by skeletonizing or panelling, although it will be less efficient than doing the entire job at once. Thermit welds can be used to eliminate rail joints at the center of the crossing.

BITUMINOUS PAVING

Some crossings are paved entirely with bituminous materials, with the flangeways either being cut by rail traffic or formed with boards such as 2 x 3s. In other crossings, rows of timber headers are placed next to the rails and fastened to the ties with drive spikes or lag screws. This may be done adjacent to the gage side of the rails only or next to both the gage side and field sides. Some crossings are constructed with rails being used instead of timbers adjacent to one or both sides of the running rails.

The depth of bituminous paving to be applied will depend on your own railroad's practice. Many railroads place ballast above the ties, then apply 3 or 4 inches of paving. Some railroads favor paving from the tops of the ties, particularly where severe highway traffic is anticipated. If ballast is placed above the ties, it is desirable to use a crushed material with sharp, angular edges. Difficulty is frequently experienced with stability if rounded gravel is used. Thorough compaction is necessary for a good job. This should start with the ballast cribs and shoulders. It is not desired to tamp so as to create center-bound track, but voids under the centers of the ties should be filled. A vibratory compactor can improve the consolidation of the ballast in the cribs and on the shoulders. Such a tool can also be useful in compacting paving, but a roller is recommended for the finished job.

Normally, a base course of paving will be placed first. After this is leveled and compacted, a finer top course is placed. This serves as the wearing surface as a sealer against the penetration of moisture. Placing excess material in anticipation of future settlement is not a good practice. This usually results in a rounded surface, being high along the center of the track, and low adjacent to the rails.

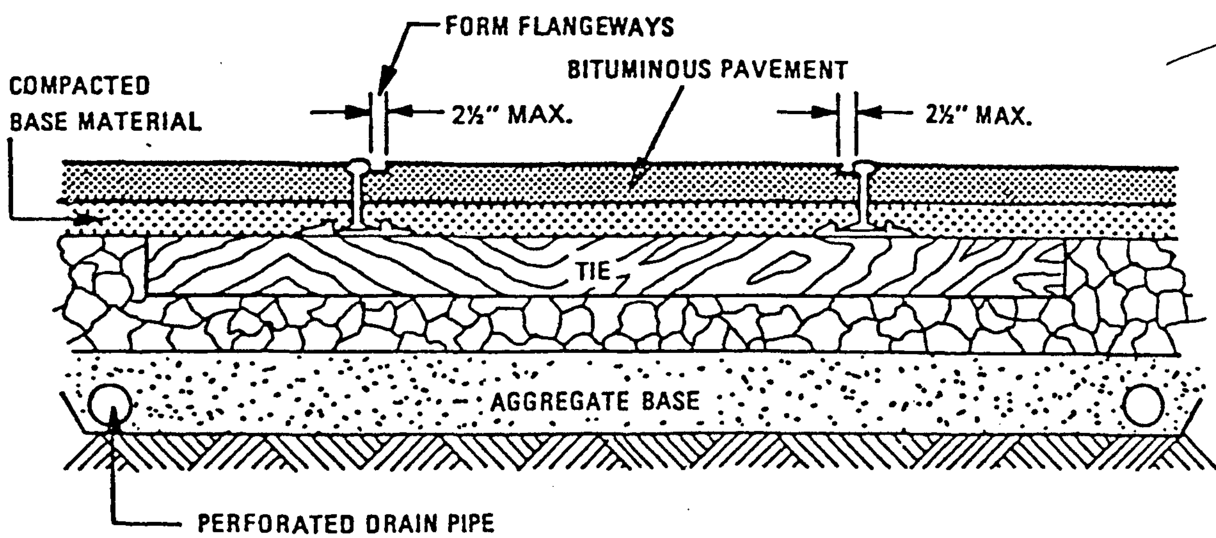
In many crossings where timbers or rails are installed next to the running rails, or where some type of panelized road surface is used, bituminous paving is placed in the openings adjacent to the running rails. This is to promote the flow of water draining from the road surface, towards the ends of the crossing. The amount of water which penetrates into the roadbed, within the crossing will be reduced.

NON-BITUMINOUS CROSSINGS

There are several types of construction used for crossings which don't involve bituminous surfaces. These will be described in the following portion of this lesson. Those which are fabricated as panelled sections are fastened to the cross ties. A major problem with such crossings is the tendency for the fasteners, usually drive spikes or lag screws, to work loose. In addition to permitting the panels to become loose, these fasteners sometimes become a hazard to highway traffic. Worn holes can be plugged, after which the fasteners can be reinstalled. When this is no longer effective, it may be desirable to shift the panels slightly or to make new holes through the panels, in order to get a firm hold in the ties.

TYPES OF CROSSING

A major advantage of the plain bituminous crossing is

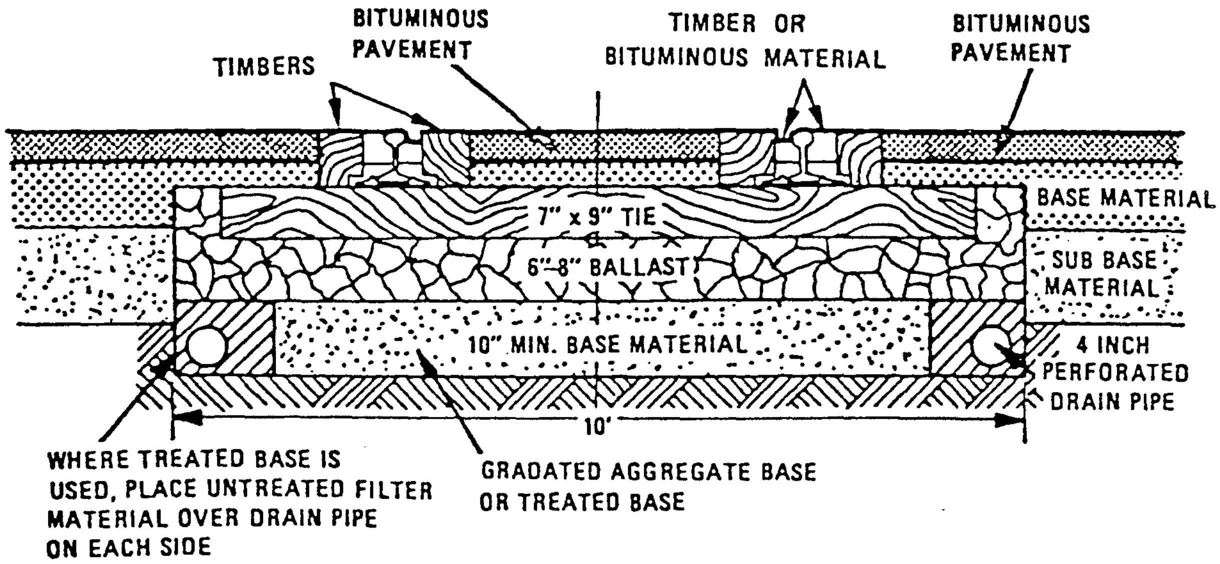


TYPICAL CROSS SECTION
THRU PLAIN BITUMINOUS CROSSING

its relatively low first cost. It serves well where there is comparatively light highway traffic, and where rail traffic does not require the track to be resurfaced at frequent intervals.

A disadvantage is that it must be completely removed and replaced when track is to be surfaced. Under heavier highway traffic, it will require frequent patching and tend to have a rough riding surface.

When timber headers are provided with a bituminous crossing, they will reduce the tendency for the edges of the bituminous paving to break out. This increases the durability of the crossing.

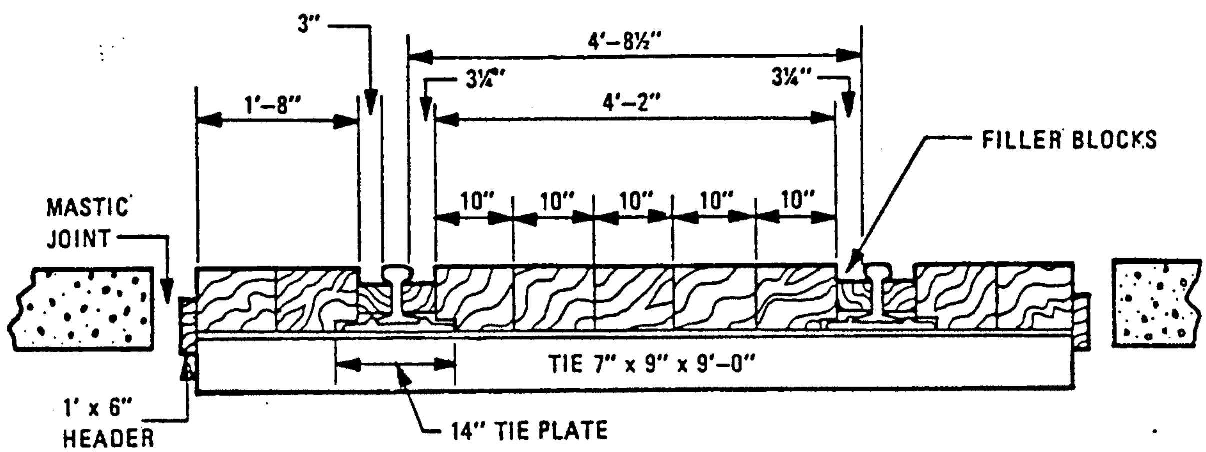


TYPICAL CROSS SECTION THRU BITUMINOUS CROSSING WITH TIMBER HEADERS

The cost of providing and installing the framed, treated timber, increases the cost of the crossing somewhat. The timbers, themselves, may become badly worn under heavy traffic and require replacement. They sometimes become unstable because of the need to cut away part of the base to provide clearance for tie plates and spikes. This crossing has the same disadvantage as the plain bituminous type when track must be surfaced.

GIRDER

If flange rails are provided with a bituminous crossing instead of timber headers, the problem of wear on the timber surfaces is eliminated. Other advantages and disadvantages remain the same. The lower diagram shows one method of placing the rails. Another method is to use Nelson rail chairs. These devices are welded to the tie plates to form a seat for the flange rail. These permit the flange rail, which is smaller than the running rail, to be installed in an upright position.

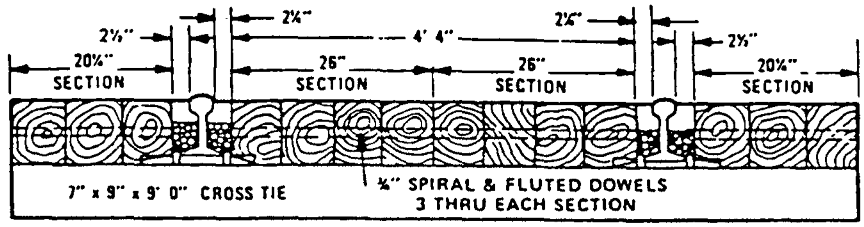


TYPICAL CROSS SECTION THRU FULL DEPTH TIMBER CROSSING

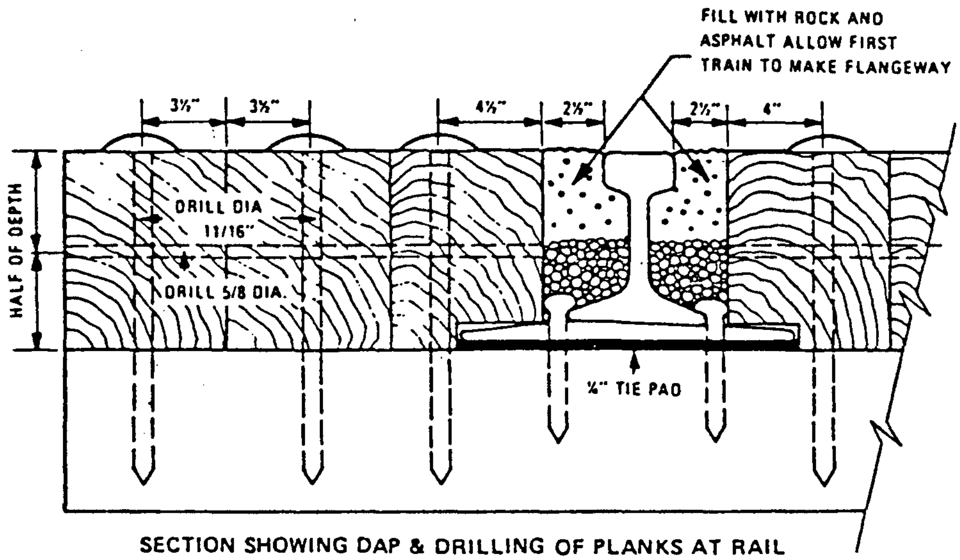
The timber plank crossing may be constructed of full-depth timbers to the tops of ties as shown here, or may consist of 4 inch thick planks laid upon shims which are laid on top of the ties. The individual planks in this crossing are not connected. Each plank is fastened to the ties separately.

The planks may be removed to permit surfacing, or other maintenance operations to be performed on the track, then reinstalled. Another advantage is that worn planks can be replaced separately, if only a small part of the crossing is deteriorating.

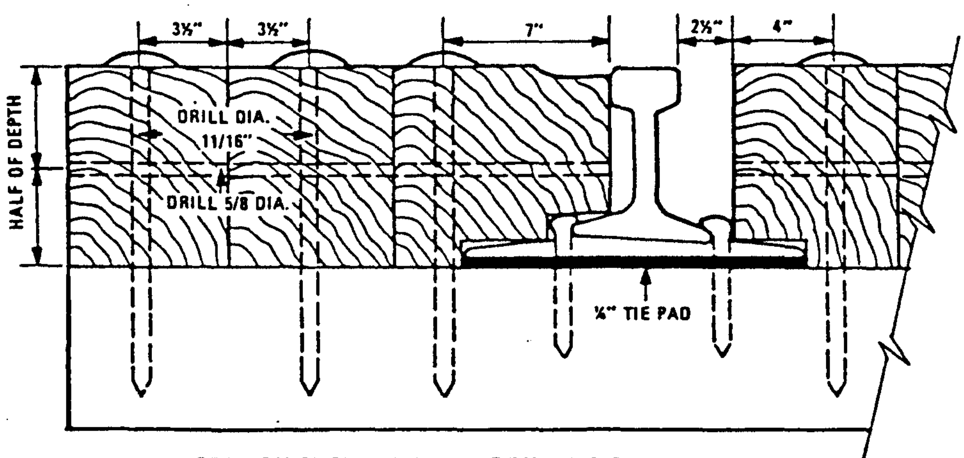
A disadvantage is the relatively large number of fasteners which must be used. There is a choice of leaving exceptionally wide openings adjacent to the rails, with increased impact against the rails, or having relatively unstable timbers with undercut bases at these locations.



ILLUSTRATIVE CROSS SECTION THRU
SECTIONAL TREATED TIMBER CROSSING



SECTION SHOWING DAP & DRILLING OF PLANKS AT RAIL

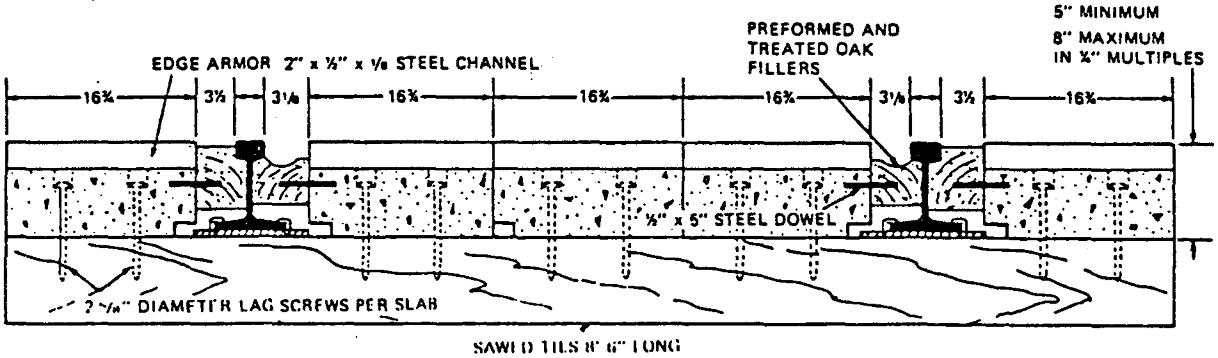


SECTION SHOWING DAP & DRILLING OF PLANKS
AT RAIL FOR ALTERNATE OUTSIDE SLAB UNIT

The sectional timber panel crossing is somewhat easier to remove for track maintenance and to reinstall than the individual plank crossing. This type of construction permits smaller openings adjacent to the rail without loss of stability, reducing impact against the rails.

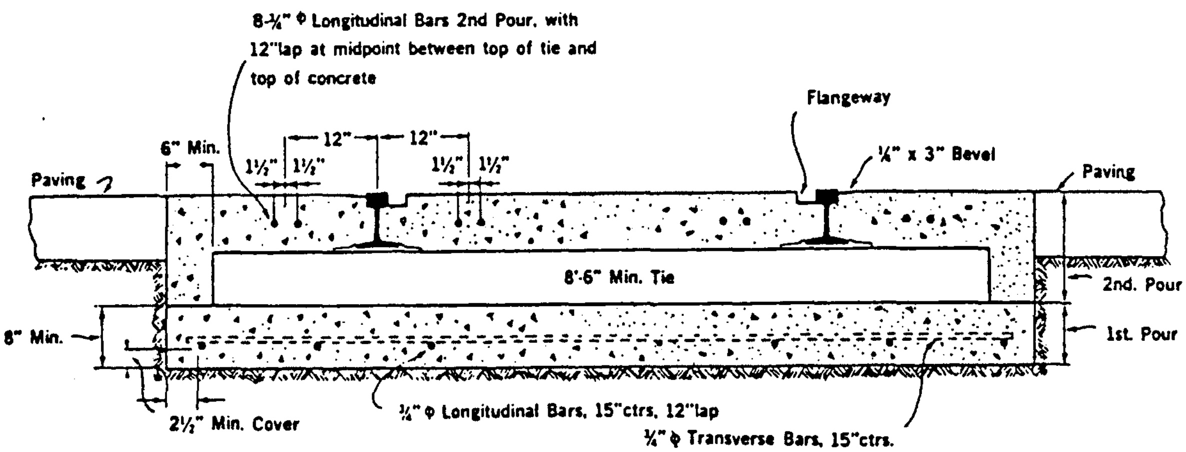
The timber wearing surfaces can be adversely affected by heavy highway traffic. This is a good type of crossing to use in important tracks which are maintained on regular cycles, where there is light to moderate highway traffic.

Precast concrete slab crossings may either be full-depth to the top of ties or placed on shims. This type of construction can provide a more durable wearing surface than timber surfaces. If spalling of the concrete surface develops, epoxy products can be used to repair the panels.



TYPICAL CROSS SECTION THRU CONCRETE SLAB CROSSING

There is sometimes a tendency for these crossings to become loose and to rock under traffic. The concrete panels are quite heavy and require hoisting equipment to set them in or remove them from track.



CROSS SECTION OF A TRACK IN A PAVED AREA

Concrete is sometimes poured for a crossing surface, either to the top of ties or including the cribs between ties. Concrete is extremely difficult to remove. This type of construction is quite inflexible. Track constructed on ballast does have some flexibility. This can result in breakage and heaving of the concrete, without the capability of correcting irregularities in track surface.

Whenever a cast-in-place concrete crossing is used, the track should be laid directly on a reinforced concrete slab. After this is done a second pour of concrete is made to form the crossing.

This type of construction should only be used where rail traffic conditions are such that the track need not be disturbed for the life of the crossing. It is not suitable for main tracks. Such construction can provide excellent riding qualities for highway traffic with very little maintenance. The initial cost of such a crossing is comparatively high.

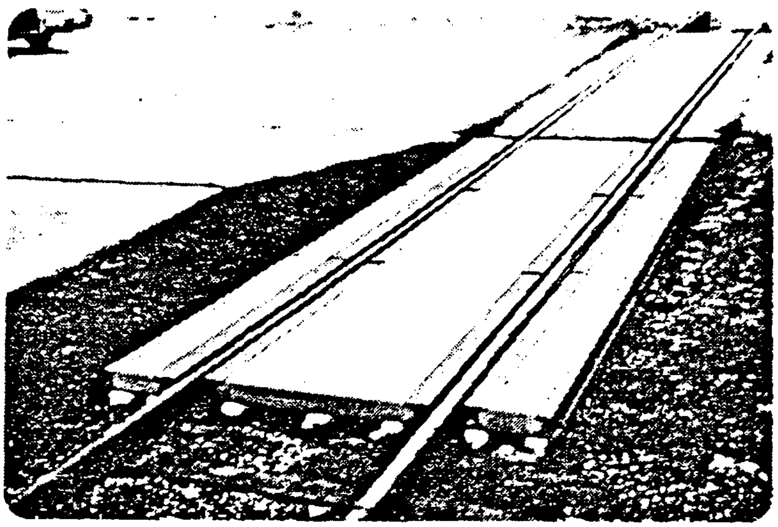
Steel reinforced rubber panel crossings can be readily removed from track maintenance and easily replaced. The flangeway openings can be closely controlled without loss of stability. The wearing qualities are very favorable, providing a relatively long life. The riding qualities for highway traffic are excellent.

The only disadvantage of this type of crossing is its initial high cost. It is considerably greater than for any other type of crossing. This limits the location where such a crossing can be justified. It is usually necessary to show that other types of construction will prove to be more expensive because of much higher maintenance costs and a shorter life.

OTHER CROSSING PANELS

Additional types of crossing panels in limited use include structural foam and metal panels of an open grating type. Steel planks have also been developed. Metal types also require extensive provision for insulation of electrical circuits for signals and grade crossing protection.

A precast concrete slab crossing developed in Germany has been gaining acceptance in the United States. Used rail forms the edges of the slabs--one center slab and one on the outside of each running rail. The standard slab is 8 ft. long and 5 in. thick. A feature of this crossing is the placement of each slab unit on several plastic bags filled with fresh grout which adjust the riding surface to the proper grade and assure uniform bearing on the supporting crossties. The slabs are not fastened to the crossties, but are held in position by specially designed steel fastening devices which secure the slabs to the running rails. This type of device can be readily used with concrete crossties because the crossing is not secured to the ties.



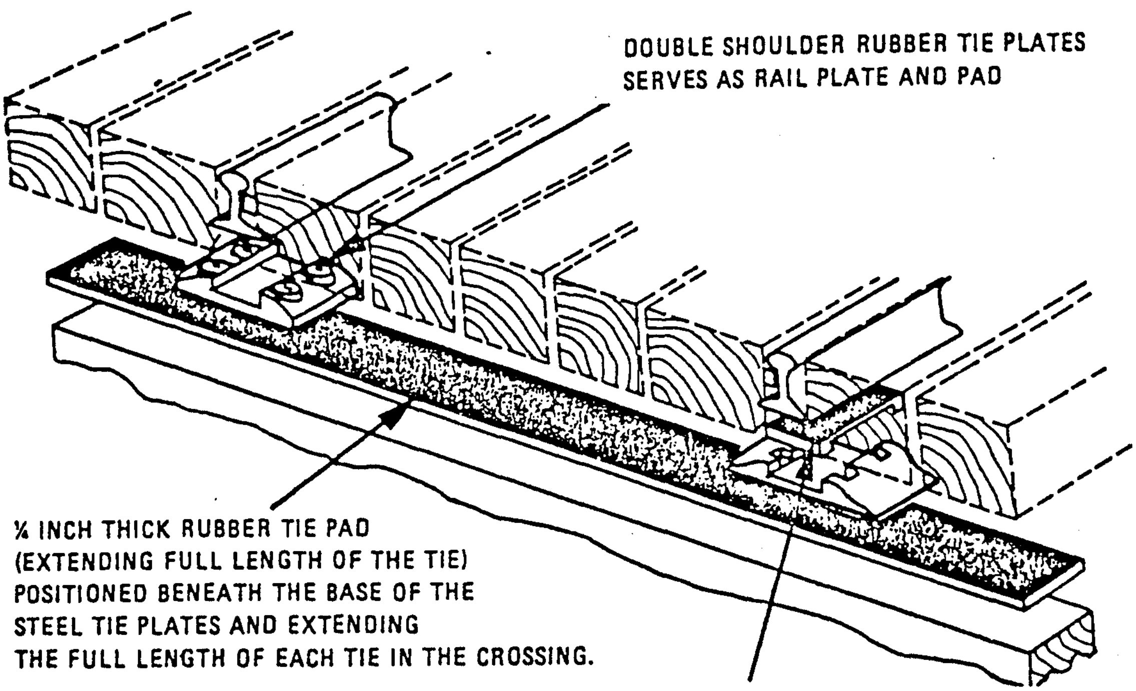


ILLUSTRATION OF VARIOUS METHODS OF RUBBER CUSHIONING stalled. Some railroads follow the practice of installing tie pads under all ties within crossings in order to reduce plate cutting.

SUMMARY

It is unlikely that all of the alternatives for grade crossing construction will have been adopted as standards by your company. It is probable that a variety of crossing types will be in use, in an effort to meet variable grade crossing conditions. Whoever determines the type of construction to be used at any crossing should understand the advantages and disadvantages of each.

Grade crossing maintenance covers a wide range of activities from minor patching to complete construction of both track and highway structures. Even small jobs, frequently repeated, due to correcting symptoms and ignoring the cause of the problem can become expensive. Major crossing jobs can involve large commitments of labor and other resources. Careful planning of each job in advance can do much to insure that the job gets done in the most efficient manner.

LESSON 15

EXERCISE QUESTIONS

1. Name three types of track defects that can be identified within a grade crossing by a Track Foreman, without removing the highway surface.

2. What is an advantage of the plain bituminous crossing?

3. What are two precautions to follow when patching a bituminous crossing in order to get a lasting job?

4. Timber headers used in bituminous crossings usually have the base undercut so that they can be installed close to the rail head. Give one reason why this is done.

5. It is desired to install perforated pipe beyond and below the ends of the ties to improve drainage in a crossing. What size pipe would you use?

6. When the track is rebuilt through a grade crossing, it is considered to be desired not to immediately restore the crossing when the track is ballasted and brought to grade. Why?

7. Name three types of work that can be done by pneumatic tools when renewing a crossing.

8. What are two advantages of the panel method of reconstructing a track through a grade crossing?

9. Why is bituminous material sometimes placed in the openings between the running rails and timber headers?

10. What type of crossing should never be used in high speed main line tracks?

11. What are two conditions that will tend to restrict the amount of track that can be skeletonized at one time?

12. What is an advantage of panel type crossing surfaces over bituminous surfaces?

Answer the following either TRUE or FALSE

13. Washed gravel makes a good base for bituminous paving in a grade crossing.

(Exercise questions continued on next page)

14. Within a crossing, voids under the centers of ties should be filled.

15. Timber panel surfaces are ideal for main line tracks where high-speed heavy truck traffic uses the highway.

16. Rail defect detection equipment will not locate rail defects within a crossing.

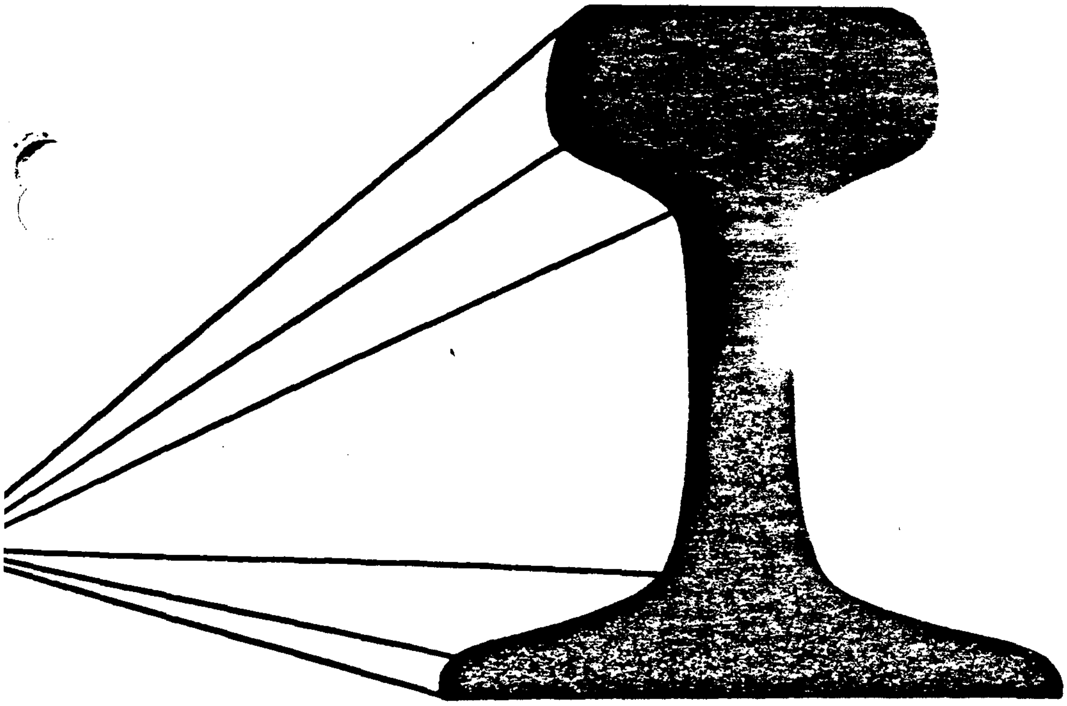
17. A backhoe is an effective machine for removing bituminous paving from a crossing.

18. Track panels should not be built at the site of a grade crossing job because there is seldom a good place to assemble them.

19. Poor track alinement in the vicinity of grade crossings is sometimes caused by rail creepage.

20. Timber plank crossings are more difficult to remove for track maintenance than timber panel crossings.

Submit your answers to these questions to The Railway Educational Bureau in the prescribed manner. Be sure to include your name, file number, address, company's name, and lesson number in the upper right hand corner of your paper.



TRACK FOREMAN'S TRAINING PROGRAM

LESSON 2

TURNOUTS AND CROSSOVERS

The Railway Educational Bureau

1809 Capitol Avenue, Omaha, Nebraska 68102

LESSON 2

TURNOUTS AND CROSSOVERS

Railroad operations require many types of movements of trains and equipment other than simply going from one point to another on a single-track. Cars need to be placed on side tracks for loading and unloading. Sidings are needed for one train to pass another in single track territory. Trains may be routed to move from the main line to a connecting branch or vice versa. Classification yards provide many tracks for sorting cars into blocks which are more efficient to handle. Trains may have to be diverted from one track to a parallel track. One track may cross another. In congested areas, it is sometimes necessary to provide special trackwork that will permit many possible routings for trains in a limited space. Sometimes the nature of the operation requires such movements to be made at considerable speed. In other cases, relatively slow speeds are quite satisfactory. There is available a wide variety of trackwork designs to meet all of these needs.

In this lesson we will study just two of these types of trackwork--the turnout and the crossover. These are the most common types in general use, by far. Other types will be dealt with in another lesson. In this lesson we will examine the principal parts used in the construction of turnouts and crossovers. We will consider some of the things in the design of these parts which people responsible for building and maintaining turnouts and crossovers should understand. It is not the purpose of this lesson to teach you how to construct or to do major maintenance work on turnouts and crossovers. This will be dealt with in succeeding lessons. The foundation which this lesson provides is necessary before you are ready to do a good job of building and maintaining such trackwork.

If you are able to observe any turnouts or crossovers as they are installed in track while you are studying this lesson, you will find this to be of considerable help in improving your understanding of this text and the illustrations included with this lesson. If you study part of this lesson in an evening, look the next day for examples of what you studied in actual installations.

It is necessary to have a good understanding of what is meant by the words turnout and crossover. The easiest way to do this is by looking at diagrams. Figures 1, 2 and 3 show three different types of turnouts. Figure 1 is a right hand turnout. Figure 2 is a left hand turnout. Figure 3 is less common and is called an equilateral turnout.

It is entirely possible that you may be in the habit of referring to a turnout as a switch. This is a fairly common practice but it is not accurate. A switch is part of a turnout. The switch consists of two switch points (or switch rails) plus the fittings needed to hold them in position. A turnout consists of a switch and a frog connected by closure rails together with the necessary timber and other parts needed to complete both routes.

DETERMINING TURNOUT DIRECTION

It can be seen that the way to determine whether a turnout is right hand or left hand is to stand at a location ahead of the switch points and look toward the turnout. From this location the curved side of a right hand turnout will go to your right. The curved side of a left hand turnout will go to your left. While standing in this position and looking toward the turnout, you are looking in the direction in which a train or other equipment makes a facing movement. This applies regardless of whether the switch is set for a straight-through movement or for movement to the curved side.

Now suppose you were to go to the other end of the turnout and turn around so that you will again be looking at the turnout. From this position you are looking in the direction in which a train or other equipment would make a trailing movement through the turnout. This would apply to movements from either the straight side or the curved side.

The curved route through a turnout is frequently referred to as the "turnout side". The straight route might be referred to as the "main track", the "parent track", the "straight side" or the "ladder track" depending on the location of the turnout.

The less-frequently used equilateral turnout might be found at a location where two main tracks converge into a single main track. The equilateral turnout splits the curvature between both sides. Neither route has the unrestricted speed that the straight side of a turnout would have, but both routes have less of a speed restriction than the turnout side of a right or left-hand turnout would have. Another location where an equilateral turnout might be found is on a main-track curve where the turnout side goes to the outside of the curve. Local circumstances will determine whether this produces a true equilateral turnout with the curvature evenly split or an approximation. EQUILATERAL TURNOUTS WILL BE USED IN POCKET TRACKS.

Figure 4 shows a right-hand crossover and Figure 5 shows a left-hand crossover. After comparing Figures 4 and 5 with

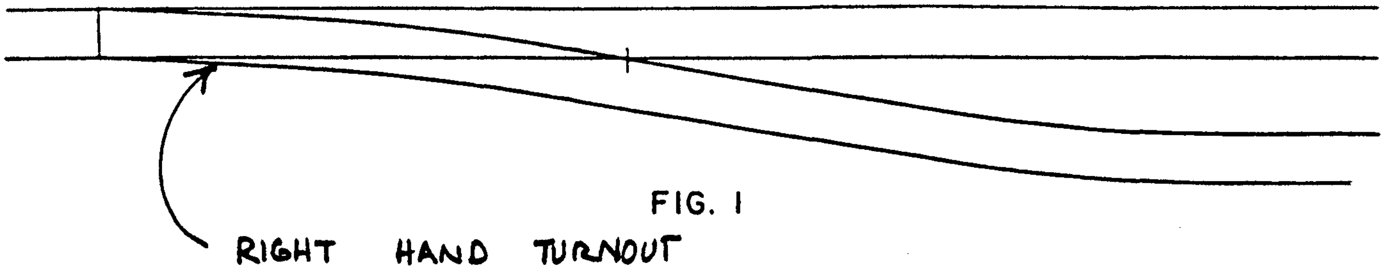


FIG. 1

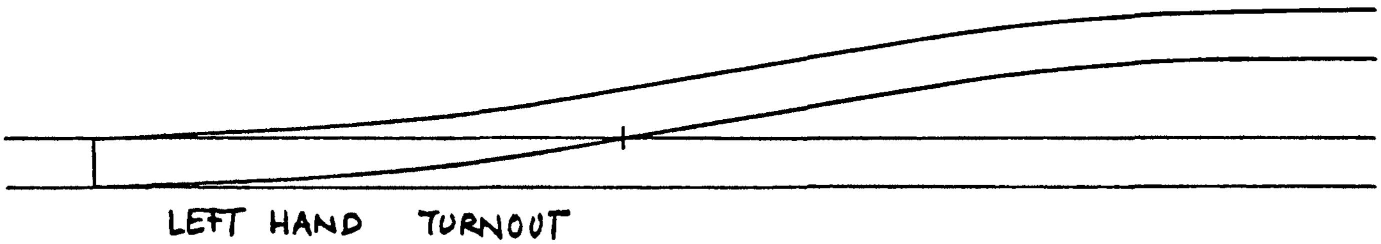


FIG. 2

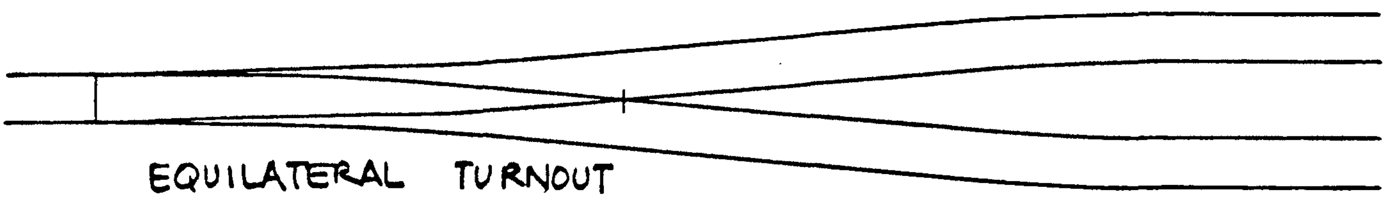


FIG. 3

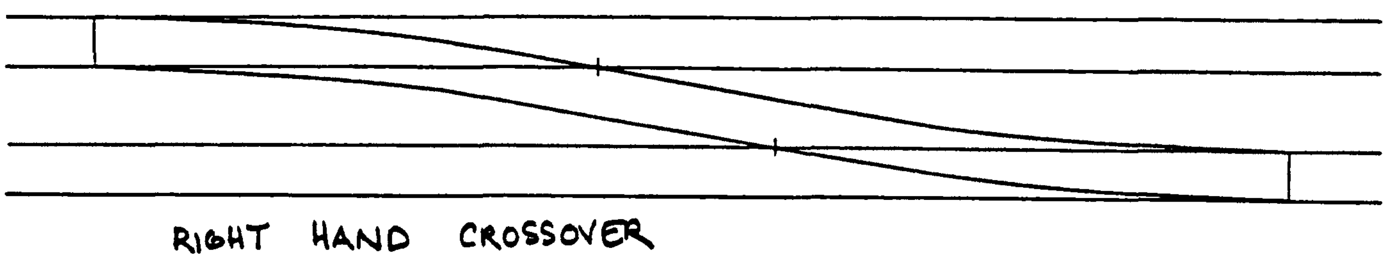


FIG. 4

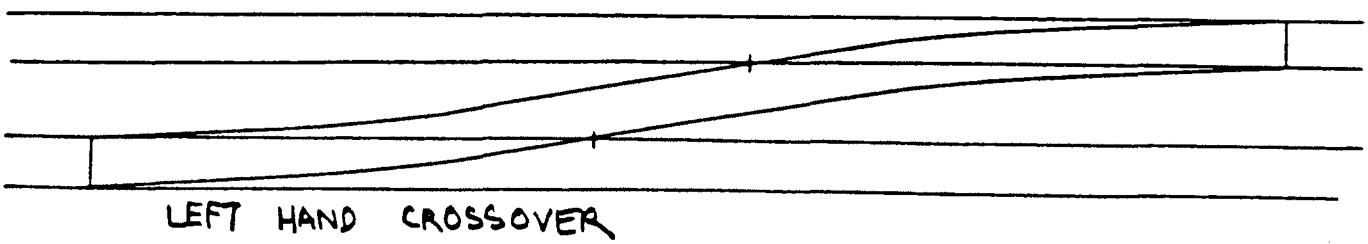


FIG. 5

Figures 1 and 2, it might be said that a crossover consists of two turnouts. This is almost true, but not quite. Behind the frog of a turnout, one of three things can happen. The turnout track can curve back to parallel the main track, as shown in Figures 1 and 2. The turnout track can continue to curve away from the parent track. Another possibility is that the turnout track may continue at the same angle as the frog. In a crossover, the track between the two frogs follows the frog angle. The timber layout for half of a crossover will be different from that of a turnout. Except for these minor limitations, a crossover might be considered as two turnouts. Most of this lesson will deal with turnouts, but the material covered will apply equally to crossovers.

LET'S LOOK AT THE FROG

The first part of the turnout structure that will be considered, is the frog. A frog is a device that permits flanged wheels running on a rail to cross another running rail. Every turnout must have a frog. In addition, turnouts are classed as to size by the frog. In determining where a turnout is to be located, it is the position of the frog that is determined first. All other parts of the turnout are then located relative to the position of the frog.

Some turnouts are designed for operating trains on both routes at substantial speeds. Others, such as a spur off a main-line track, are designed for high-speed operation on one route and low-speed on the other route. At other locations, such as in yards, they are designed for low-speed operation only. Turnouts of various types and sizes are available to meet the requirements of local conditions. The size of a turnout will be considered first. The sizes are usually stated as a whole number. Some of the more frequently used turnouts are the No. 6, No. 8, No. 10, No. 12, No. 15 and No. 20. Quite a few other sizes are sometimes used, but on most railroads some or all of the above sizes are commonly used. Actually, these numbers refer to the frog angle.

It is because the frog angle is so important in determining the size of the turnout that this designation is used to indicate the size of the turnout. The frog angle is the angle between the two gage lines of a frog. Figure 6 shows what the frog angle is. Angles are usually measured in degrees, but an easier method is used to measure frogs. All track foremen should know how to measure a frog angle. The first thing to find is the intersection of the two gage lines, brought forward from the point portion of the frog. The actual point of the frog is blunt. If the frog were constructed with the actual point brought forward to the intersection

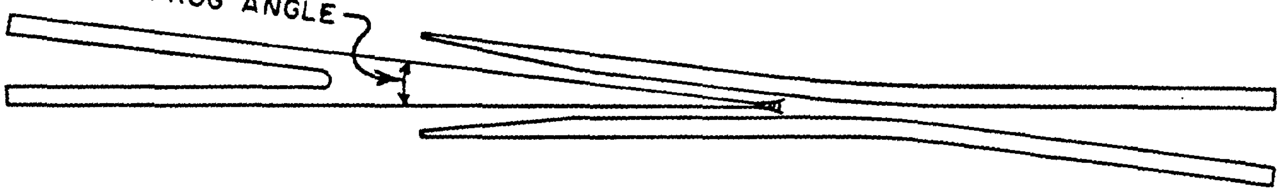


FIG. 6

of the gage lines, the point would come to a knife edge and would quickly break off under traffic.

Determine where the gage lines come together. This can be done with a straight edge or a piece of string. If there is not much wear it might be done by sighting. It does not have to be highly accurate. Mark the location. If you are within an inch of the right point, that's good enough. Next, you will need something to measure with. Anything of a convenient fixed length will do. You can use a pencil and measure in pencil lengths. Let's assume you have a pocket ruler. Go back on the point of the frog and find where the distance between the two gage lines is exactly one foot. Now, mark the point of this line midway between the gage lines. Next, measure the distance from that point to the point you located at the intersection of the gage lines. Let us suppose it is 8 feet. This tells you that it is a No. 8 frog. Possible you have measured 7' 11-1/4", or perhaps 8' 1-3/8". You still have a No. 8 frog, because your method of measuring is not that accurate, and most frogs are built to whole numbers. However, if your distance is about 7' 6-1/2", you had better remeasure more carefully. It might be a No. 7 frog.

Try another example. Locate the intersection of the gage lines the same way. This time in determining the spread, you find that you would have to go back a long way to find a one foot spread. Take a more convenient unit. A six inch spread will do. After locating the point midway between gage lines on the six inch spread, measure from there to the intersection point, that you located first. Suppose it comes to about ten feet. Remember, that you are no longer using one-foot units. This time you are counting six-inch units. Ten feet is 20, six-inch units, so this is a No. 20 frog. Maybe you had to use a pencil. You find the location where there is a spread of one pencil length. Then count ahead in pencil lengths to where the gage lines intersect. The number of pencil lengths will tell the frog number.

SIZE AND FROG NUMBER

The smaller the frog number, the larger the frog angle will be. The larger the frog angle, the sharper the curve will be through the turnout. The sharper the curvature, the lower the maximum permitted speed will be. For example, a No. 20 turnout is usually found in main tracks where substantial speeds are required on both the straight side and the turnout side. A No. 8 turnout, if well maintained will permit high speeds on the straight side but only low speeds on the turnout sides.

It has previously been stated that the point of a frog is somewhat blunted so that it does not break off under traffic. The location where the frog point ends is called the "actual point". The intersection of the gage lines, which has also been described, is also known as the "theoretical point" of the frog. The theoretical point, in addition to its importance in determining the number of a frog, is of value to surveyors in determining the proper location of a turnout. There is another frog point which you need to be familiar with. This is the so called "half inch point". This is usually located a short distance ahead of the actual point and on most frogs is identified with a chisel mark. It is so named because it is at the location where the gage lines on either side of the frog point are one half inch apart. It is from the half inch point that most distances that you will have to work with are taken.

The two legs of the frog closest to the switch are known as the toe of the frog. The two legs of the frog furthest from the switch are known as the heel of the frog. The toe length and heel length of a frog are measured from the half inch point to the end of a toe or the end of a heel.

TYPES OF FROGS

You should know what the principal types of frogs are, be able to identify them, and know where they should be used. Figure 7 is a plan of a bolted rigid frog. This type of frog is constructed of tee rail planed and bent to form the shape of a frog and held together with filler blocks and bolts. This type of frog is generally intended for relatively light-duty locations. It is relatively economical in price but is not recommended for heavy-tonnage, high-speed traffic.

Figure 8 is a plan of a rail-bound manganese-steel frog. The cross-sectional drawings show the central manganese steel casting as well as the surrounding tee rails from which the term "rail bound" is taken. This type of frog is suitable for high-speed, heavy-tonnage main-line use.

Figure 9 is a plan of a solid manganese-steel frog. Note that this frog does not include the additional support of the tee rails used in the rail-bound manganese-steel frog. This type of frog may be used at locations where there is heavy traffic, but moderate speeds.

Figure 10 shows a self-guarded frog. It is in the throat of a frog, immediately ahead of the actual point, that the wheel flanges are not guided by the gage side of a running rail. Other means of guiding must be provided to prevent

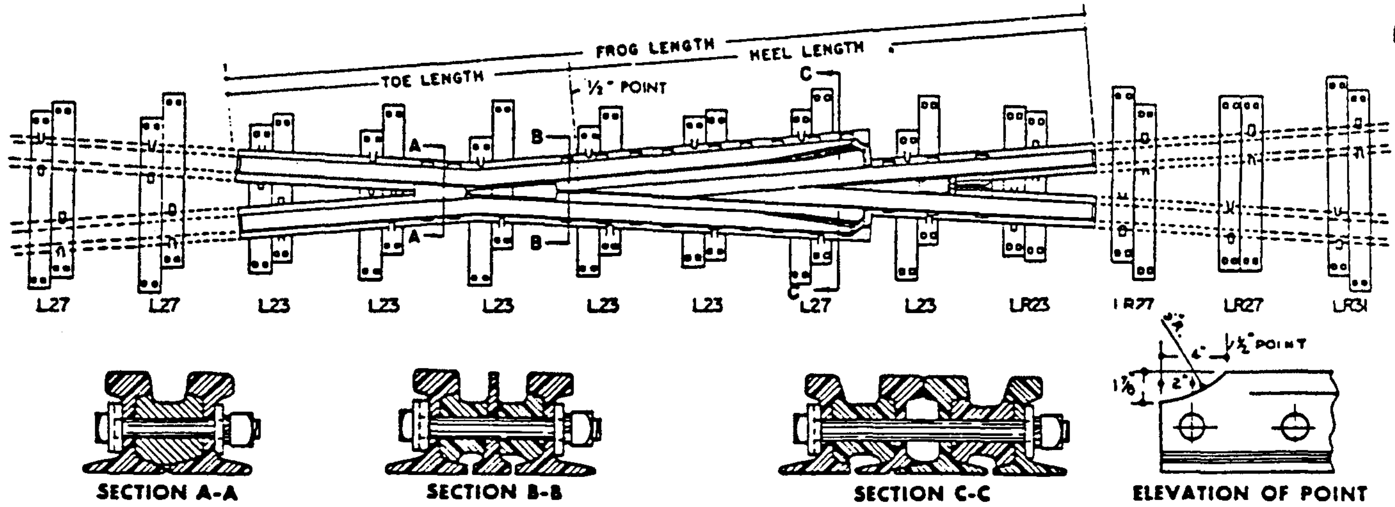


Figure 7

BOLTED RIGID FROG

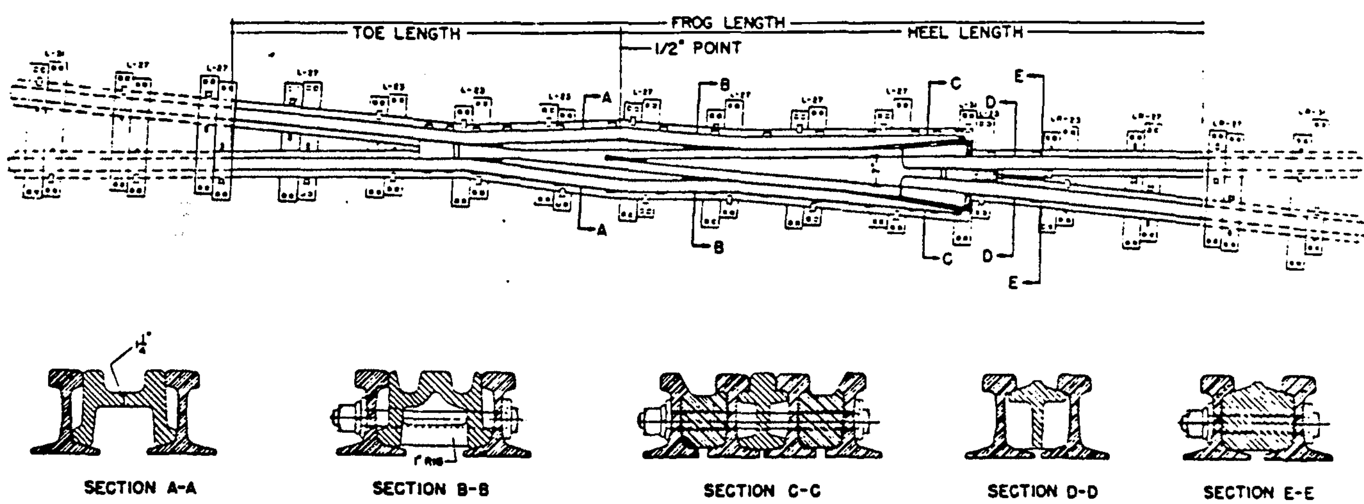
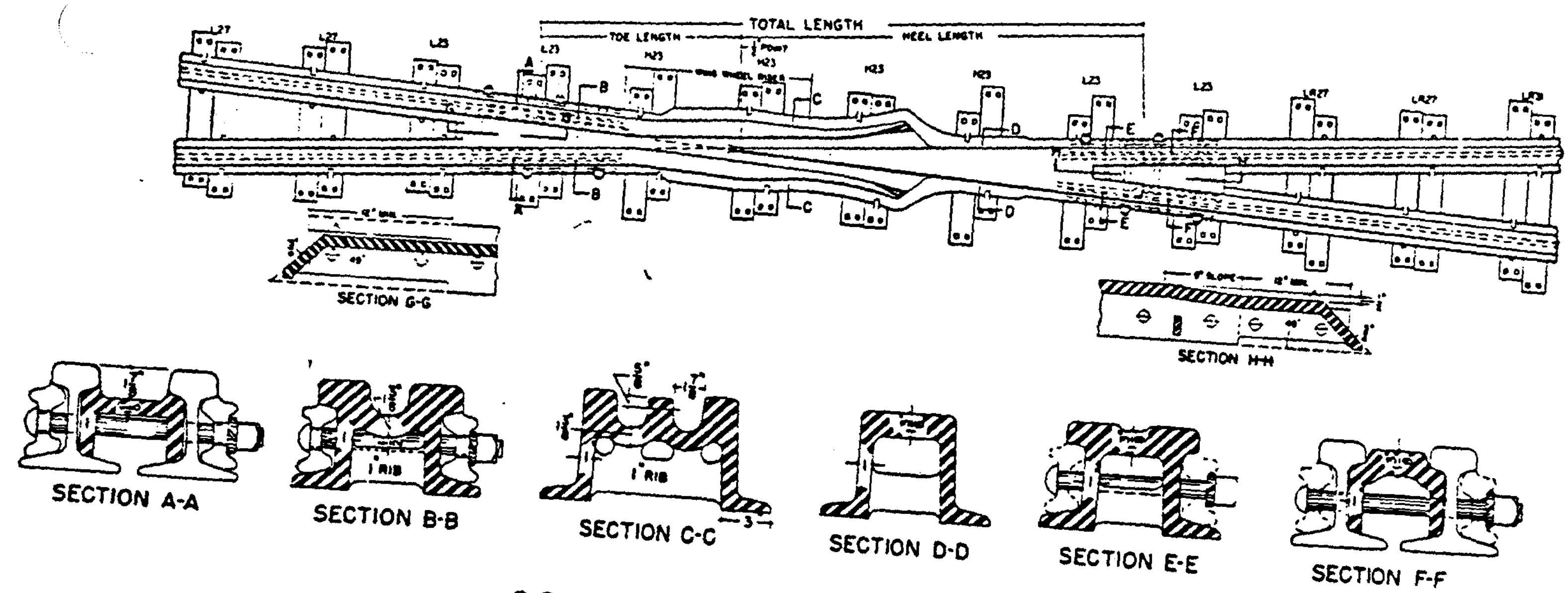


Figure 8

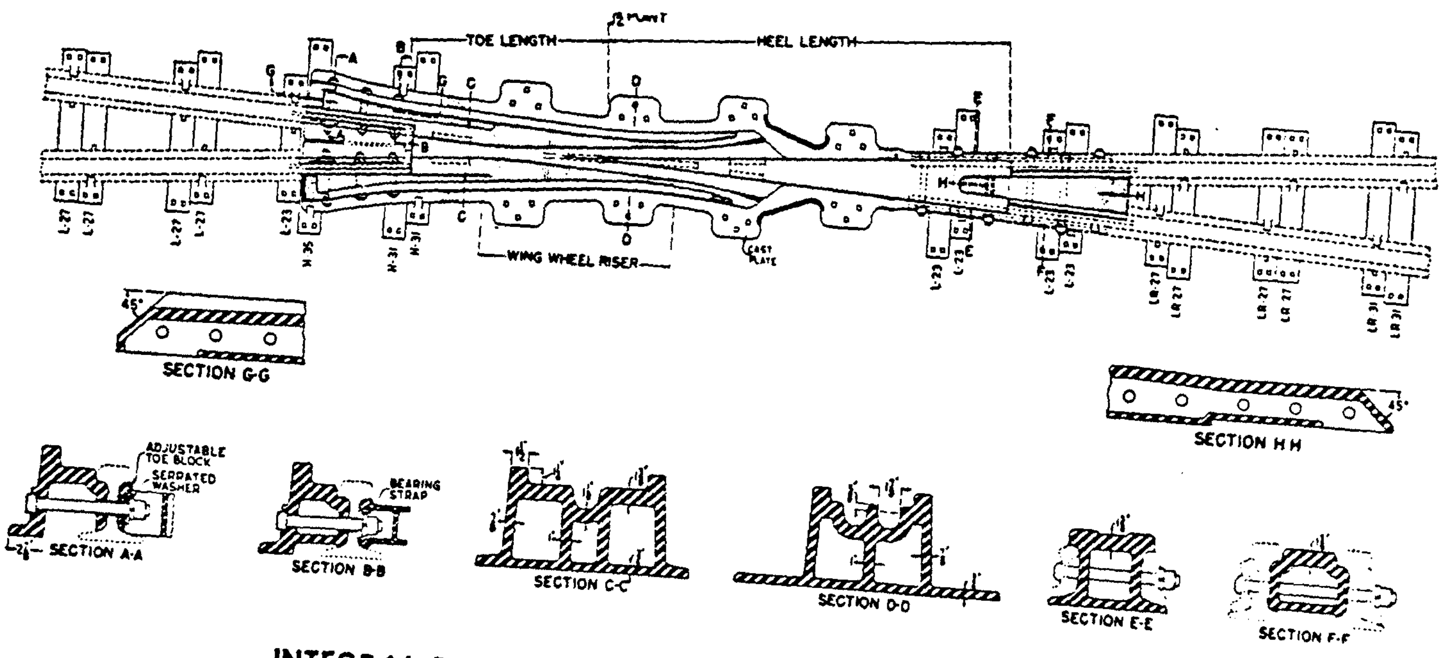
RAIL BOUND MANGANESE STEEL FROG

Courtesy of the Abex Corp.-Racor



SOLID MANGANESE STEEL FROG.

Figure 9



INTEGRAL BASE SELF-GUARDED MANGANESE STEEL FROG

Figure 10

Courtesy of the Abex Corp.-Racor

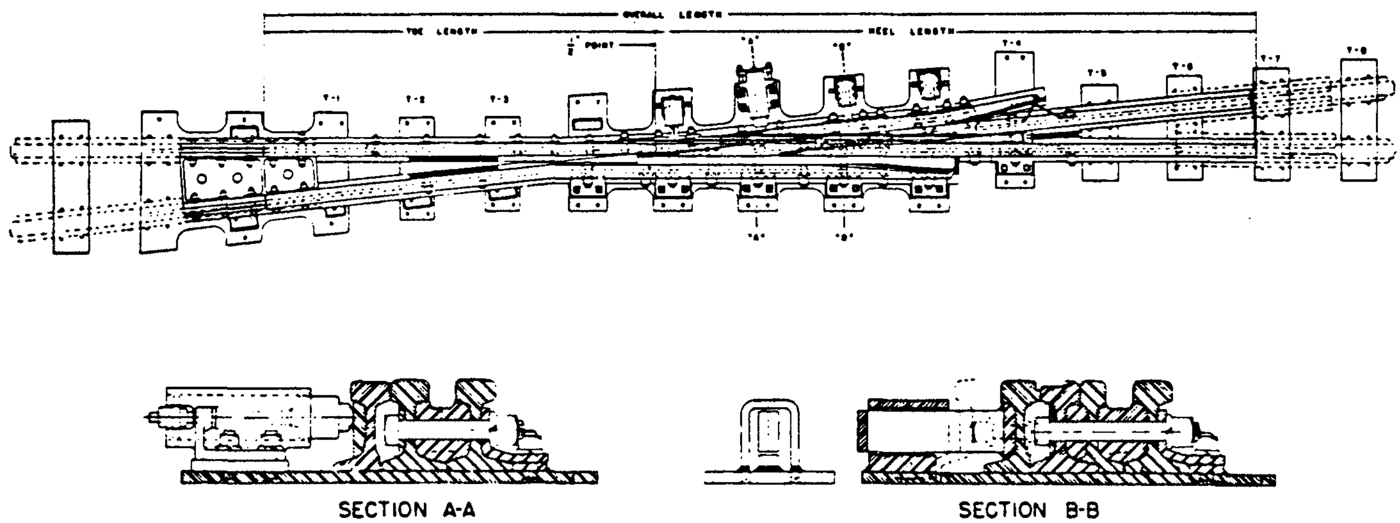


Figure 11

SPRING FROG

wheel flanges from drifting out of the proper direction of travel, thus either climbing up onto the frog point or entering the wrong flangeway as it passes the point. In the case of the self-guarded frog, this guiding is provided by the high outer ridge on either side of the casting which restrains the outer edge of the wheel rim to the proper route. Such frogs can be used in locations with heavy traffic, but only where relatively slow speeds are permitted. They are particularly suitable for busy yard locations. They have the advantage of not requiring conventional frog guard rails.

Figure 11 indicates a spring frog. The cross sectional views show the closed flangeway on the turnout side, the hold down device and the spring arrangement which permits wheels moving through the turnout side of the frog to open a flangeway, which is reclosed by the spring. This eliminates the flangeway gap for movements on the straight side of the turnout, making possible a better ride on that route. This type of frog is suitable for main-line use where a smooth ride is desired on the main-track side, but only light traffic uses the turnout side.

The types of frogs which have been described are the principal ones used on North American railroads. Not all railroads use all of these types. You should know the types used on your railroad and be able to recognize each type readily. You should also determine your railroad's standards for locations where each type should be used. In addition to being able to determine the number of a frog angle with ease, you should become familiar with the basic dimensions of each type frog for each number. These dimensions include the total length of the frog, the toe length and the heel length. It is not necessary to memorize these lengths, but it would be well to begin making a list in your notebook and add to the list as you have the opportunity. Remember also, that there are different sized frogs for each rail weight and section in use on your railroad.

PURPOSE OF GUARD RAILS

It has already been shown that a wheel moving through the open flangeway of a frog must be guided along the proper route. On all frogs other than self-guarded frogs, this is done by means of guard rails. Guard rails must be provided on both the straight and turnout sides. Guard rails guide wheels moving through a frog throat by applying pressure to the back of the flange of the wheel on the other end of the axle. The restraint is therefore transmitted through the entire assembly of both wheels and the axle. Figure 12 shows a typical guard rail installation.

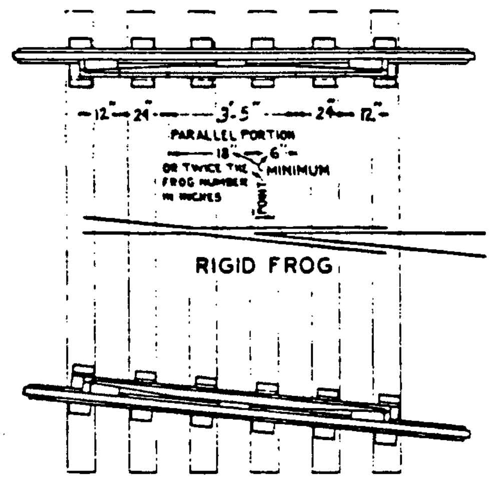


Figure 12
A.R.E.A. Plan No. 502-71
LOCATION OF FROG GUARD RAILS

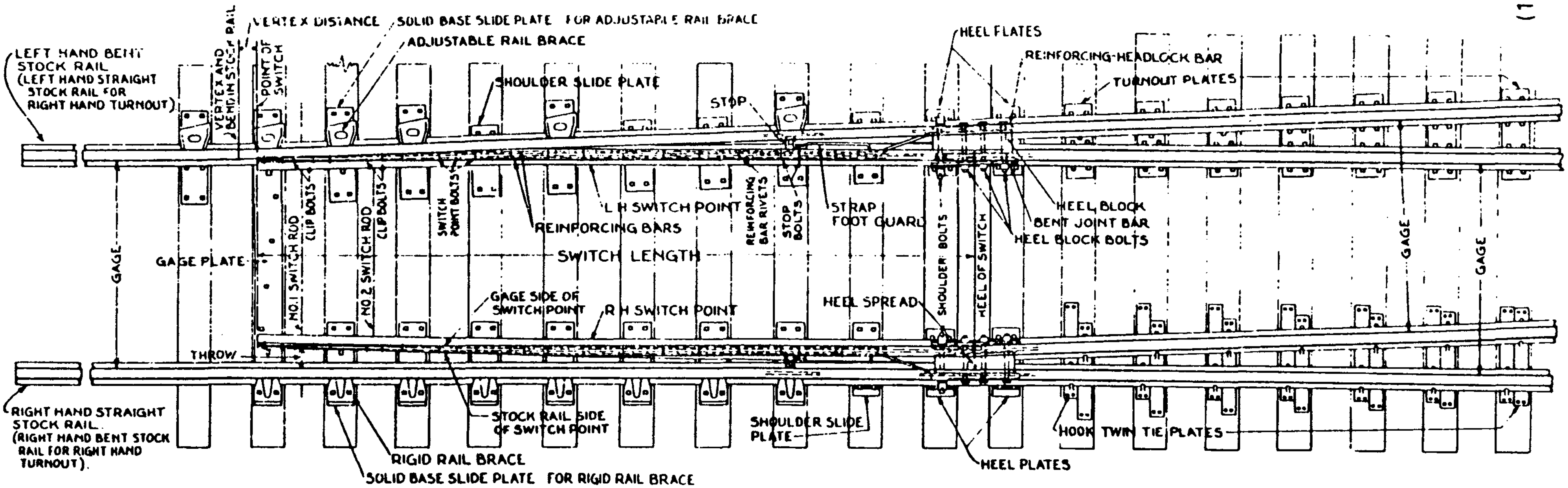
There are several kinds of frog guard rails in general use. Most of them can be grouped in one of two general types. One is the type fastened directly to the running rail, using either bolts or clamps with spacer blocks. These are usually made of tee rail with the ends flared and tapered. The other type includes base plated permanently attached to the guard rail. These base plates, generally, extend under the running rail serving as tie plates for the running rail. An advantage of this construction is that when the guard rail is called upon to provide lateral restraint to a wheel, the weight of that wheel load is being transmitted through the running rail to the guard rail base, helping to keep the guard rail from moving.

Your railroad may have standards requiring the use of certain types of frog guard rails in specific situations. Also, there may be more than one length of frog guard rail provided to meet certain conditions. These you must determine so that you will be prepared to install and maintain guard rails in accordance with your company's requirements.

EXAMINING A SWITCH

The next part of the turnout that will be considered is the switch. It has already been shown that the switch is made up of a number of parts. The two largest parts are the switch points. Every switch has a right-hand and a left-hand switch point. To determine the hand of a switch point, stand in the center of the track at a point ahead of the switch. Look toward the switch (this will be in the direction of a facing train movement). The right-hand switch point will be to your right and the left-hand switch point will be to your left. The thin, tapered end of a switch point is known as the point of the switch. The other end of the switch point, with the full tee rail section, is known as the heel of the switch. Figure 13 shows a typical switch with the names of the various parts.

A switch point is the means by which wheels are diverted from the rail on which they have been running to another route. To do so, the shape of the point of the switch and the manner in which it fits against the adjacent rail (stock rail), must be designed and maintained within rather close limits. A switch which has an exposed point that the flange of a wheel may strike, during a facing movement presents a very real danger of derailment, should a wheel flange climb onto the top of the switch point. Such an exposed point can be due to improper fit between the switch point and the stock rail. A point which is too thin may not have enough strength to withstand loads placed upon it, nor would it have a reasonable



PLAN VIEW INDICATING (FOR ILLUSTRATION ONLY) VARIOUS PARTS OF SWITCH LAYOUTS
DRAWN FOR LEFT HAND TURNOUT

Figure 13
A.R.E.A. Plan No. 190-59

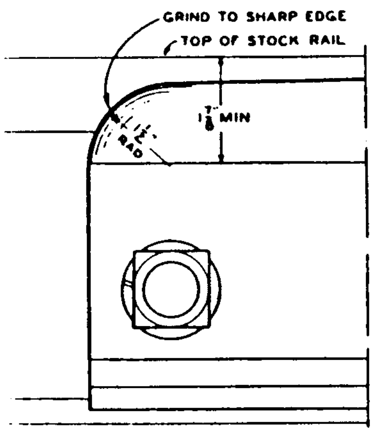
life under traffic conditions which cause wear on the switch point. On the other hand, a thickly constructed switch point may present a blunt point for the wheel flanges to strike. Figure 14 shows the cross-sections at the point of switch of typical switch points.

In any switch, one switch point will be used by traffic using one route through the turnout, and the other switch point will be used by traffic on the other route. If there are appreciable differences in the traffic utilizing the two routes, then there will probably be substantial differences in the wear patterns of the two switch points.

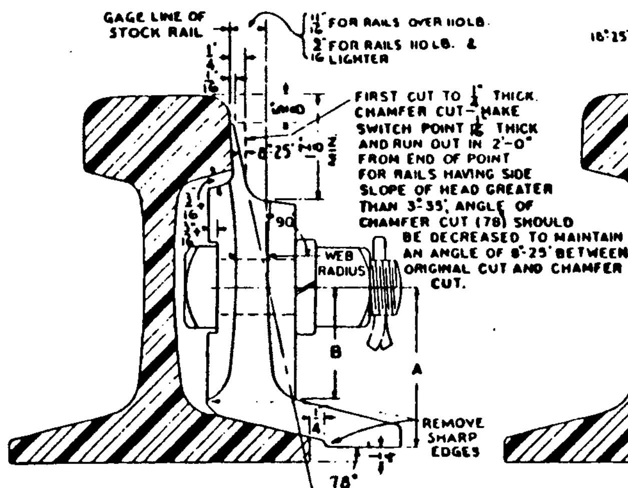
A switch point that is in position against its stock rail, so that wheels will move from the stock rail to the switch point during a facing movement, or from the switch point to the stock rail during a trailing movement, is said to be in the closed position. A switch point that is not in contact with the stock rail, permitting movements of a wheel entirely on the stock rail, is said to be in its open position. As a switch point is moved between these two positions, it pivots about a joint at the heel of the switch point. This heel joint acts somewhat like a hinge. In some cases the heel joint is an ordinary rail joint, connecting the switch point to the closure rail.

The preferable arrangement for heavy-duty use includes a heel block, which is inserted between the heel joint and the stock rail, through which both the heel of the switch point and the closure rail are bolted to the stock rail. A standard joint bar may be used on the field side of the stock rail in a heel block joint. A special bent bar is used on the gage side of the switch point and closure rail to permit the movement of the switch point. It should be recognized that there is a minimum practical distance between the gage line of the stock rail and the gage line of the switch point at the heel of the switch. This is determined by the width of the head of the switch point, and the need to keep an adequate flangeway opening between the stock rail and switch point for wheels moving on that route.

When a set of wheels with an axle moves through the straight side of a turnout, if the turnout is on tangent track, the switch point which one wheel moves on, and the stock rail which the other wheel moves on, are both a continuation of the straight line of the tangent. The wheels undergo no change of direction. Practical speeds are limited only by the quality of the maintenance. The length of the switch point on this route is not particularly critical.

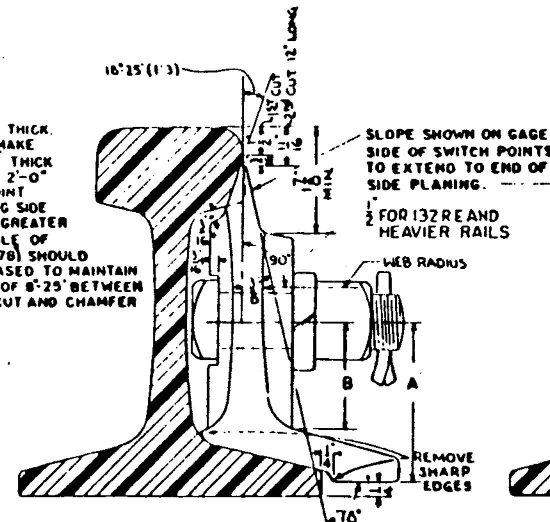


SIDE VIEW
OF END OF
SWITCH POINT



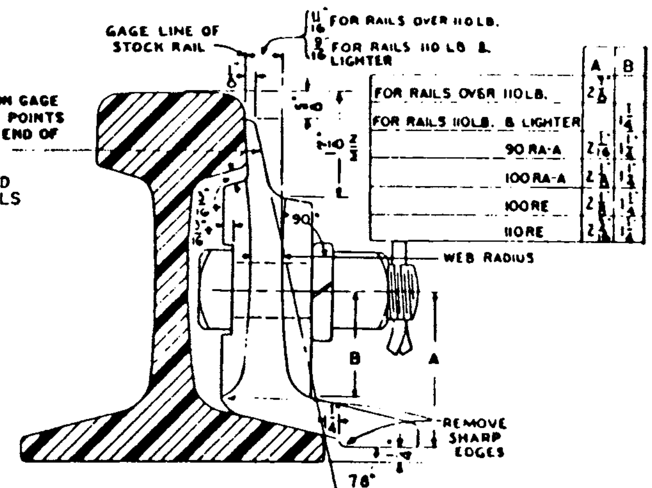
DETAIL 4000

ALTERNATE CONSTRUCTION FOR STRAIGHT AND CURVED SWITCH POINTS.



DETAIL 5100

PREFERRED CONSTRUCTION FOR CURVED SWITCH POINTS.
ALTERNATE CONSTRUCTION FOR STRAIGHT SWITCH POINTS.



DETAIL 6100

PREFERRED CONSTRUCTION FOR STRAIGHT SWITCH POINTS
ALTERNATE CONSTRUCTION FOR CURVED SWITCH POINTS

Figure 14
A.R.E.A. Plan No. 221-62

CHANGING WHEEL DIRECTION

When a wheel set moves through the other side of a switch, leading to or from the turnout side, the wheels do undergo a change of direction. A change of direction does impose restrictions on speeds which can be permitted. The extent to which speeds must be restricted depends on how abrupt the change of direction is.

Two things which determine the abruptness of the change of direction are the spread between gage lines at the heel of the switch, and the distance between the point of the switch, and the heel of the switch. The distance between these points is the length of the switch point. A deflection from a straight line of, say 6 inches, occurring within the length of a 10 foot switch point will be more abrupt than a similar deflection occurring in the length of a 39 foot switch point. Thus, it can be seen that relatively long switch points are needed in order to permit substantial speeds on the turnout side. The length of the point on the straight side is not important from the standpoint of speed. However, if both switch points in a turnout were not of the same length, it would not be possible to maintain uniform gage through the turnout side of the switch. Therefore, both points within a turnout are normally of the same length.

There is one other thing that can help determine the abruptness of the change of direction at a switch point. Consider a switch point on the turnout side which has a straight gage line throughout its length. The change in direction occurs suddenly, at the point of the switch. On the other hand, if this switch point is provided with a curved gage line, the change in direction is more gradual. The change of direction is continual throughout the entire length of the switch point and less severe at any one point. Because of this, some switches are designed with a curved switch point on the turnout side. Other switches, where speed or a smooth ride are not considered essential, are designed with a straight switch point on the turnout side. Straight switch points are always used on the straight side.

By now, it should be apparent that you will have to deal with a considerable number of different kinds of switch points in your work. There will be a range of points for each weight and section of rail used on your railroad for turnouts. There will be various lengths of points, the longer lengths being designed for use in turnouts with higher frog numbers and the shorter lengths with lower frog numbers. There will always be straight points to deal with, and sometimes curved points as well. There will also be right-hand and left-hand points in each category. There may be even more variety if heavy-duty designs are used for certain locations, rather than a standard switch point design. This might consist of heat treatment of a conventionally designed switch point. It may involve use of the Samson type point or a manganese tipped point.

You will probably never see all possible combinations of switch point types in your entire career. You should become familiar with the types used by your railroad, learn how to identify them, and become knowledgeable about locations where each type is to be used. Some of the classifications you will learn to recognize by a general inspection of the switch point.

THE STOCK RAIL

The next part of the turnout structure that will be examined is the stock rail. The stock rail is the conventionally shaped tee rail against which the switch point fits, when the point is in the closed position. When the switch point is in the open position, the stock rail is part of the route on which the wheels travel instead of the switch point route. Each switch point must have a stock rail; therefore, each turnout must have two stock rails. Stock rails are designated as right-hand or left-hand in the same manner as switch points. A straight stock rail is used on the straight side of a turnout and a curved stock rail on the curved or turnout side.

Stock rails need to be able to do certain things in relation to the switch point with which they are matched. One of these things is to jointly provide a good fit at the point of the switch, so that an exposed point will not be available for wheel flanges to strike on facing movements. To do this properly, a full contour on the head of the stock rail is needed. A worn rail head will not adequately protect the switch point. In most cases when a switch point needs replacement, the stock rail should also be replaced. It is not good practice to place a new switch point against even a moderately worn stock rail. It should be remembered that a switch point is usually a much more costly piece of trackwork than a stock rail and that the emphasis should be on attaining maximum useful life from the switch point.

Another method sometimes used to protect a switch point, is to provide a recess in the gage side of the stock rail. This is limited to the portion of the stock rail with which the switch point makes contact. It is sometimes done in a shop, usually by planing. In other cases, it is accomplished on the ground, usually immediately after installing a stock rail in track. In such instances, it is usually done with a grinder. A switch point which fits into such a recess or pocket will be less exposed to an oncoming wheel flange at the tip of the point.

BEND IN STOCK RAIL

Another way in which the point of a switch is protected from wheel flanges, is by bending the stock rail a short distance ahead of the point of the switch. This is commonly done to the stock rail on the turnout side which is matched with the switch point on the straight route. It is not done with the stock rail on the straight side. Figure 15 shows a stock rail with such a bend. It can be seen that this procedure can be of substantial help in protecting the point of the switch.

Another important function of the stock rail, in relation to the switch point, is one of support. Since a switch point can only be used when in the closed position, the lateral support provided by the gage side of the stock rail bearing against the back side of the switch point is an important part of the total support of the switch point. Certainly, the stock rail must be able to provide substantial support for the switch point.

One complicating factor in this, is that the base of the gage side of the stock rail cannot be spiked within the limits of the switch point. This is because of lack of clearance between the switch point and the stock rail, in the closed position. To overcome this problem, additional support is provided to the field side of the stock rail by means of braces. Such braces are fastened to switch plates and bear against the web of the stock rail. In some cases they also bear against the underside of the rail head. In this manner, considerable resistance is developed against any tendency for the stock rail or the switch point to be rolled over. While it may not be so in some older designs, most modern types of stock rail brace are adjustable. This aids in setting the stock rail so that a good bearing can be had with the switch point throughout the entire intended contact area.

We have seen how switch point--stock rail installations must provide protection against potential hazards that could exist for equipment moving in the facing direction. Movements in the trailing direction are not with out the potential for a hazardous condition, either. Consider a switch point and a stock rail which fit well, but in which the head of the switch point throughout its length is slightly lower than the head of the stock rail. As a wheel moves along the switch point in the trailing direction, from the heel toward the point, as the outer edge of the wheel rim first makes contact with the stock

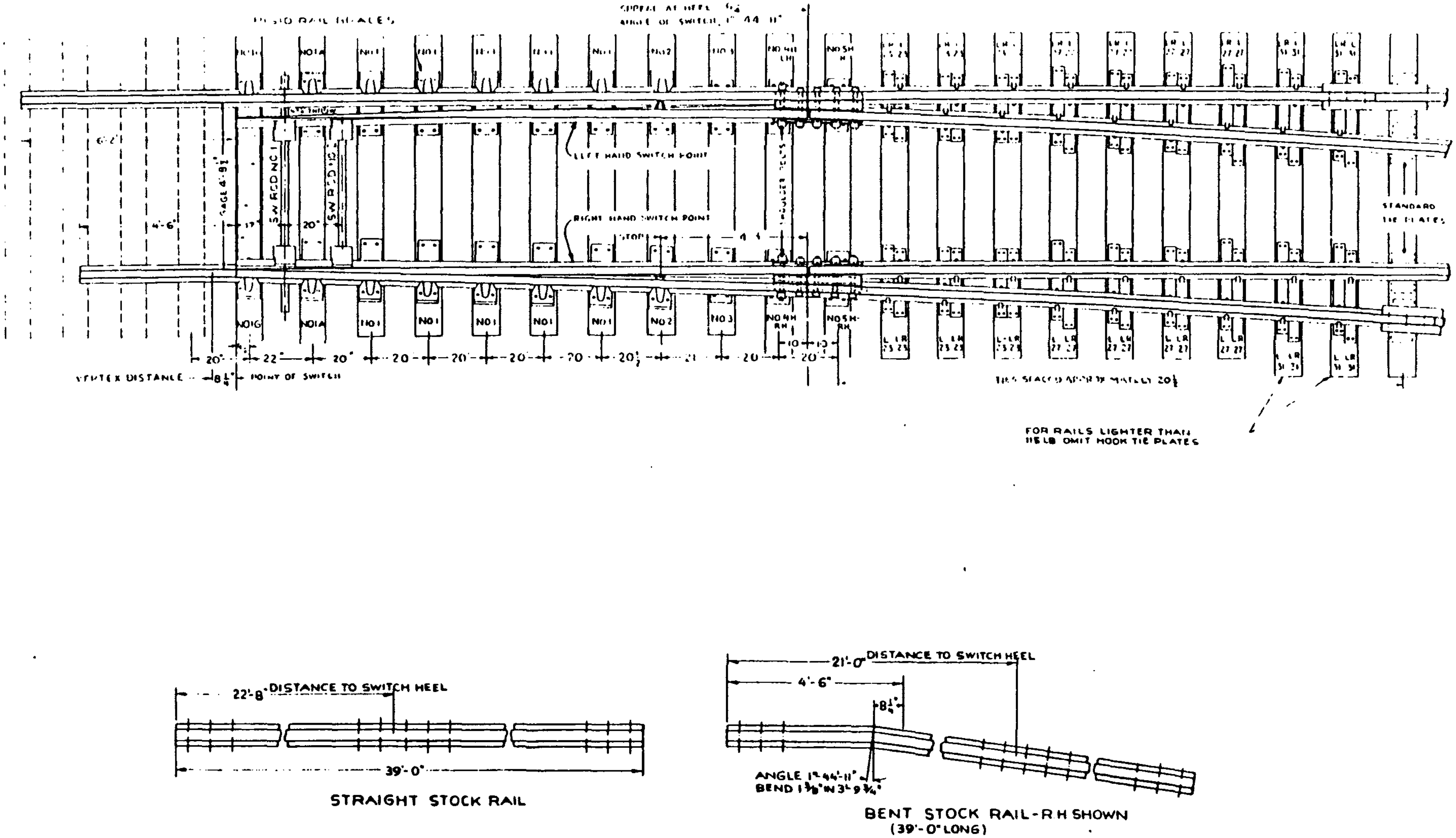


Figure 15
A.R.E.A. Plan No. 8-62 Sheet 2
16' 6" STRAIGHT SPLIT SWITCH
NON INSULATED

rail, the wheel probably will not climb up onto the head of the stock rail. Instead, the wheel might very well stay inside the gage side of the stock rail, forcing the stock rail to be spread away from the switch point. This would almost certainly result in a derailment. If both the stock rail and the switch point were at the same level, this probably would not happen. But suppose the head of the switch point acquired more wear than the stock rail. Or suppose, a badly worn wheel were to make such a movement. The wheel might have more tread wear close to the flange than at the outer edge of the tread. In either case the results could be the same. The stock rail could be forced to the field side, resulting in a derailment immediately ahead of the switch point.

The way to protect against this hazard, is to provide for the head of the switch point to be raised higher than the head of the stock rail, in the area where wheels make this transition from the switch point to the stock rail, on trailing movements. To do this, switch points are bent vertically in manufacture. Remember that it is equally important for the point of the switch not to be higher than the stock rail because of the dangers of point breakage and wheel climbing in facing movements. Figure 16 shows how a switch point is elevated in relation to its stock rail.

SPECIAL PLATES UNDER POINTS

This vertical shaping would be of no value if matching support were not provided for the base of the switch point. If the switch plates provided the same level of support for the switch point that they did for the stock rail, the weight of traffic would soon remove the vertical contour of the switch point. Examine a set of switch plates carefully. If possible look at both a set of plates which are in track and a set which are stock piled. You will be able to see that there is a variety of plates with different relative elevations provided for the switch point and stock rail. The usual difference in elevation at the maximum point is 1/4 inch.

At this point it should be noted that there are two basic types of switch point riser design in use. Some railroads use only one type; others use both types. The two designs are generally similar between the point of the switch and the point of maximum riser height. It is behind this point that the difference in design occurs. If the difference in elevation is run out within the limits of the switch point, (which means that the stock rail and switch point are at the same elevation within the heel block), the switch is said to have graduated risers. However, if a less sudden change in elevation is desired for a smooth ride at high speed, then this

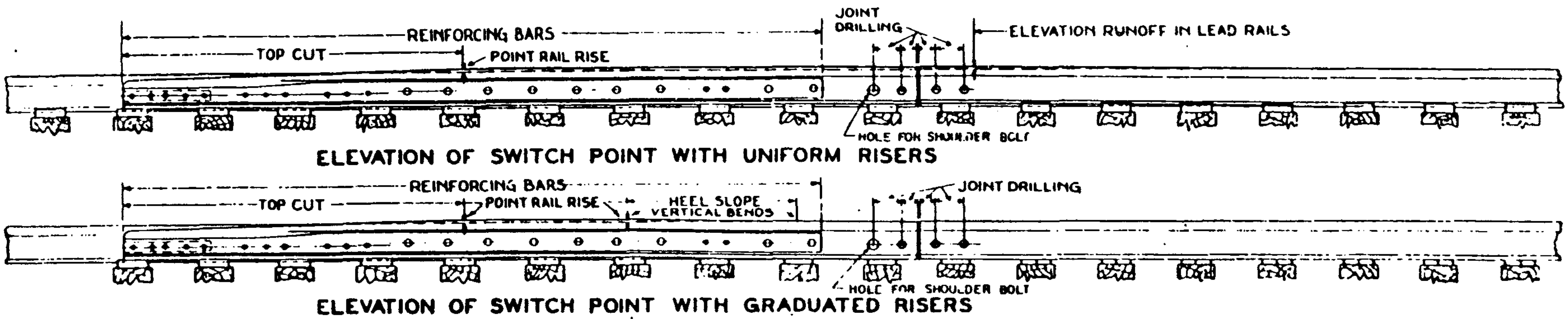


Figure 16
A.R.E.A. Plan No. 190-59

difference in elevation can be run out behind the heel block on the closure rails. This design requires special switch plates under the portion of the closure rails within the limits of the run off. A switch so designed is said to have uniform risers. Figure 16 shows the profile of each type of switch riser. Again, you should determine what is in use on your railroad. You may only have to work with one type, but if you have to work with both, you should recognize the difference.

SWITCH ROD ARRANGEMENT

At this point, we should direct our attention to some of the other fittings within a switch. In the operation of a switch, it is highly desirable to have both points move in unison, that is, as one point is being closed, the other is being opened. Without such an arrangement, there would be opportunity for error in aligning a switch. A derailment can occur with both points in the open position or with both points in the closed position. Switch rods are used to connect the right and left-hand switch points so that one switch point cannot be operated independently of the other.

The switch rod which is located closest to the point of the switch is called the No. 1 rod. Each rod in order, moving towards the heel of the switch is numbered according to its position. A short switch may only have two rods; longer switches will have additional rods. The designations such as No. 2 rod, No. 3 rod or No. 4 rod also indicate different drillings. A No. 4 rod, for example, should not be used in the No. 2 position because the drilling would be wrong.

The No. 1 rod is usually distinctively different from the other switch rods. The reason for this is that there is another rod which is connected on one end to the No. 1 switch rod. The other rod is not called a switch rod; it is an operating rod. The end of the operating rod, which is not connected to the switch rod is connected to whatever type of mechanism is provided for moving the switch from one position to the other. The necessary thrust for throwing the switch is transmitted through the operating rod to the No. 1 switch rod, and through the No. 1 rod to the switch points themselves. On some of the longest switch points, there will be a switch rod which looks similar to the No. 1 rod, located somewhere about midway between the point and the heel of the switch. This switch rod will have a rod or arrangement of rods connected to it and to a power source which provides assistance in throwing such long switch points.

It is not practical to connect switch rods directly to the switch points. This is accomplished through an intermediate fitting known as a switch clip. Figure 17 illustrates a typical switch clip. The bolts which fasten a switch clip to a switch point are known as switch clip bolts. The bolts which connect a switch rod to the switch clips are known as switch rod bolts.

You may find cases in which there is another difference in types of switch rods. If the width of a switch rod is greater than its height, it is known as a horizontal switch rod. In such rods, the switch rod bolts are installed in a vertical position. If its height is greater than its width, it is a vertical switch rod. Such rods require a different type of switch clip and the switch rod bolts are installed horizontally.

COOPERATE WITH SIGNAL FORCES

Mention has already been made of the necessity of some sort of mechanism with which to throw the switch from one position to the other and back again. There are various ways in which such devices can be classified. At some important locations power operated machines are used. The installation and maintenance of such equipment is usually the responsibility of signal forces. Track Foremen, generally, are not responsible for it.

Most switches are operated manually. If they are in signalled territory, signal forces will again be involved in the functioning of the switch operating mechanism. As there are differences in the extent of the responsibilities of track and signal forces between railroads, it is necessary that you determine what the agreed upon practice is in your area. One thing is certain, there is always a need for close cooperation between these two crafts in such work. Many switches are manually operated and are not connected to any signal circuits. Usually, the devices used for operating them are exclusively the responsibility of the Track Foreman. So many different designs of switch stand are in use that it is not possible here to go into the details of each type. You may be fortunate and only have one type to work with. Or you may have various types in use in your territory. Whatever the case, you should take advantage of opportunities to examine such switch stands closely, ask questions of employees experienced in maintaining them, and become knowledgeable in their care.

OTHER SPECIAL PLATES

A number of different types of tie plates are required

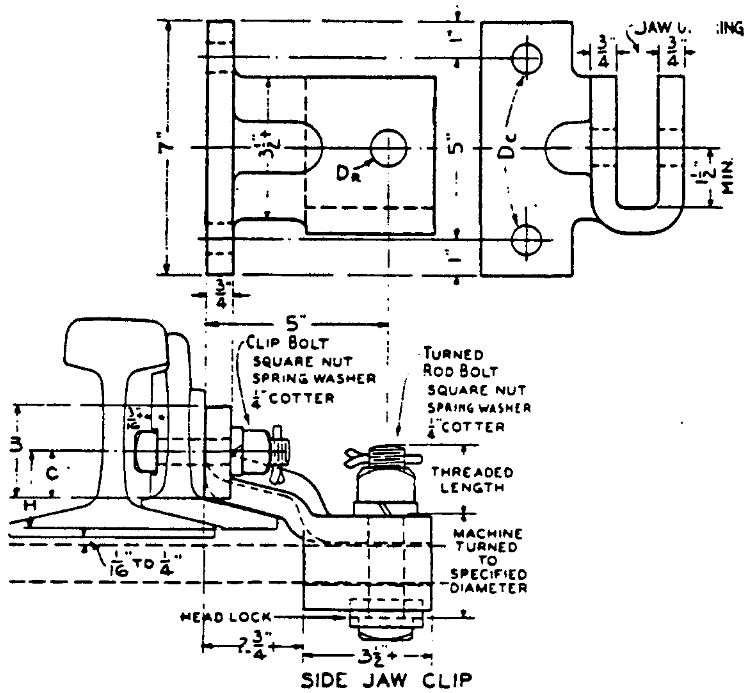


Figure 17
A.R.E.A. Plan No. 222-66

under various parts of a turnout. Special plates are required under the frog guard rails and adjacent running rails, if the guard rails don't have integral plates. We have seen how special switch plates are required under switch points and the adjacent portions of the stock rails. Some types of frogs may have integral tie plates, but many frogs do not. In these cases, hook type plates are generally used. Close clearance to adjacent rails near the switch heel blocks and possible the legs of the frog create the need for special plates. Figure 18 shows the use of hook plates at such locations. Where special construction or close clearance does not require these special tie plates, standard tie plates are used.

This lesson has been concerned mostly with special trackwork parts used in turnouts and crossovers. Conventional track materials, such as standard tie plates, joint bars, spikes, bolts, rail anchors and ballast need no special consideration here, having been covered in the lesson on the track structure. Some attention should be given to the use of rail within turnouts and crossovers. The only tee rails which have been considered so far are the stock rails, which it has been shown require special preparation. The balance of the rails used within turnouts and crossovers do not need special preparation, but the location of joints connecting these rails requires careful attention. A list of several facts and desirable goals regarding the location of joints within turnouts and crossovers would include the following:

It is necessary to install insulated joints in turnouts and crossovers located within signal circuits.

Insulated joints must be located with a minimum stagger distance because of electrical requirements.

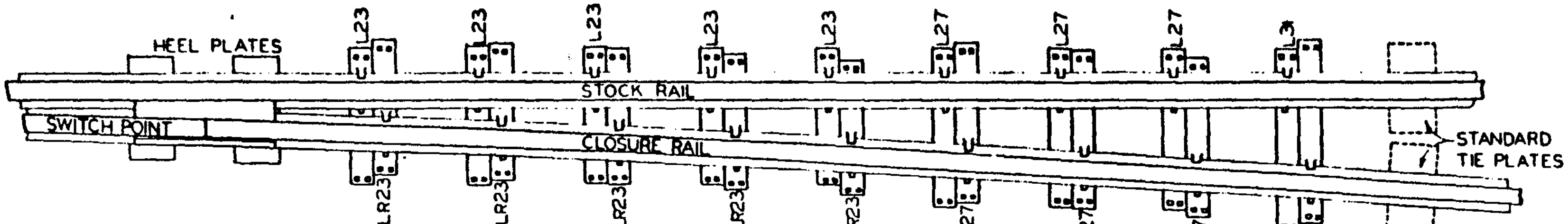
It is preferable to maximize the stagger of all joints from the stand point of track stability.

It is not practical to locate joints within the limits of frog guard rails or switch points.

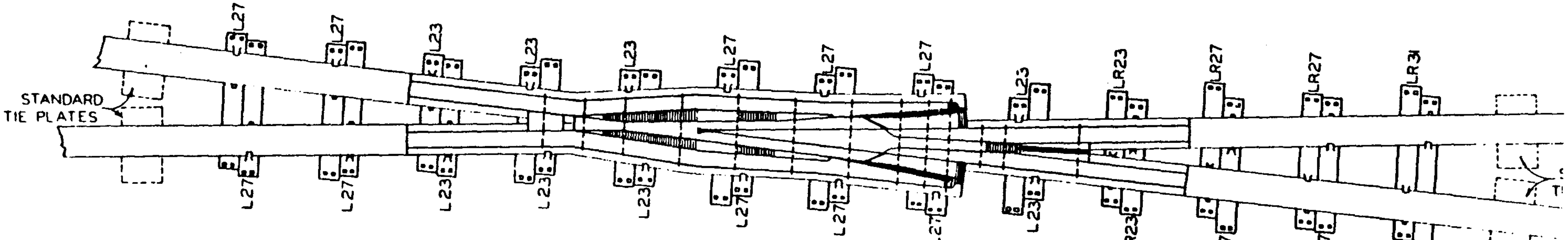
It is not good practice to have a stock rail terminate in a heel block joint.

It is sometimes desirable to build or replace turnouts with preassembled panel sections. This type of construction lends itself to minimum stagger of joints.

It can be seen that some of the above conditions are not compatible with each other. This lends to a situation where the stagger of joints within turnouts and crossovers is less



SPLIT SWITCH WITH GRADUATED RISERS



RAIL BOUND MANGANESE STEEL FROG

Figure 18
A.R.E.A. Plan No. 241-55

than desirable. Many railroads have standard plans for turnouts and crossovers which among other things show the recommended locations for joints in such trackwork. In some cases, pre-cut lead rails of special lengths are available to reduce cutting and drilling of rails on the job site. You should become familiar with such plans, not necessarily to the extent of learning the various rail lengths and locations, but to the extent of being able to find the needed information when you need to put it to use.

TURNOUT CLOSURE RAILS

The rails which connect the heels of the switch with the toes of the frog are the closure rails. In a right-hand or left-hand turnout, the length of the curved closure will be slightly longer than the length of the straight closure. In the case of an equilateral turnout, the two closures will be of equal length. In most cases more than one rail will be required to complete each closure. In signal circuited territory, an insulated joint will be required at an intermediate point within the curved closure if the normal route of traffic is to the straight side.

In present-day practice, there is a trend toward the reduction in the number of joints in turnouts and crossovers through the use of welded rail. There can be a good deal of variation in the extent to which this practice is carried out. Where only light traffic is anticipated on the turnout side, the effort to eliminate joints may be limited to the main-track side. In other cases, the effort to eliminate joints may receive equal attention on both routes. In some instances, joints at the toe and heel of the frog are eliminated through welding. Many times they are not welded, and either conventional or adhesive type joints are installed. Stock rails may be prepared in a shop, and after installation the ends may be either field welded or connected with joints. In other cases, continuous welded rail may be laid through the stock-rail locations. The drilling, bending and grinding operations can then be performed in track.

If it is desired to eliminate as many joints as possible, this can be accomplished with the exception of the heel joints between switch points and closure rails and the insulated joints.

SWITCH TIES ALWAYS OF WOOD

With very few exceptions, switch ties are made of timber. Although a good deal of interest is being shown in substitute materials for cross ties, such as reinforced concrete and steel, this interest does not extend to switch ties. One important reason for this is, that such other materials require a pre-set arrangement for fastenings, as the tie is constructed. In constructing turnouts, no two switch ties will have an identical arrangement of fasteners. The ability of the timber switch tie to be spiked in whatever locations are required, is a very important factor in favor of this material for use in turnouts and crossovers.

Some railroads purchase switch ties in increments of 6 inches in length. Others use increments of 1 foot. Usually the minimum length is 9 feet with the increments increasing to about 16 feet. Ties several feet longer than this are also provided for crossovers, the actual length being dependent upon prevailing track centers. Turnout and crossover plans usually indicate the number of switch ties required of each length and their location for commonly used track layouts. The usual practice is to maintain a uniform alignment of switch tie ends on the straight side at a fixed distance from the near rail. The tie ends on the turnout side will then follow a stopped pattern for each increment in length. Figure 19 shows a typical pattern of switch tie layout for a turnout.

Usually, the greatest care in maintaining spacing between switch ties, as shown on the plan, has to be in the vicinity of the switch and the frog. This is due to the need for clearance for the switch rods and clips, and for proper placement of frog guard rails.

No effort has been made in this lesson to explain how to detect any of the many types of defects which can develop in turnouts and crossovers through use. Nor has any attempt been made to deal with the construction and maintenance of such trackwork. These subjects will be dealt with later in this course. A good understanding of the principles of the design of turnouts and crossovers which this lesson has covered, will benefit you when you undertake the study of these other subjects. In the meantime, when opportunities are available, look closely at turnouts and crossovers in track. Learn to identify each part properly. Acquire a knowledge of the types of each part with which you are likely to come in contact.

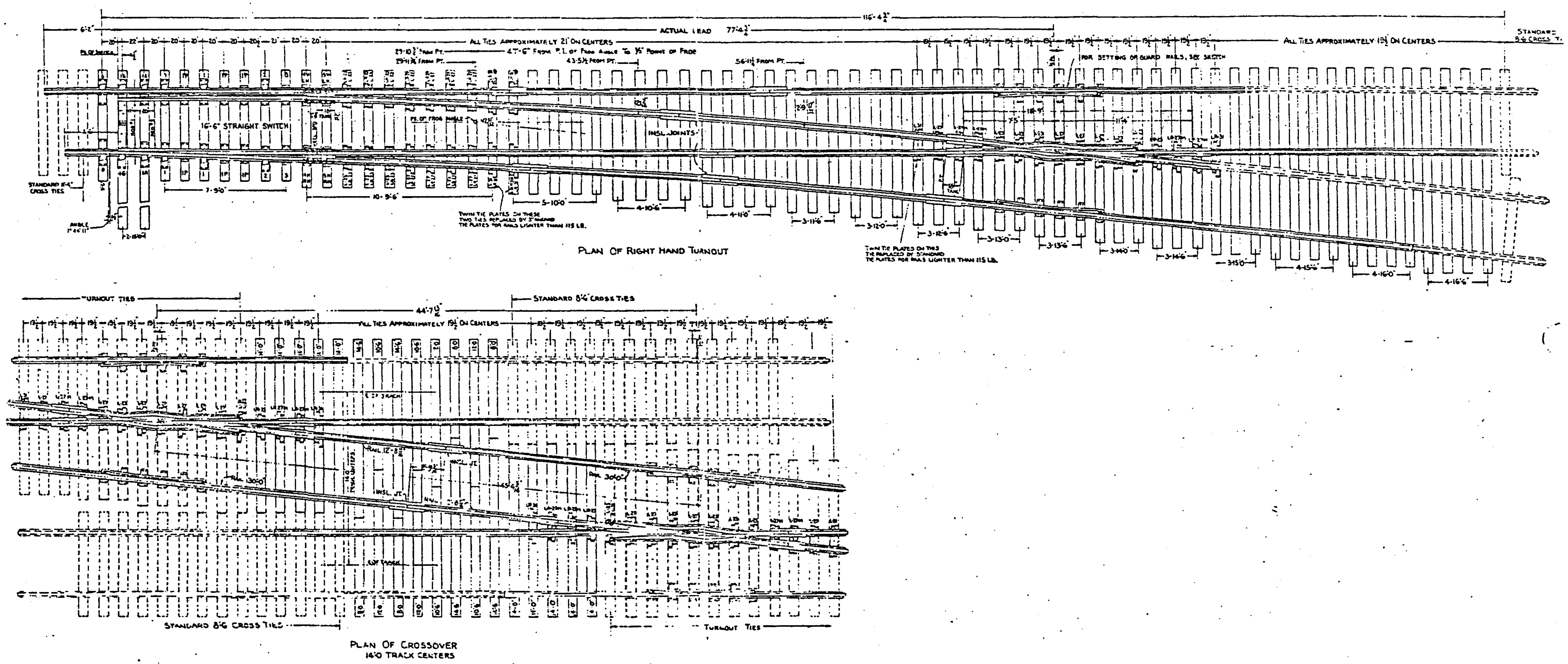


Figure 19
A.R.E.A. Plan No. 10-71 Sheet 1
No. 10 TURNOUT AND CROSSOVER

LESSON 2

EXERCISE QUESTIONS

1. A turnc .t with which frog is capable of higher speed train movements?

   a) No. 10
   b) No. 15

2. What type of frog should be restricted to locations with light traffic only on the turnout side?

3. Which end of a frog is placed closest to the switch, the toe or the heel?

4. Indicate the proper switch point to use with a left-hand curved stock rail.

   a) Right hand curved switch point
   b) Left hand straight switch point
   c) Left hand curved switch point
   d) Right hand straight switch point

5. With which type of switch are hook plates likely to be used under the closure rails behind the heel blocks?

   a) Uniform risers
   b) Graduated risers

6. Which of the following types of frog is suitable for the most severe traffic conditions?

   a) Solid manganese steel frog
   b) Bolted rigid frog
   c) Rail-bound manganese steel frog

7. What is the name of the device which connects a switch rod to a switch point?

8. At what type of joint is a bent joint bar used?

9. What is the name of the bolt which connects a switch clip to a switch rod?

10. What is the part called which connects the mechanism by which the switch is moved to the switch?

(Exercise Questions continued on next page)

11. Where are closure rails used?

12. Where in a turnout are adjustable braces used?

13. What prevents wheel flanges from climbing onto a frog point?

14. What is the rod called to which the operating rod is attached?

15. Why should both switch points in a switch be of the same length?

Indicate whether the following statements are true or false.

16. Self-guarded frogs should not be used for high-speed traffic.

17. Two sets of switch ties for turnouts make one set for a crossover.

18. The best place for the joint of the stock rail which is on the turnout side is in the heel block.

19. The theoretical point of a frog is usually not marked on the frog.

Submit your answers to these questions to The Railway Educational Bureau in the prescribed manner. Be sure to include your name, file number, address, company's name and lesson number on the upper right hand corner of your paper.

22 CIRCULAR CURVES

22-1. GENERAL. Straight (tangent) sections of most types of transportation routes, such as highways, railroads, and pipelines, are connected by curves in both the horizontal and vertical planes. An exception is a transmission line, in which a series of straight lines is used with direct angular changes at tower locations.

Two types of horizontal curves are employed—circular arcs and spirals. A *simple curve*, Fig. 22-1(a), is a circular arc connecting two tangents. A *compound curve*, Fig. 22-1(b), is composed of two or more circular arcs of different radii tangent to each other, with their centers on the same side of the common tangent. The combination of a short length of tangent connecting two circular arcs having centers on the same side, as in Fig. 22-1(c), is called a *broken-back curve*. A *reverse curve*, Fig. 22-1(d), consists of two circular arcs tangent to each other, the centers being on opposite sides of the common tangent. Reverse, compound, and short-tangent (less than 100 ft) broken-back

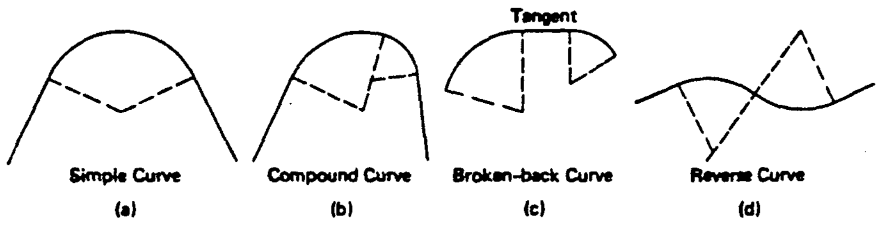


Figure 22-1. Circular curves.

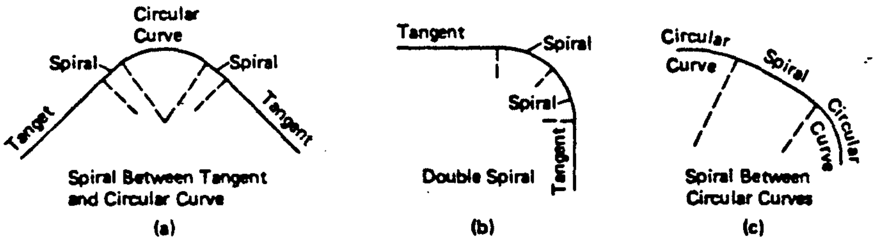


Figure 22-2. Use of spiral transition curves.

curves are unsuitable for modern high-speed highway, rapid transit, and railroad traffic.

Easement curves are desirable to lessen the sudden change in curvature at the junction of a tangent and a circular curve. A *spiral* makes an excellent easement curve because its radius decreases uniformly from infinity at the tangent to that of the curve it meets. Spirals are used to connect a tangent with a circular curve, a tangent with a tangent (double spiral), and a circular curve with a circular curve and compounded or reversed curves. Figure 22-2 illustrates most of these arrangements.

The effect of centrifugal force on a vehicle passing around a curve can be balanced by *superelevation* of the outer rail of a track and outer edge of a highway pavement. Correct superelevation on a spiral increases uniformly with the distance from the beginning of the spiral, and is in inverse proportion to the radius at any point. Properly superelevated spirals ensure smooth and safe riding qualities with less wear on equipment. For detailed coverage of the spiral and superelevation, the reader is referred to one of the books on route surveying listed in the References, Appendix B.

Circular arcs and spirals are used for curves in the horizontal plane because they are readily laid out in the field by transit and tape.

Grade lines are joined in the vertical plane by parabolic curves, discussed in Chapter 23. Elevations on parabolic curves are easily computed and can be established on the ground by leveling.

22-2. DEGREE OF CURVE. In European practice and the majority of American highway work, circular curves are designated by their radius; for example, "1500-m curve" and "1000-ft curve." American railroads and some highway departments prefer to identify curves by their *degree*, employing either chord or arc definition.

In railroad practice (and early highway construction), the degree of curve has been the angle at the center of a circular arc subtended by a chord of 100 ft. This is the *chord definition* shown in Fig. 22-3(a). In most highway work, degree of a curve is the central angle subtended by a circular arc of 100 ft,

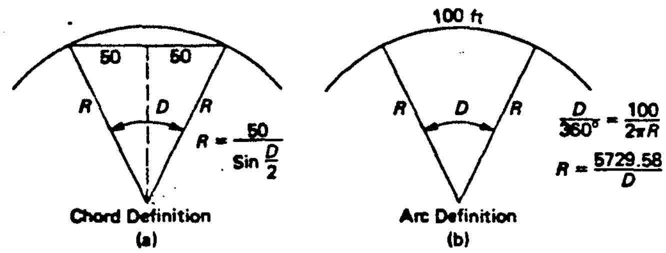


Figure 22-3. Degree of curve.

the *arc definition*, Fig. 22-3(b). Formulas relating the radius R and degree D are shown beside the illustrations.

Radii of chord- and arc-definition curves for values of D from 1° to 6° are given in Table B-6. Although the differences appear to be small in this range, they have some significance in computations.

A chord-definition curve is consistent in using chords for computation and layout with 100.00-ft tape lengths for full stations on large-radius curves. Its disadvantages are: (a) R is not directly proportional to the reciprocal of D; (b) the formula for length is slightly approximate; (c) small corrections must be added in using the "shortcut" formulas for tangent distance and external distance; and (d) greater difficulty is encountered in checking sharp curves.

The arc-definition curve has the disadvantage that most measurements between stations are less than a full tape length. Computations are facilitated since exact answers for the radius, tangent distance, and external distance are obtained by dividing tabular values for a 1° curve by the degree D. Also, the formula for length is exact, this being an advantage in preparing right-of-way descriptions.

Arc and chord definitions give practically the same result when applied to the flat curves common on modern highways and railroads.

Circular curves are usually laid out in the field by deflection angles and taped chords.

22-3. DERIVATION OF FORMULAS. Circular-curve elements are shown in Fig. 22-4. The *point of intersection* of the tangents (PI) is also called the *vertex* (V). The *beginning of the curve* (BC) and the *end of the curve* (EC) are also termed the *point of curvature* (PC) and the *point of tangency* (PT). Other expressions for these points are *tangent to curve* (TC) and *curve to tangent* (CT).

The distance from the BC to the PI, and from the PI to the EC, is the *tangent distance* (T). A line connecting the BC and EC is the *long chord* (LC). *Length of curve* (L) is the distance from BC to EC measured along the curve for arc definition, or by 100-ft chords for the chord definition.

The *external distance* (E) is the length from vertex to curve on a radial line. *Middle ordinate* (M) is the (radial) distance from midpoint of the long chord to midpoint of the curve. Any *point on the curve* is a POC, on a *tangent*, POT. The degree of any curve is D_a (arc definition), or D_c (chord definition).

The change in direction of the two tangents is the intersection angle I, which is equal to the central angle.

By definition, and inspection of Fig. 22-4, relations for the *arc definition* follow:

$$\frac{D^\circ}{360^\circ} = \frac{100}{2\pi R} \quad \text{and} \quad R = \frac{100 \times 360}{2\pi D} = \frac{5729.58}{D} \tag{22-1}$$

$$T = R \tan \frac{I}{2} \tag{22-2}$$

$$T_a = \frac{T_{1^\circ}}{D_a} \tag{22-3}$$

$$L = 100 \frac{I}{D} \tag{22-4a}$$

$$= RI \text{ (} I \text{ in radians)} \tag{22-4b}$$

$$\text{LC} = 2R \sin \frac{I}{2} \tag{22-5}$$

$$\frac{R}{R+E} = \cos \frac{I}{2}; \; E = R\left(\sec \frac{I}{2} - 1\right) = R \operatorname{exsec} \frac{I}{2} \tag{22-6}$$

$$E_a = \frac{E_{1^\circ}}{D_a} \tag{22-7}$$

$$\frac{R-M}{R} = \cos \frac{I}{2}; \; M = R\left(1 - \cos \frac{I}{2}\right) = R \operatorname{vers} \frac{I}{2} \tag{22-8}$$

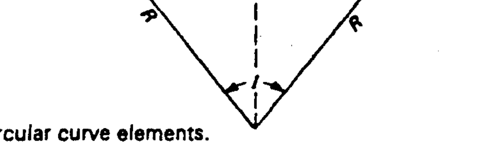


Figure 22-4. Circular curve elements.

In Eqs. (22-3) and (22-7), T_a and E_a are the tangent distance and external distance respectively for the given value of D_a, while $T_{1°}$ and $E_{1°}$ are their lengths (listed in tables) for a 1° curve and different values of I.

The formulas for T, L, E, and M apply also to a chord-definition curve. Small corrections must be added to the values of T_a and E_a found by Eqs. (22-3) and (22-7), respectively.

The formula relating R and D for a chord-definition curve is as follows:

$$R = \frac{50}{\sin D/2} \tag{22-9}$$

$D = 2 \text{ ARCSIN } \frac{50}{R}$

22-4. SAMPLE COMPUTATION.

Assume that field measurements show $I = 8°24'$ and the station of the PI is 64 + 27.46, and terrain conditions require use of the maximum degree of curve permitted by the specifications, which is, say, 2°00′. Then, for an *arc-definition* curve,

$$R = \frac{5729.58}{2} = 2864.79 \text{ ft}$$

$$T = 2864.79 \times 0.073435 = 210.38 \quad \text{or} \quad T = \frac{420.75}{2} = 210.38$$

$$L = 100 \times \frac{8.40}{2} = 420.00$$

$$E = 2864.79 \times 0.002693 = 7.71 \quad \text{or} \quad E_a = \frac{E_1}{D_a} = \frac{15.42}{2} = 7.71$$

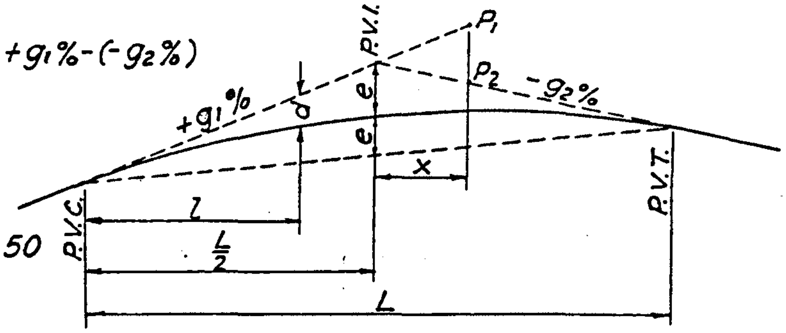
$$M = 2864.79 \times 0.002686 = 7.69 \text{ ft}$$

$$\begin{aligned} \text{Station PI} &= 64 + 27.46 \\ -T &= \underline{\ \ 2 + 10.38} \\ \text{Station BC} &= 62 + 17.08 \\ +L &= \underline{\ \ 4 + 20.00} \\ \text{Station EC} &= 66 + 37.08 \end{aligned}$$

Calculations for the stations of the BC and EC should be arranged as shown. Note that the station of the EC *cannot* be obtained by adding the tangent distance to the station of the PI, although location of the EC on the ground is determined by measuring the tangent distance from the PI. Points representing the BC and EC must be carefully marked, and placed exactly on the tangent lines at the correct distance from the PI, so other computed values will fit their fixed positions on the ground. Field notes for this curve are given in Plate A-13. An instrument setup station on the curve is denoted by POC.

Since normally a route survey is a series of tangents having continuous stationing, an adjustment has to be made at each EC after curves have been

HIGHWAYS - CURVES-I



ɔulas
Alnebraic difference of grades = $+g_1\% - (-g_2\%)$

$\frac{\ell \Lambda}{2L}$; $d = 4e(\frac{l}{L})^2$
ɔple
ven:
$g_1\% = +3.00\%$; $g_2\% = -2.00\%$; $L = 3.00$; $l = 0.50$
quired:
A, e and d.
lution:
$A = 3.00 - (-2.00) = 5.00$
$e = \frac{5.00 \times 3.00}{8} = 1.875'$
$d = \frac{0.50^2 \times 5.00}{2 \times 3.00} = 0.208'$
$d = 4(1.875)(\frac{0.50}{3.00})^2 = 0.208'$

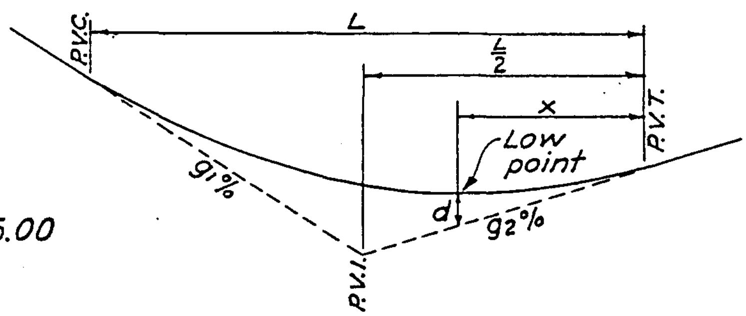
VERTICAL SUMMIT CURVE

Length of vertical summit curves should provide required sight distance. See page 12-13.

NOTE: All horizontal distances shown on this page - L, l, l_1, l_2, x, x_1, x_2 - are expressed in 100' stations.

FIND STA. OF P.V.I. WHEN ELEVATIONS P_1 AND P_2 ARE KNOWN.
ɔula
$x = \frac{\text{elev. } P_1 - \text{elev. } P_2}{A}$
ɔple
ven:
Elev. $P_1 = 154.50$; Elev. $P_2 = 150.00$; $A = 5.00$
quired:
x = distance in 100' stations from known point to P.V.I.
lution:
$x - \frac{154.50 - 150.00}{5.00} = 0.90$ (100' stations)

D LOW POINT ON SAG CURVE
ɔulas
$x = g$ (lesser gradient) $\frac{L}{A}$
d (at low point) $= \frac{x^2 A}{2L}$
ɔple
ven:
$g_1\% = -3.00\%$; $g_2 = +2.00\%$; $L = 3.00$; $A = 5.00$
quired:
x and d
lution:
$x = 2.00 \times \frac{3.00}{5.00} = 1.20$
$d = \frac{1.20^2 \times 5.00}{2 \times 3.00} = 1.20'$



VERTICAL SAG CURVE

Length of vertical sag curve should provide headlight illumination for a safe stopping distance. See page 12-15.

: High point on summit curve can be found by same method.

FIG. A - SYMMETRICAL VERTICAL CURVES.

ılas
$e = \frac{l_1 l_2}{2(l_1 + l_2)} A$; $y_1 = e(\frac{x_1}{l_1})^2$; $y_2 = e(\frac{x_2}{l_2})^2$
ɔle
en:
$g_1 = +3.00\%$; $g_2 = -2.00\%$; $L = 4.00$; $l_1 = 1.50$; $l_2 = 2.50$; $x_1 = 0.50$; $x_2 = 1.00$
uired:
e, y_1 and y_2
ution:
$e = \frac{1.50 \times 2.50}{2(1.50 + 2.50)}(3.00 + 2.00) = 2.34'$
$y_1 = $?35$(\frac{0.50}{1.50})^2 = 0.26'$
y 5$(\frac{1.00}{2.50})^2 = 0.38'$

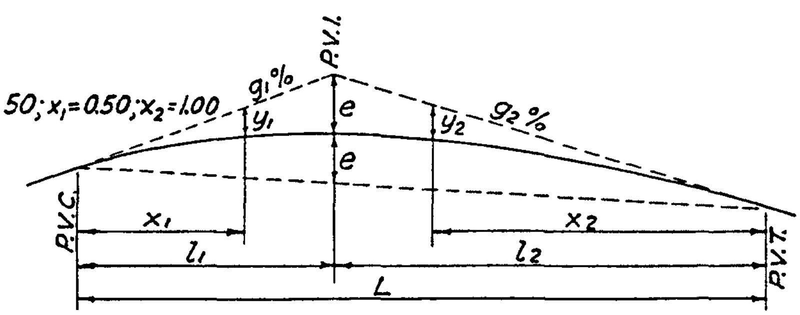
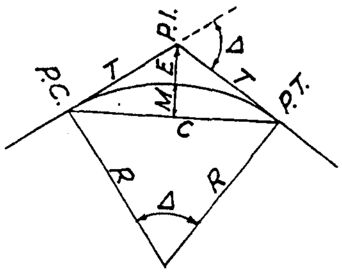


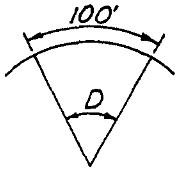
FIG. B - UNSYMMETRICAL VERTICAL CURVES.

Used to fit unusual conditions

HIGHWAYS – CURVES-2

ARC DEFINITION.





D (in degrees) subtends 100' of arc.

$$D = \frac{5729.58}{R}$$

Formulas

$R = \frac{5729.58}{D}$

$T = R \tan \frac{\Delta}{2}$; $T = \frac{\tan 1^\circ \text{ curve for } \Delta}{D}$

$L = \text{Length} = \frac{100\Delta}{D}$

$M = R(1 - \cos \frac{1}{2}\Delta)$

$E = R\left(\frac{1}{\cos\frac{1}{2}\Delta} - 1\right)$; $E = \frac{\text{ext. } 1^\circ \text{ curve for } \Delta}{D}$

$C = 2R \sin \frac{\Delta}{2}$

DEFINITIONS

L = Length of circular curve
P.I. = Point of intersection
P.C. = Point of curvature
P.T. = Point of tangency

Example

Given:

$\Delta = 54^\circ 20'$; $D = 7^\circ 40'$; P.I. = Sta. 125 + 39.88

Required:

R; T; L and Sta. of P.C. and P.T.

Solution:

$R = \frac{5729.58}{7^\circ 40'} = 747.34'$

$T = 747.34\,(\tan 27^\circ 10') = 747.34\,(0.513195) = 383.53'$

Also- From Pg.12-27 (Funct. 1° Curve) by interpolation tan 1° curve for Δ 54° 20' = 2940.4

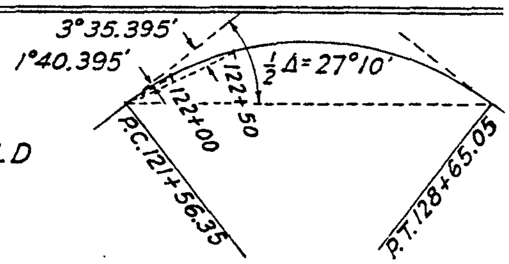
$\therefore\ T = \frac{2940.41}{7^\circ 40'} = 383.53'$

P.C. = Sta. 125 + 39.88 − 383.53 = Sta. 121 + 56.35

$L = \frac{100\Delta}{D} = \frac{100(54^\circ 20')}{7^\circ 40'} = 708.70'$

P.T. = Sta. 121 + 56.35 + 708.70 = Sta. 128 + 65.05

DEFLECTIONS



Formulas

Deflection angle = $\frac{D}{2}$ for 100'; $\frac{D}{4}$ for 50', etc.

For "c" feet (in minutes) = 0.3 cD

Deflection angle (in minutes) from P.C. to P.T. = 0.3LD

Also- Deflection angle (in degrees) from P.C. to P.T. = $\frac{\Delta}{2}$

Example

Given:

$\Delta = 54^\circ 20'$; $D = 7^\circ 40'$; L = 708.70; P.C. = Sta. 121+56.35; P.T. = Sta. 128+65.05

Required:

Deflection angle from P.C. to Sta. 122+00; Sta. 122+50 and P.T. Sta. 128+65.05

Solution:

Sta. 122+00 − P.C. Sta. 121+56.35 = 43.65'

$\therefore$ Deflection angle to Sta. 122+00 = $0.3 \times 43.65 \times 7^\circ 40' = 100.395' = 1^\circ 40.395'$

Deflection angle to Sta. 122+50 = $1^\circ 40.395' + \frac{7^\circ 40'}{4} = 1^\circ 40.395' + 1^\circ 55' = 3^\circ 35.395'$

Deflection angle to P.T. Sta. 128+65.05 = $0.3 \times 708.70 \times 7^\circ 40' = 27^\circ 10'$

Also- Deflection angle to P.T. Sta. 128+65.05 = $\frac{\Delta}{2} = \frac{54^\circ 20'}{2} = 27^\circ 10'$

EXTERNALS

Example

Given:

$\Delta = 54^\circ 20'$; $D = 7^\circ 40'$; R = 747.34'

Required:

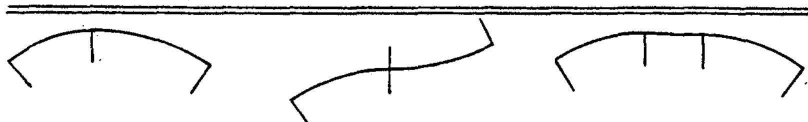
External "E"

Solution:

$E = 747.34\left(\frac{1}{.8896822} - 1\right) = 92.67'$

Also- From Pg.12-27 (Funct. 1° curve) by interpolation external 1° curve for Δ 54° 20' = 710.48

$\therefore\ E = \frac{710.48}{7^\circ 40'} = 92.67'$

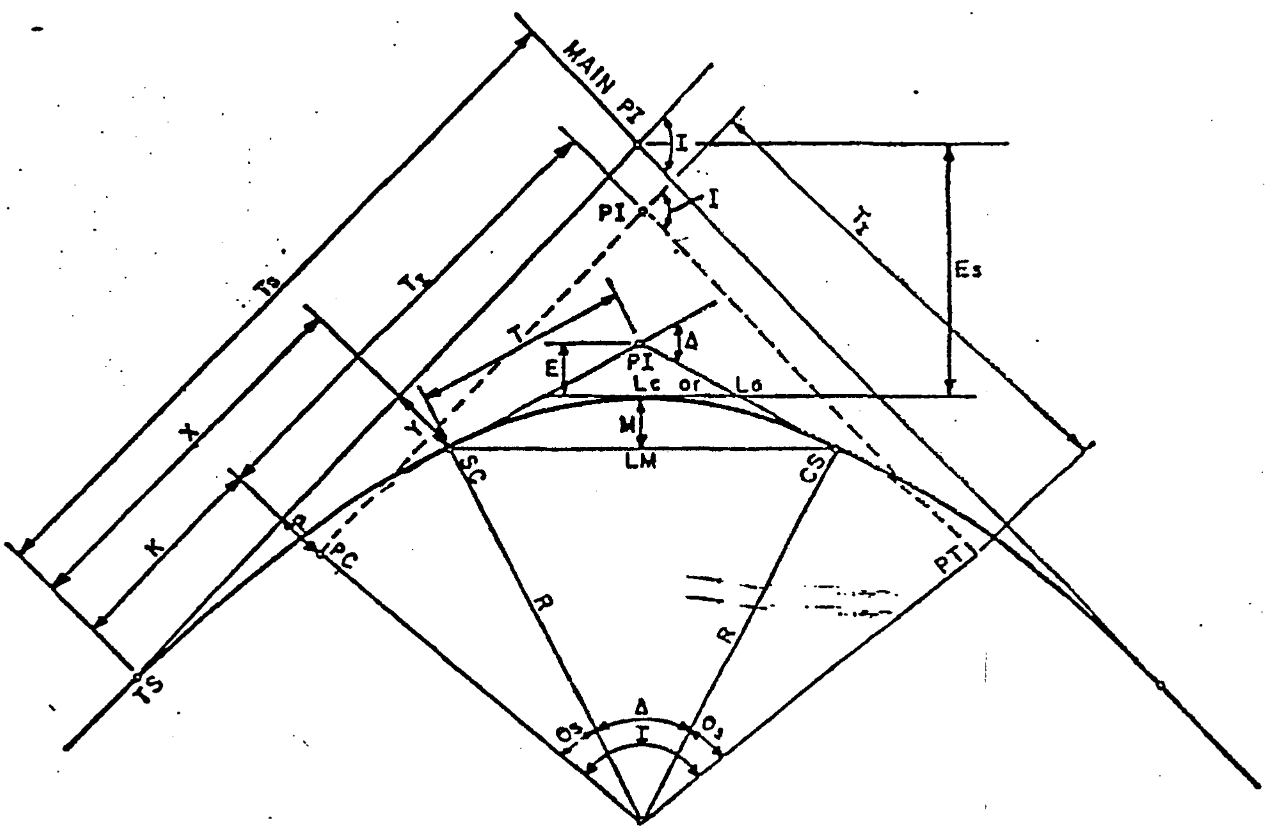


Compound curve Avoid — Reverse curve Avoid — Broken-back curve Avoid

TANGENT OFFSETS: The approximate offset from the tangent to the curve at any dista[nce] from the P.C. distance?

CIRCULAR CURVES

- I = TOTAL INTERSECTION ANGLE
- Δ = CENTRAL ANGLE OF CIRCULAR CURVE = $I - 2\theta_s$ (EQUAL SPIRAL LENGTHS)
- Δ = CENTRAL ANGLE OF CIRCULAR CURVE = $I - (\theta_{s1} + \theta_{s2})$ (UNEQUAL SPIRAL LENGTHS)
- D_c = DEGREE OF CURVE (100 FT. CHORD DEFINITION) = $2 \text{ ARC SIN} \frac{50}{R}$
- D_a = DEGREE OF CURVE (ARC DEFINITION) = $\frac{18,000}{\pi R}$
- R = RADIUS OF CIRCULAR CURVE
- T = TANGENT LENGTH OF CIRCULAR CURVE = $R \tan \frac{\Delta}{2}$
- L_c = LENGTH OF CIRCULAR CURVE (CHORD DEFINITION) = $\frac{\Delta}{D_c} \times 100$
- L_a = LENGTH OF CIRCULAR CURVE (ARC DEFINITION) = $\frac{\Delta}{180} \pi R$
- E = EXTERNAL DISTANCE = $R \,\text{EXSEC} \frac{\Delta}{2}$
- LM = CHORD LENGTH OF CIRCULAR CURVE = $2R \sin \frac{\Delta}{2}$
- M = MIDDLE ORDINATE DISTANCE = $R(1 - \cos \frac{\Delta}{2})$
- PC = POINT OF CURVE
- PT = POINT OF TANGENCY
- TS = TANGENT SPIRAL
- SC = SPIRAL CURVE
- CS = CURVE SPIRAL
- ST = SPIRAL TANGENT
- PI = POINT OF INTERSECTION
- T_I = TANGENT LENGTH FROM P.C. TO P.I. $T_I = R \tan \frac{I}{2}$



MASSACHUSETTS BAY TRANSPORTATION AUTHORITY
SOUTHWEST CORRIDOR PROJECT
ENGINEERING DESIGN MANUAL

HORIZONTAL CURVES
CIRCULAR CURVES

FIG II-E

SPIRAL TRANSITION CURVE

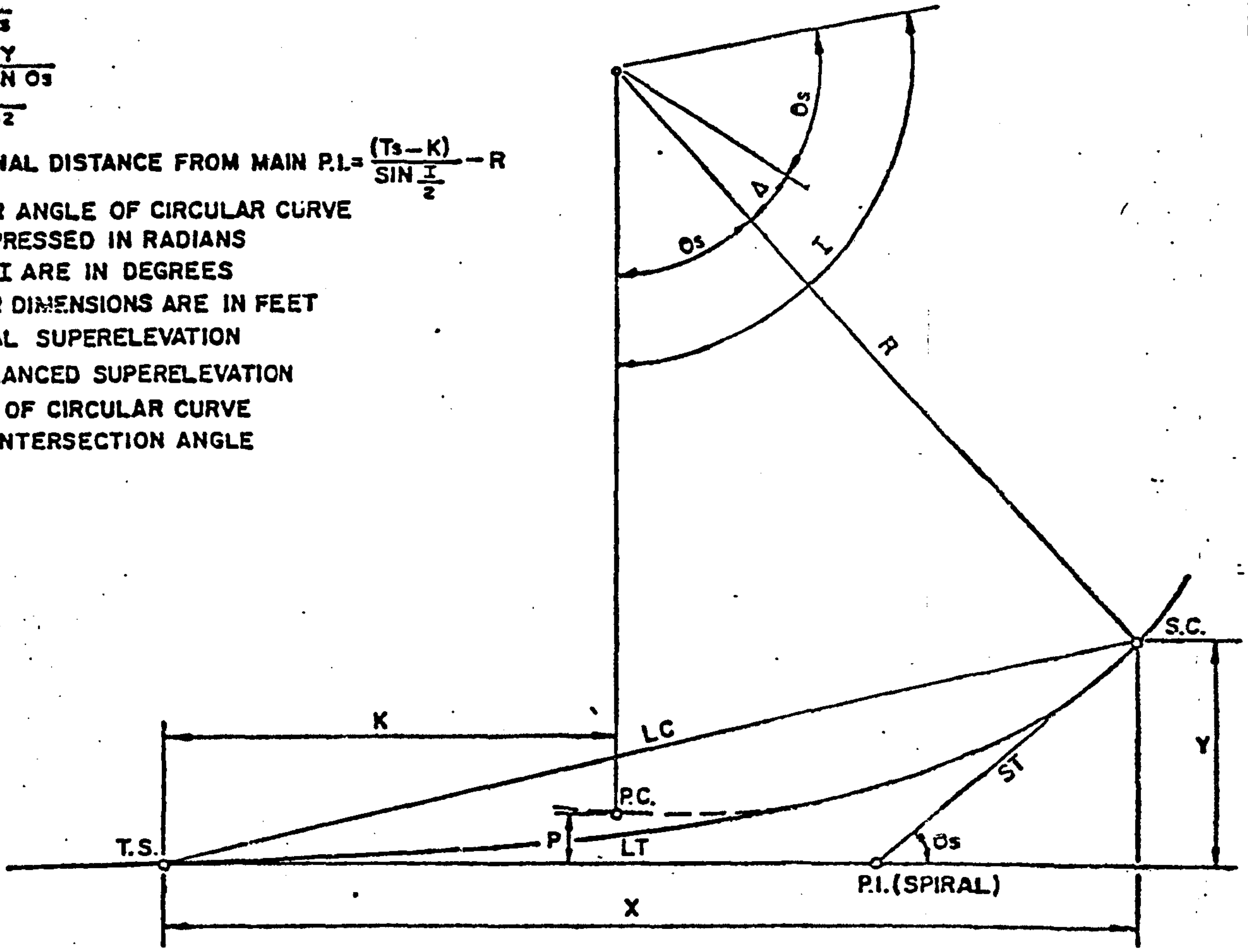
- Ls = LENGTH OF SPIRAL
- θs = SPIRAL ANGLE = $\frac{Ls\,Dc}{200}$ (CHORD DEFINITION) = $\frac{Ls\,Da}{200}$ (ARC DEFINITION)

$$X = Ls\left(1 - \frac{\delta s^2}{10} + \frac{\delta s^4}{216} - \frac{\delta s^6}{9360} + \frac{\delta s^8}{685{,}440}\right)$$

$$Y = Ls\left(\frac{\delta s}{3} - \frac{\delta s^3}{42} + \frac{\delta s^5}{1320} - \frac{\delta s^7}{75{,}600} + \frac{\delta s^9}{6{,}894{,}720}\right)$$

- $P = Y - R\,(1 - \cos\theta s)$
- $K = X - R\sin\theta s$
- Ts = TANGENT LENGTH FROM T.S. TO MAIN P.I. (EQUAL SPIRAL LENGTHS) $= (R+P)\tan\frac{I}{2} + K$
- $Ts_1 = T_2 + K + \frac{P_2 - P_1\cos I}{\sin I}$ (UNEQUAL SPIRAL LENGTHS)
- $Ts_2 = T_1 + K + \frac{P_1 - P_2\cos I}{\sin I}$
- $ST = \frac{Y}{\sin\theta s}$
- $LT = X - \frac{Y}{\tan\theta s}$
- $LC = \sqrt{X^2 + Y^2}$
- Es = EXTERNAL DISTANCE FROM MAIN P.I. $= \frac{(Ts - K)}{\sin\frac{I}{2}} - R$

Δ = CENTER ANGLE OF CIRCULAR CURVE
δs = θs EXPRESSED IN RADIANS
Dc, θs, Δ & I ARE IN DEGREES
ALL OTHER DIMENSIONS ARE IN FEET
Ea = ACTUAL SUPERELEVATION
Eu = UNBALANCED SUPERELEVATION
R = RADIUS OF CIRCULAR CURVE
I = TOTAL INTERSECTION ANGLE



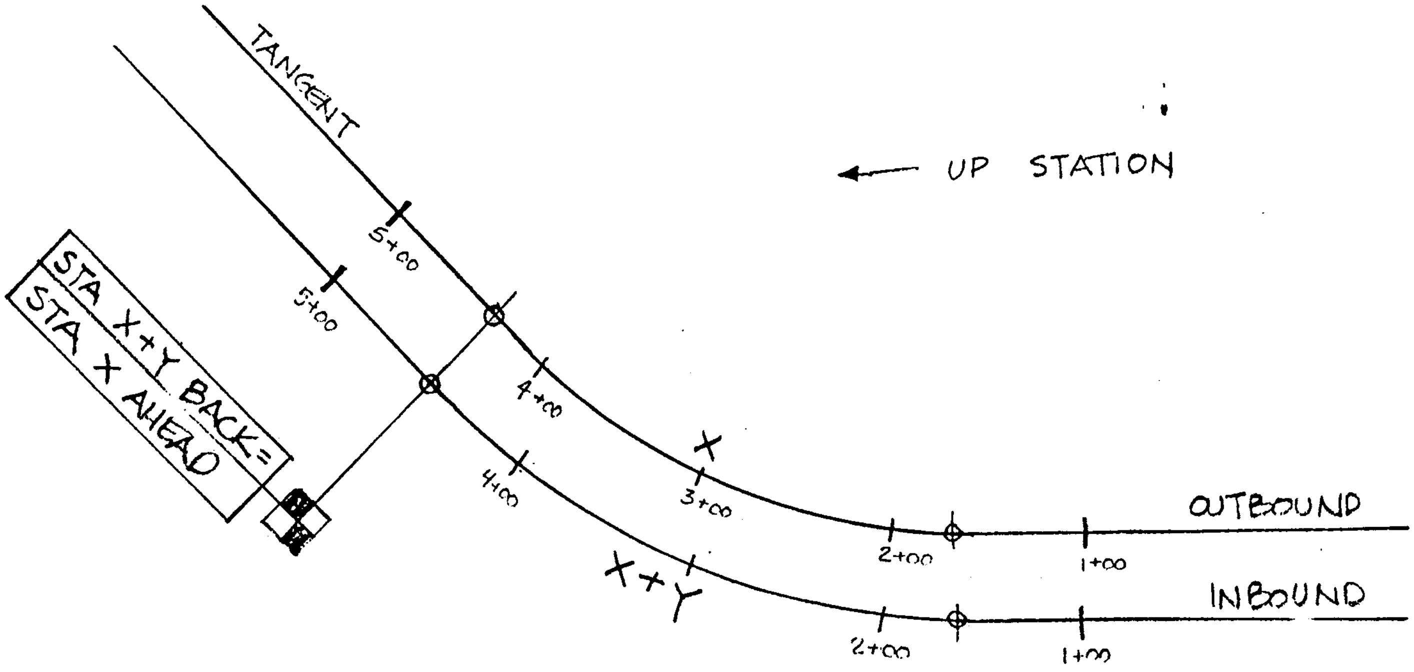
SUPERELEVATION

ACTUAL SUPERELEVATION (Ea) WILL BE ATTAINED AND REMOVED LINEARLY THROUGHOUT THE FULL LENGTH OF THE SPIRAL TRANSITION CURVE

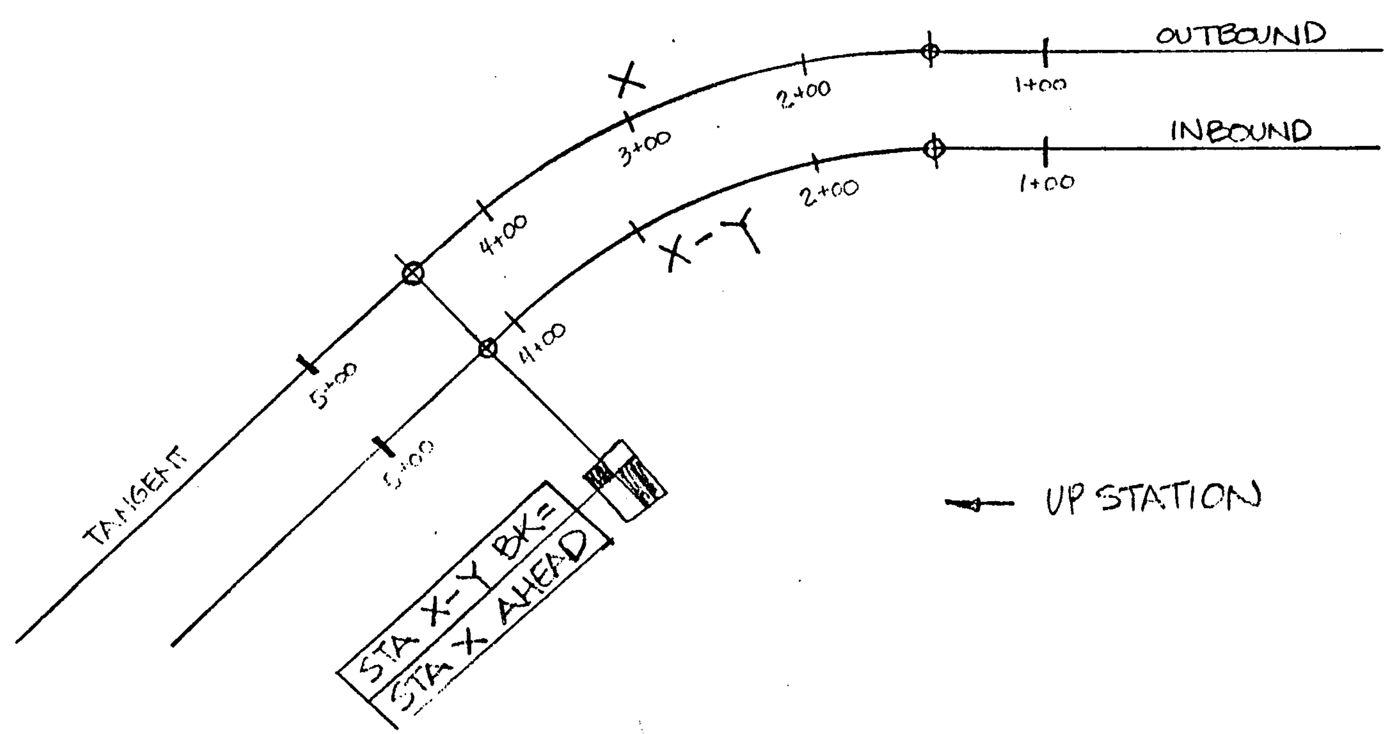
NO SCALE

MASSACHUSETTS BAY TRANSPORTATION AUTHORITY SOUTHWEST CORRIDOR PROJECT ENGINEERING DESIGN MANUAL KAISER ENGINEERS, INC / FAY, SPOFFORD & THORNDIKE, INC	HORIZONTAL CURVES SPIRAL TRANSITION CURVES	FIG II-D
REV: 0	DATE: 9-15-78	APPROVED: WJC

BOUND CURVE IS LONGER
IAN OUTBOUND CURVE



INBOUND CURVE IS SHORTER
THAN OUTBOUND CURVE



KC/TSI

A JOINT VENTURE

JOB NO. KM-6

SHEET 1 OF 1

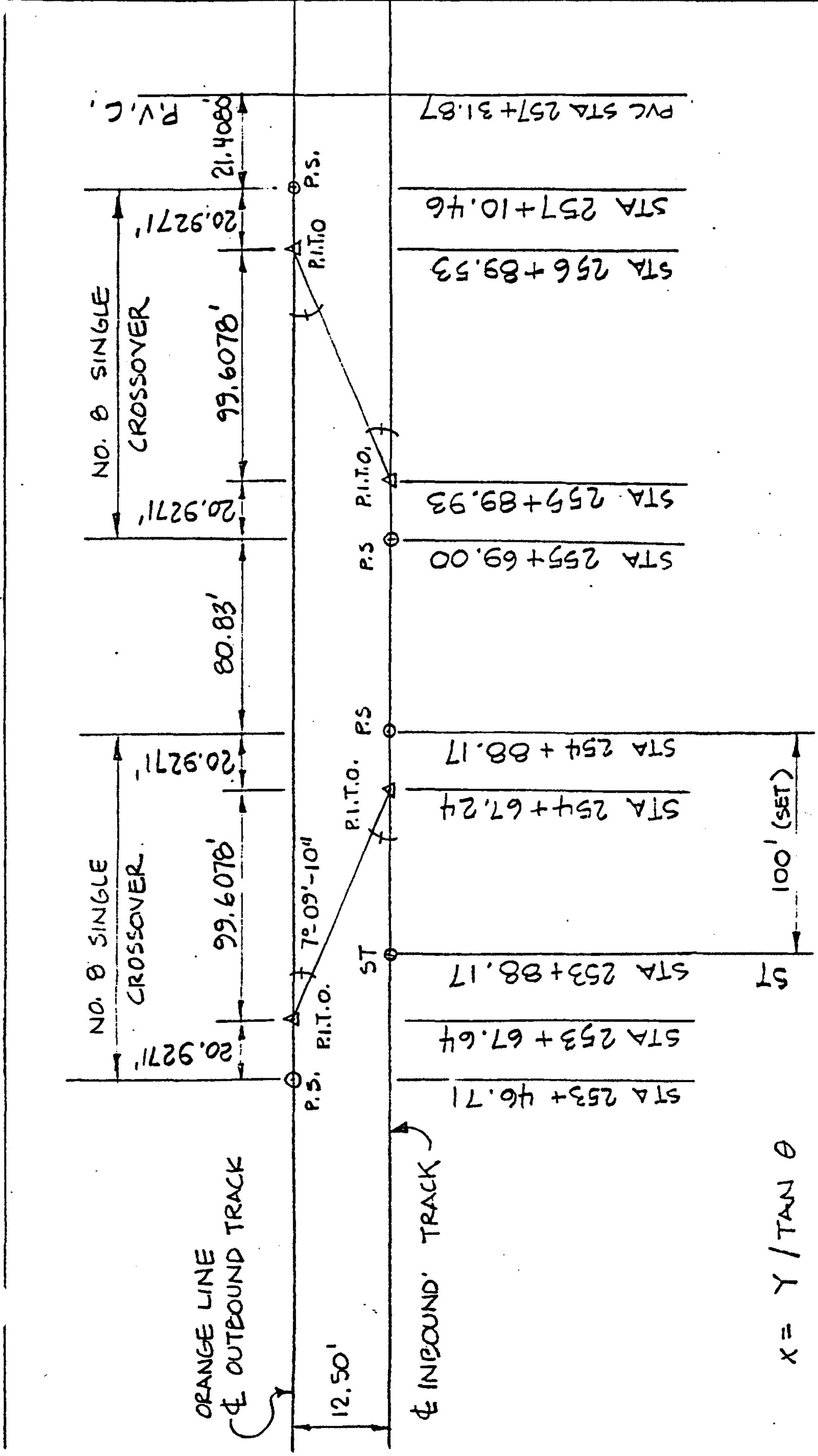
BACK BAY

NO. 8 SINGLE CROSSOVERS

ORANGE LINE

DESIGNED BY SK DATE 6/25/79

CHECKED BY WDH DATE 7/3/79



$X = Y / \tan \theta$

$X = 12.50 / \tan 7°\text{-}09'\text{-}10''$

$= 99.6078$

$= 99.61'$

TRACK CONSTRUCTION TOLERANCES

Type of Track	Rate of Change of Alignment	Gauge Variation	Cross Level and Superelevation Variation	Vertical Track Alignment: Total Deviation	Vertical Track Alignment: Middle Ordinate In 62' Chord (See 5)	Horizontal Track Alignment: Total Deviation	Horizontal Track Alignment: Middle Ordinate In 62' Chord or deflection in 31' tangent
Mainline Ballastless Track	1/8" in 31'	± 1/8"	±1/16 flat curves and tangents ± 1/8" superelvated curves	± 1/4"	± 1/8"	± 1/4"	± 1/8"
Mainline Ballasted Track	1/8" in 31'	± 1/8"	±1/16 flat curves and tangents ±1/8" superelevated curves	± 1/2" ± 1/4" at stations	± 1/8"	± 1/2"	± 1/8"
Yard Track	1/8" in 20'	+ 1/4" - 1/8"	± 1/4"	± 1/2"	± 1/4"	± 1/2"	± 1/4"

Notes:

(1) Total deviation is measured between the theoretical and actual alignment at any point in the track.
Total horizontal deviation in station area shall be zero inches toward the platform and 1/4 inch away from the platform.

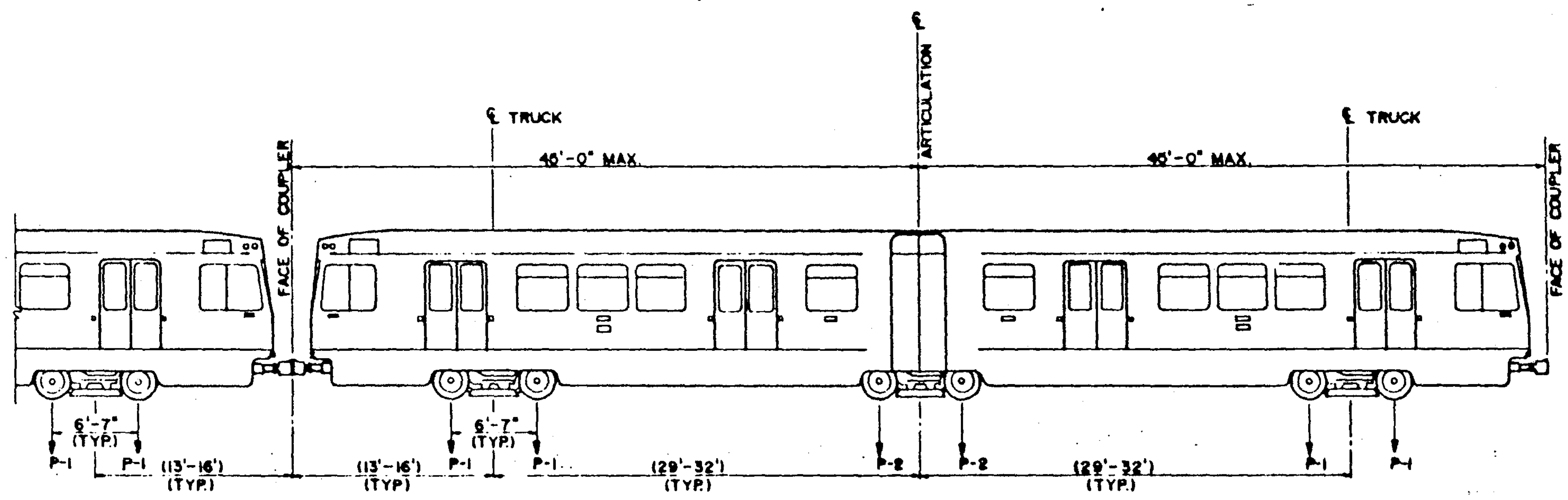
(2) Cant may vary between 1 in 40 and 1 in 30

(3) Maximum twist is 1 in 1000

(4) Rate of change of profile 1/8" in 31'

NOTES

1. VEHICLE DIMENSIONS REFLECT RANGES OR MAXIMUMS.
2. GUIDEWAY STRUCTURAL DESIGN LOAD OF 135000 LBS IS A MAXIMUM VALUE.

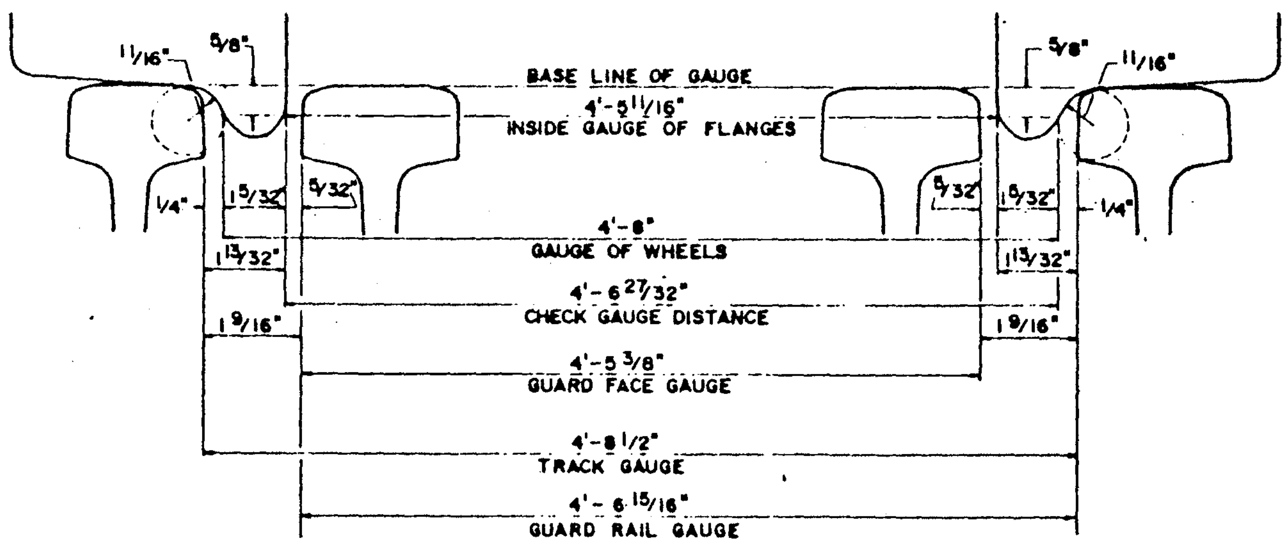


LRV DESIGN LOADING

NOT TO SCALE

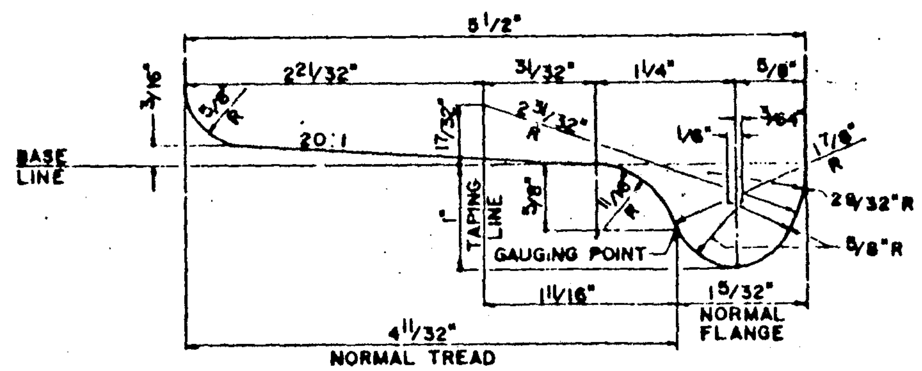
ESTIMATED LOADING DISTRIBUTION (LBS)

CONDITION	% DISTR. TO ℄ TRUCK	P-1	P-2	TOTAL
UNLOADED	20%	18200	10600	94000
	30%	16675	13650	94000
FULLY LOADED	20%	26400	14700	135000
	30%	23850	19800	135000



WHEEL MOUNTING DETAIL

NOT TO SCALE



WHEEL PROFILE

NOT TO SCALE

9/15/86	ISSUED FOR BID		
	DESCRIPTION	BY	APP

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DESIGNED BY: A. Gould
DRAWN BY
CHECKED BY: D. Sterley
APPROVED BY: R.S. Newland
DATE: 07/21/86

LOS ANGELES COUNTY TRANSPORTATION COMMISSION
The Long Beach-Los Angeles Rail Transit Project

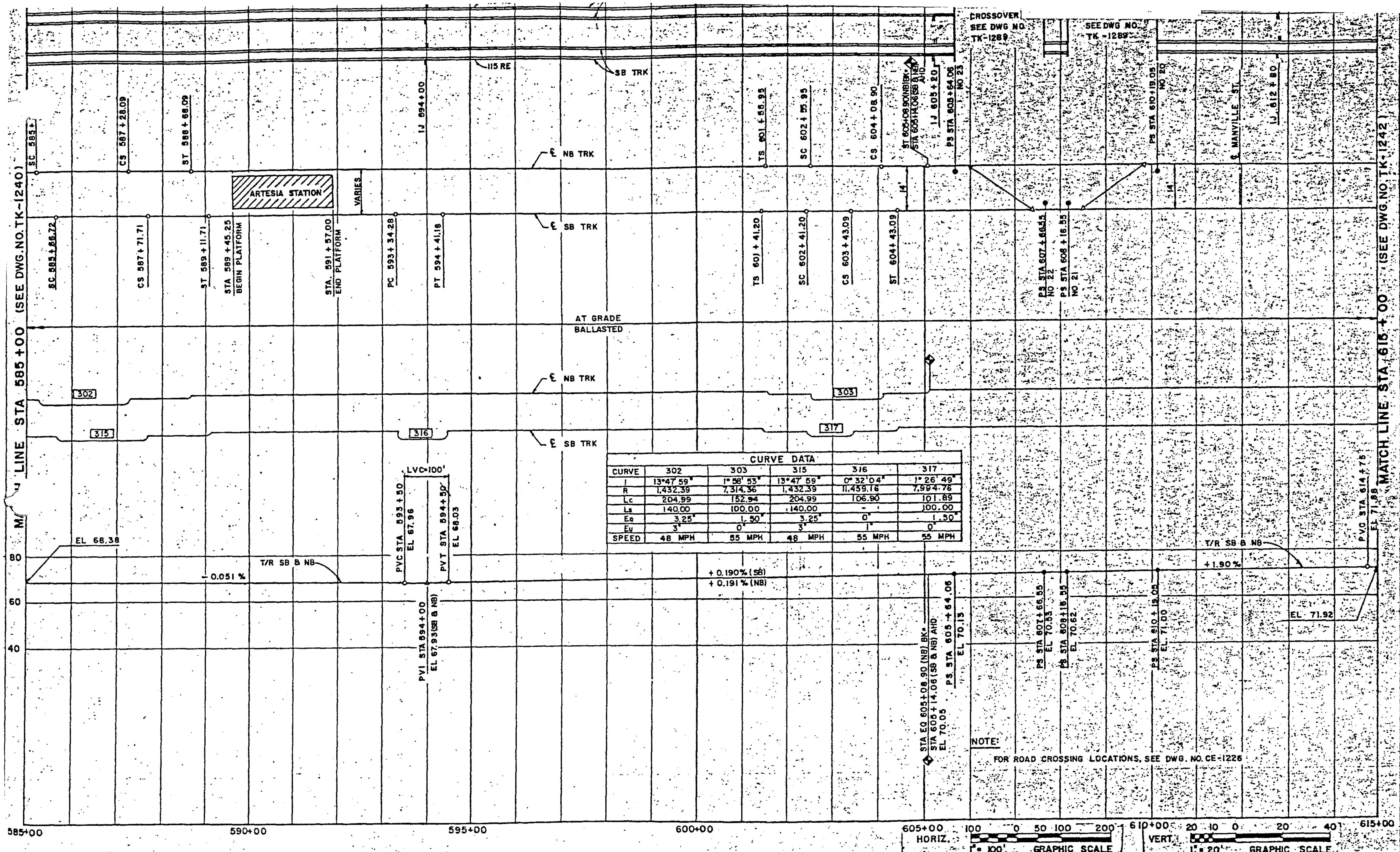
DMJM

SUBMITTED:

Southern California Rail Consultants
A Joint Venture of
Parsons Brinckerhoff Quade & Douglas, Inc.
Kaiser Engineers (California) Corporation
Daniel, Mann, Johnson & Mendenhall
APPROVED

SPECIAL TRACKWORK PROCUREMENT
LRT VEHICLE CHARACTERISTICS

CONTRACT NO. R01-T03-F830
DRAWING NO. TK-0182
REV
SHEET NO. 6
SCALE: NOT TO SCALE



CURVE DATA					
CURVE	302	303	315	316	317
I	13°47'59"	1°58'53"	13°47'59"	0°32'04"	1°26'49"
R	1,432.39	7,314.36	1,432.39	11,459.16	7,994.76
Lc	204.99	152.94	204.99	106.90	101.89
Ls	140.00	100.00	140.00	-	100.00
Ea	3.25"	1.50"	3.25"	0"	1.50"
Eu	3"	0"	3"	1"	0"
SPEED	48 MPH	55 MPH	48 MPH	55 MPH	55 MPH

NOTE:

FOR ROAD CROSSING LOCATIONS, SEE DWG. NO. CE-1226

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DESIGNED BY J.L. Patterson
DRAWN BY
CHECKED BY
APPROVED BY
DATE 03/27/87

REGISTERED PROFESSIONAL ENGINEER WAYNE K. SAN FILIPPO No. 19837 CIVIL STATE OF CALIFORNIA

LOS ANGELES COUNTY TRANSPORTATION COMMISSION
The Long Beach-Los Angeles Rail Transit Project

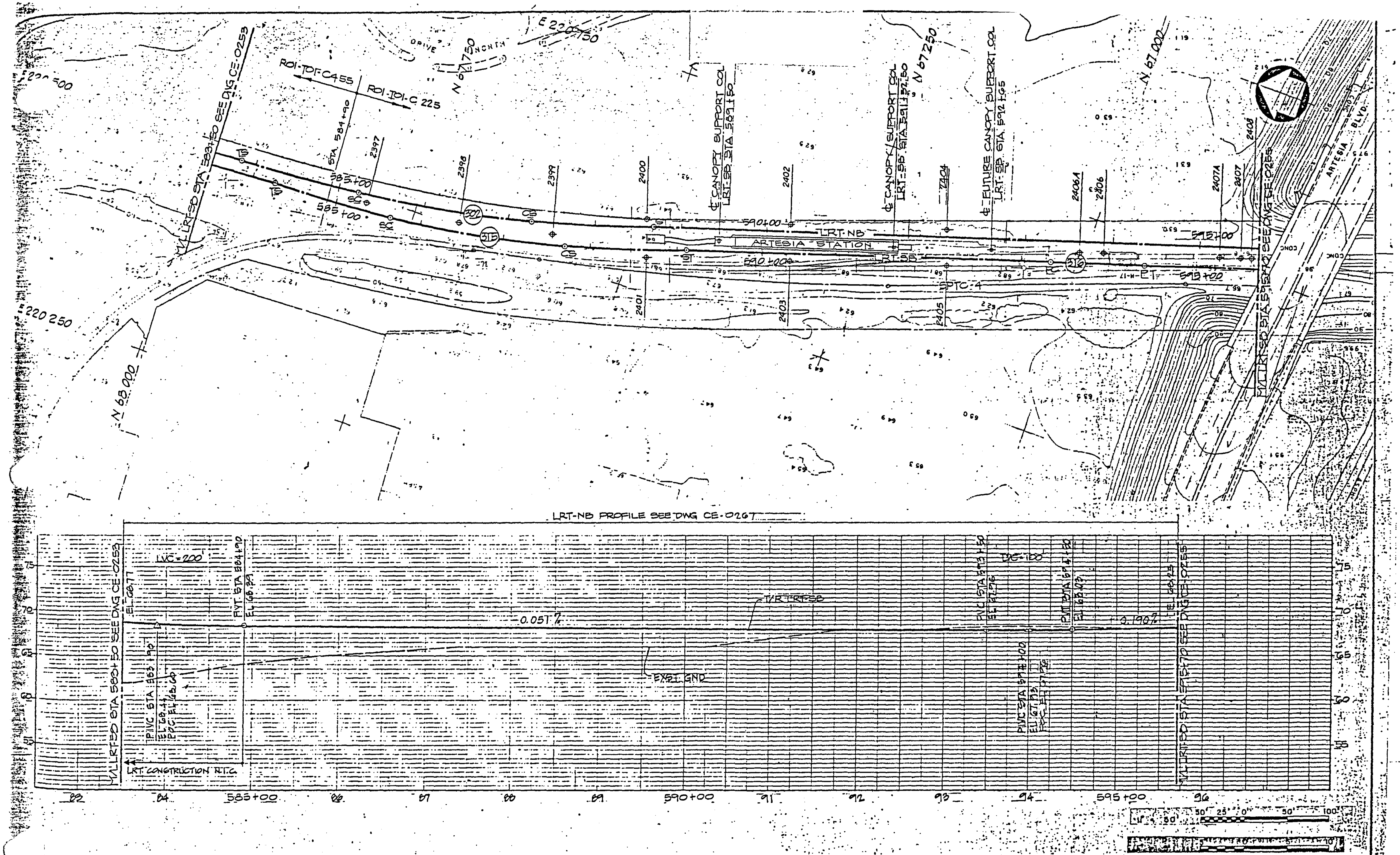
DMJM

SUBMITTED:

Southern California Rail Consultants
A Joint Venture of
Parsons Brinckerhoff Quade & Douglas, Inc.
Kaiser Engineers (California) Corporation
Daniel, Mann, Johnson, & Mendenhall
APPROVED:

LRT TRACKWORK INSTALLATION
TRACK CHART (C225)
STA. 585+00 TO STA. 615+00

CONTRACT NO. R01-T08-C258
DRAWING NO. TK-1241
REV.
SHEET NO. 75
SCALE AS NOTED



08/86	ISSUED FOR BIDS	
DATE	DESCRIPTION	BY / APP.

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DESIGNED BY C. SHEETS
DRAWN BY J. OBANDO
CHECKED BY
APPROVED BY
DATE 08/08/86

LOS ANGELES COUNTY TRANSPORTATION COMMISSION
The Long Beach-Los Angeles Rail Transit Project

SCRC Southern California Rail Consultants

Southern California Rail Consultants
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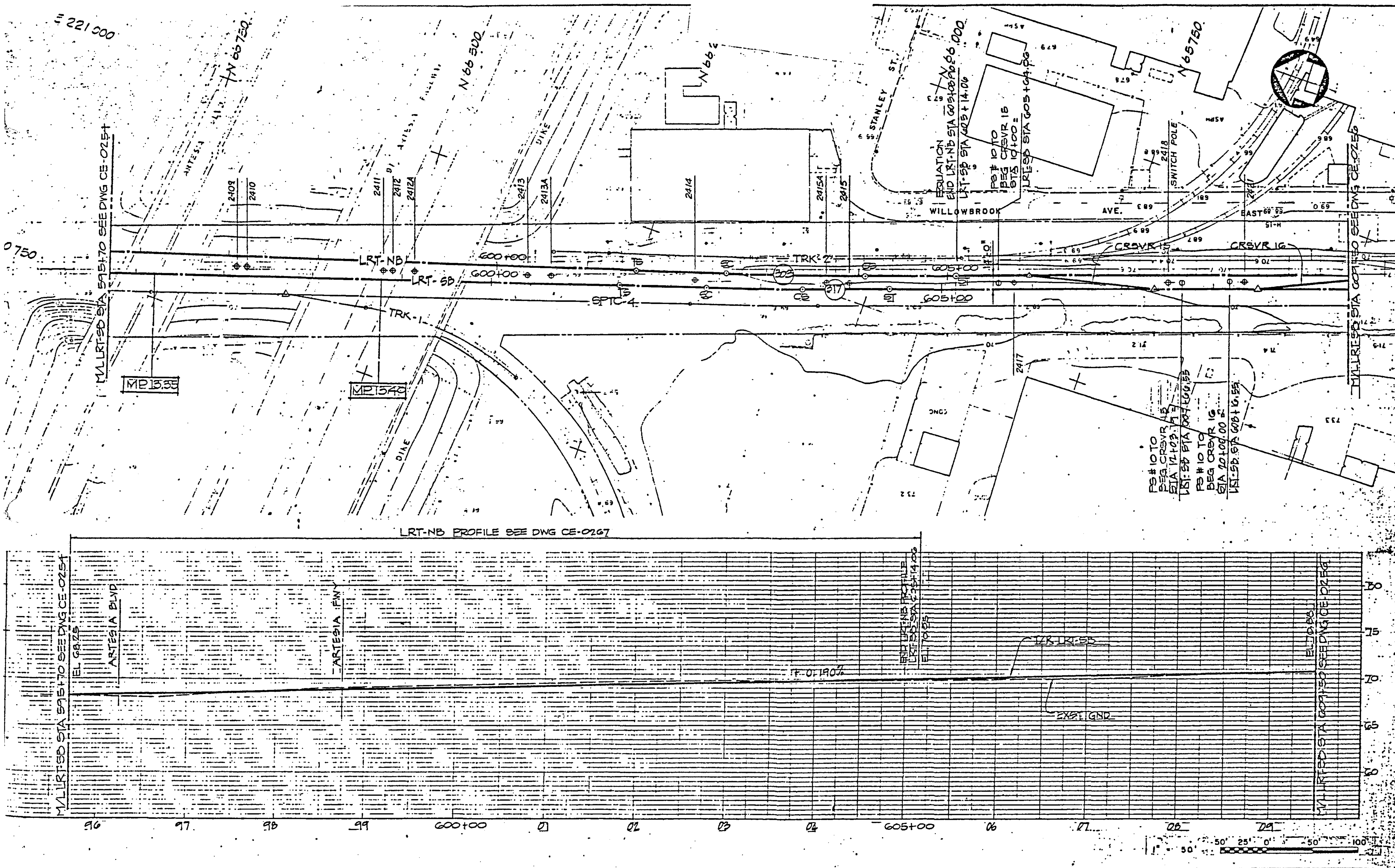
Parsons Brinckerhoff Quade & Douglas, Inc.
Kaiser Engineers (California) Corporation
Daniel, Mann, Johnson, & Mendenhall

SUBMITTED:
APPROVED:

MID-CORRIDOR SITE WORK AND RAILROAD RECONSTRUCTION
MYRRH STREET TO LOS ANGELES RIVER BRIDGE
LRT PLAN AND PROFILE SH. 5

CONTRACT NO. R01-T01-C225
DRAWING NO. CE-0254
SHEET NO. 79
SCALE 1" = 50' HORIZ. 1" = 5' VERT.



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DESIGNED BY S. DWORNIK
DRAWN BY J. OLANDO
CHECKED BY
APPROVED BY
DATE 08/08/86

LOS ANGELES COUNTY TRANSPORTATION COMMISSION
The Long Beach-Los Angeles Rail Transit Project

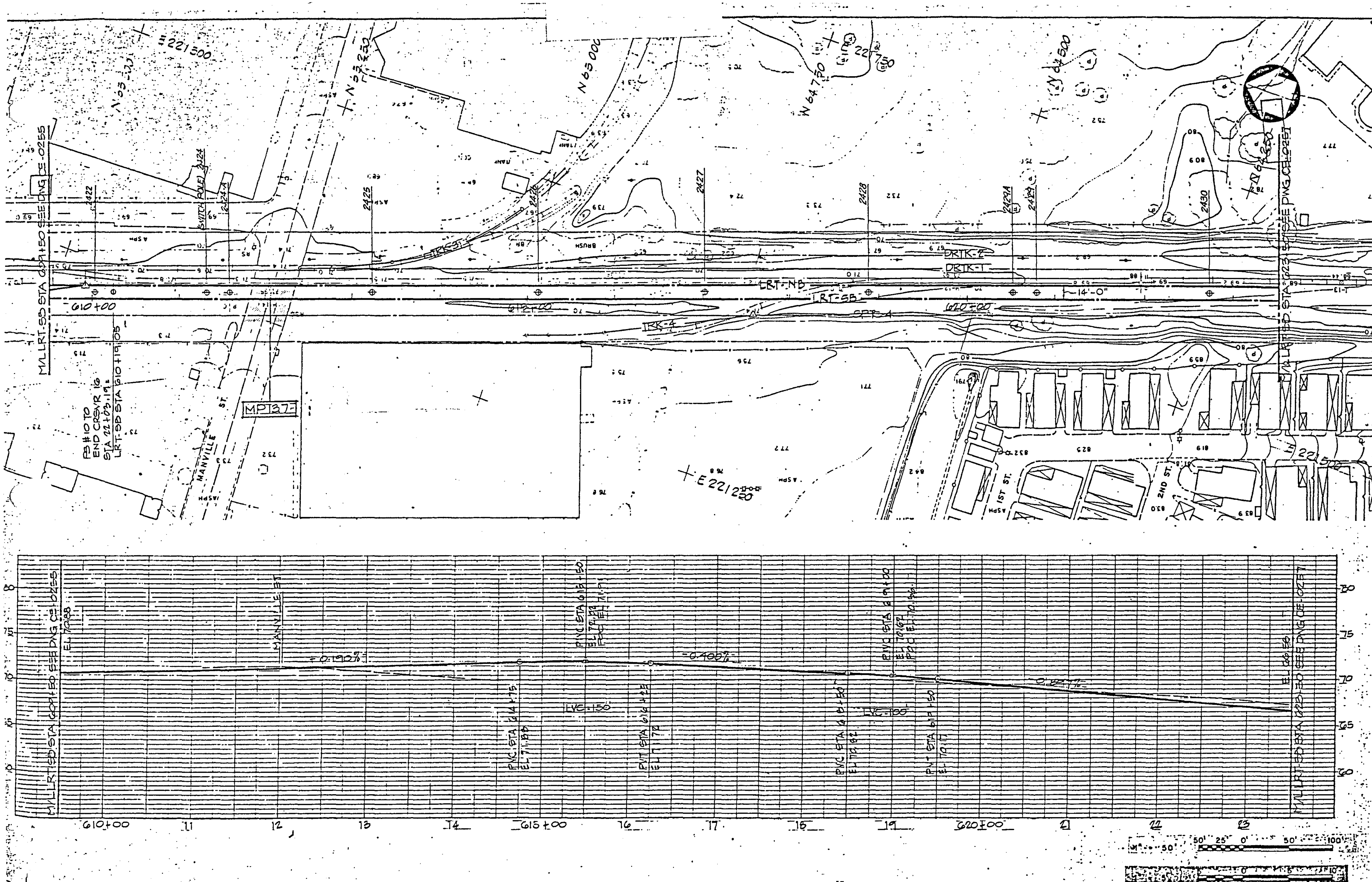
Southern California Rail Consultants

Southern California Rail Consultants
A Joint Venture of
Parsons Brinckerhoff Quade & Douglas, Inc.
Kaiser Engineers (California) Corporation
Daniel, Mann, Johnson, & Mendenhall

SUBMITTED:
APPROVED:

MID-CORRIDOR SITE WORK AND RAILROAD RECONSTRUCTION
MYRRH STREET TO LOS ANGELES RIVER BRIDGE
LRT PLAN AND PROFILE SH. 6

CONTRACT NO. R01-T01-C226
DRAWING NO. CE-0255
REV.
SHEET NO. 80
SCALE 1" = 50' HORIZ. 1" = 5' VERT.



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DESIGNED BY S. DWORNIK
DRAWN BY J. OBANDO
CHECKED BY [signature]
APPROVED BY [signature]
DATE 08/08/86

No. 32268 CIVIL STATE OF CALIFORNIA

LOS ANGELES COUNTY TRANSPORTATION COMMISSION
The Long Beach-Los Angeles Rail Transit Project

LACTC

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- Kaiser Engineers (California) Corporation
- Daniel, Mann, Johnson, & Mendenhall

SUBMITTED: [signature]
APPROVED: [signature]

MID-CORRIDOR SITE WORK AND RAILROAD RECONSTRUCTION
MYRRH STREET TO LOS ANGELES RIVER BRIDGE

LRT PLAN AND PROFILE SH. 7

CONTRACT NO. R01-T01-C226
DRAWING NO. CE-0256
REV.
SHEET NO. 81
SCALE 1" = 50' HORIZ.

COMPARATIVE SPECIFICATIONS FOR CROSSTIES

	American Railway Engineering Association (AREA) 1975	Railway Tie Association (RTA) 10-22-70	Federal Specification MM-T-371E 7-31-75
Material:			
Kinds of Wood* *Unless otherwise specified the following woods suitable for crossties will be accepted under the designated specification.	Ashes Beech Birches Catalpas Cedars Cherries Cypresses Douglas Fir Elms Firs (true) Gums Hackberries Hemlocks Hickories Larches Locusts Maples Mulberries Oaks Pines Poplars Redwoods Sassafras Spruces Sycamores Walnuts	Same as AREA	Ash Beech Birch Douglas Fir Gum Black Red Hemlock (western) Hickory Larch (western) Locust Black Honey Maple Oak Pine Jack Lodgepole Ponderosa Red Southern Walnut
Physical Requirements:			
General Quality	Except as hereinafter provided, all ties shall be free from any defects that may impair their strength or durability as crossties, such as decay, large splits, large shakes, slanting grain or large or numerous holes or knots.	Same as AREA	Same as AREA

	American Railway Engineering Association (AREA) 1975	Railway Tie Association (RTA) 10-22-70	Federal Specificatior. MM-T-371E 7-31-75
Physical Requirements: (Cont'd.)			
Resistance to Wear	When so ordered, ties from needle-leaved trees (conifers) shall be of compact wood throughout the top fourth of the tie, where any inch of radius from the pith shall have six or more rings of annual growth.	Density requirement of conifers, if any, to be specified by the buyer.	Ties from needle-leaved trees shall be medium grain — average four annual rings per inch — or average 1/3 summer wood.
Design:			
Dimensions	(a) Before manufacturing ties, producers shall ascertain which of the following lengths, shapes, or sizes will be accepted, and whether ties are to be hewed or sawed, and in either case whether on the sides as well as on the top and bottom.	Same as AREA except no mention of hewed ties.	Ties shall conform to the dimensions specified in Table I. The thickness and width shall be measured in the rail-bearing area of the tie. (See below under "Inspection-Dimensions").
	(b) Except as hereinafter provided, standard gage railway ties shall be 8 ft., 8ft. 6 in., or 9 ft. long.	Same as AREA	Same as AREA
	(c) Except as hereinafter provided, ties shall measure as follows throughout both sections between 20 in. and 40 in. from the middle of the tie:	Same as AREA	Same as AREA

Measurement between 20" to 40" from mid point of tie	AREA Size	AREA Body	AREA Face	RTA Size	RTA Body	RTA Face	Fed. Size	Fed. Body	Fed. Face
	5	7 x 9	9"	5	7 x 9	8" min.	5	7 x 9	8" min.
	4	7 x 8	8"	4	7 x 8	7" min.	4	7 x 8	7" min.
	3A	7 x 7	7"		7 x 9		3A	7 x 7	6" min.
	3	6 x 8	8"	3	6 x 8	7" min.	3	6 x 8	7" min.
	2	6 x 7	7"	2	6 x 8	6½" min.	2	6 x 8	6½" min.
	1	6 x 6	6"	1	6 x 8	5½" min.	1	6 x 8	5½" min.

Manufacture:	Except as hereinafter provided, all ties shall be straight, well hewed or sawed, cut square at the ends, have bottom and top parallel and have bark entirely removed.	Same as AREA	Same as AREA
Inspection:			
Place	Cross ties will be inspected at suitable and convenient places, at point of shipment or at destination as may be agreed between the supplier and the buyer.	Essentially same as AREA	See Paragraph #4 "Quality Assurance Provisions" per MM-T-371E
Manner	Inspectors will make a reasonably close examination of the top, bottom, sides and ends of each tie. Each crosstie will be judged independently without regard for the decisions on others in the same lot.	Essentially same as AREA	Details per Paragraph #4 "Quality Assurance Provisions" per MM-T-371E
Tolerances			
Decay	The following decay will be allowed: in cedar and cypress "pipe or stump rot" and "peck" respectively, up to the limitations as to holes. Blue stain is not decay and permissible in any wood.	Same as AREA	Ties shall contain no decay. Although blue stain is not decay, and is not a defect, ties shall be inspected with extra care for presence of decay in heavily stained areas.
Holes	A large hole (other than one caused by "pipe or stump rot" in cedar) is one more than 1/2" in diameter and 3" deep within the sections of the tie between 20" and 40" from its middle — or 1/4 the width of the surface on which it appears and 3" deep outside this 20" to 40" section.	Same as AREA	Same as AREA

	American Railway Engineering Association (AREA) 1975	Railway Tie Association (RTA) 10-22-70	Federal Specification MM-T-371E 7-31-75
Inspection: (Cont'd.)			
Holes (Cont'd.)	A cedar tie with a pipe or stump rot hole more than 1-1/2" in diameter and 15" deep will be rejected. Numerous holes are any number equalling a large hole in damaging effect. Such holes may be caused in manufacture or otherwise.		
Knots	A large knot is one whose average diameter exceeds 1/4 the surface on which it appears; such a knot may be allowed if it occurs outside the sections between 20" and 40" from mid-tie. Numerous knots are any number equalling a large knot in damaging effect.	A large knot is one having an average diameter of 1/3 the width of the surface on which it appears; such a knot may be allowed if it appears outside the rail bearing area. Numerous knots are any number equalling a large knot in damaging effect.	Large knot in rail bearing area same as AREA. Large knot outside rail bearing area cannot exceed 1/3 width of surface on which it appears. Numerous knots are not permitted if total exceeds single knot limitations in either bearing or non-bearing area.
Shake	Shall not exceed 1/3 width of tie.	Shall not exceed 1/2 width of tie — and not nearer than 1" to any surface. Procedure illustrated to be used in determining length of shake.	One shake only — shall not exceed 1/3 width of tie.

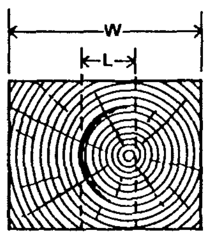


FIG. A

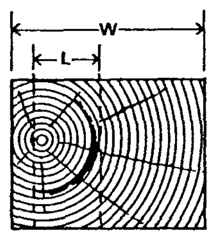


FIG. B

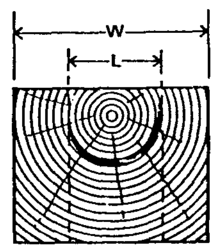
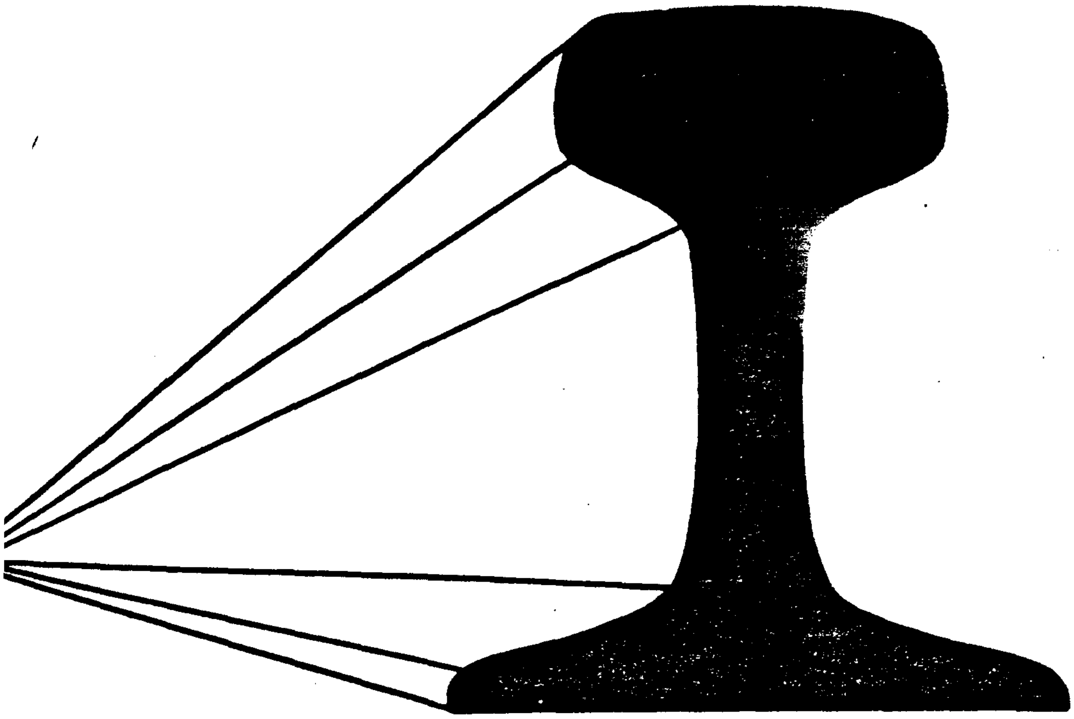


FIG. C

Checks	No mention – season checks are considered a natural characteristic of wood in the process of drying.	Same as AREA	Checks are acceptable on all faces, provided depth in a seasoned tie is less than 1/4 of tie thickness and shorter than 1/2 the length of the tie.
Splits	A split is a separation of the wood extending from one surface to an opposite or adjacent surface.	Same as AREA	Same as AREA
	Must not exceed 5". Purchaser will specify anti-split devices, if any.	Must not exceed 1/8" width or 4" length in green tie – or 3/16" width and no longer than face on which it occurs in a seasoned tie. A split exceeding this limit is acceptable when anti-split devices approved by the buyer are applied.	Before treatment a single split less than 1/2" and 10" long is acceptable if properly dowelled. After treatment, a single split less than 1/2" and 10" long is acceptable without dowels – also after treatment a split on each end not exceeding 1/8" in width and 4" in length is acceptable without dowelling.
Slope of Grain	Not to exceed 1" in 15" – when measured the entire length of the tie. Local variations do not apply in determination.	Same as AREA	Same as AREA
Manufacture	Straightness – A line along top from middle of one end to middle of other end must fall within the tie. A line along a side from the middle of one end to middle of the other end must remain more than 2" from top or bottom along the full length.	Same as AREA	Same as AREA
	Workmanship – Ties shall be considered well manufactured when surfaces are even and not scored to a depth in excess of 1/2".	Same as AREA	Same as AREA

	American Railway Engineering Association (AREA) 1975	Railway Tie Association (RTA) 10-22-70	Federal Specification MM-T-371E 7-31-75
Inspection: (Cont'd.)			
Manufacture (Cont'd.)	Parallel top and bottom — A tie will be considered parallel if any difference in thickness at the sides or ends does not exceed 1/2".	Same as AREA	Same as AREA
Dimensions	(a) Lengths, thicknesses and widths specified are minimal. Ties over 1" longer, thicker or wider than standard will be rejected. (b) All thicknesses and widths apply to the sections of the tie between 20" and 40" from the middle of the tie. All determinations of widths will be made on the top of the tie, which is the narrower of the horizontal surfaces. When both horizontal surfaces are equal, the top shall be the surface without heartwood or the narrower heartwood.	(a) For green ties, lengths, thicknesses and widths specified are minimal. For seasoned ties, lengths, thicknesses and widths are considered acceptable if not more than 1/4" thinner or narrower than specified size. Ties over 1" thicker or wider than specified may be rejected. Ties over 2" longer or 1" shorter than specified may be rejected. (b) Same as AREA	(a) Fully air seasoned or treated ties shall allow the following tolerances based on minimum specified dimensions: Length: +1", −1" Thickness: +1", −¼" Width: +1", −¼" (b) Same as AREA



TRACK FOREMAN'S TRAINING PROGRAM

LESSON 5

TRACK ALINEMENT AND GAGE

The Railway Educational Bureau

1809 Capitol Avenue, Omaha, Nebraska 68102

LESSON 5

TRACK ALINEMENT AND GAGE

An ideal railroad to operate and maintain would be constructed on a straight line from one end to the other. It would be the shortest possible route and therefore the fastest and most economical. From an operating standpoint, there would be no speed restrictions, due to curvature. Engine crews would have long sight distances in front of the trains. Maintenance of track, as well as locomotives and cars, would be simplified in many ways.

Such a railroad is not an ideal one to construct. Railroads are built on many kinds of terrain. Sometimes, the only practical route through a narrow valley, or over a mountain pass consists of a succession of curves for many miles. In other cases, geographical conditions may permit the construction of a long stretch of track on a straight line. But, sooner or later, it will be necessary to use curves in order to get past obstacles along the route.

It is not your job as a track foreman to lay out a railroad route or to establish the proper alinement. That is the responsibility of engineers and surveyors. Should you be assigned the responsibility for constructing a new track, they will provide you with line stakes, or other suitable means of references, so that you can build the track to the proper alinement. Probably, you will be called on more frequently to perform maintenance operations, in which the proper alinement of a track must be preserved or reestablished. This lesson is intended to provide you with a sufficient understanding of track alinement, so that you can properly carry out such work.

Locations where problems with track gage are likely to occur are closely related to track alinement. This subject will therefore be considered as part of the same lesson.

Before problems of alinement can be dealt with, it is necessary to understand a few basic terms and some concepts which are followed in establishing alinement.

The first term is that used to describe a length of straight track. A length of straight track between two curves is known as a tangent. A tangent may be only a few feet in length, connecting two closely situated curves. A tangent might be several miles in length, if such is the distance between one curve and the next.

DESCRIPTION OF A CURVE

The simplest type of curve used in track alinement is the circular curve. Figure 1 illustrates a circular curve with a tangent on either end. All points on a circular curve are the same distance from a certain fixed point, located to the inside of the curve. This distance is known as the radius. The greater the radius, the flatter the curve will be. The shorter the radius, the sharper the curve will be. On sharp curves, there are limits on how fast a train can be operated without danger of derailment. On flatter curves, the speed limits may be determined by the quality of maintenance, rather than curvature.

While the sharpness of a curve can be described by giving its radius, the more common way is to describe it by the degree of curvature. Figure 2 shows how the engineer determines degree of curvature. You will not have to determine it in this way, but you can see that the curvature is measured as an angle. Angles are measured in degrees. Degrees are subdivided into minutes. There are 60 minutes in one degree. If a curve is described to you as a 2 degree, 30 minute curve (usually written as 2°30'), you should know that it is a 2-1/2 degree curve. If a curve is described as a 5°45' curve, you should know that it is a 5-3/4 degree curve by reducing the fraction 45/60 to 3/4. The greater the degree of curvature, the sharper the curve will be.

Sometimes it is necessary to put two different curves together to fit the track to the terrain. For example, one end of the curve may be a 1°30' curve, as shown in Figure 3. At some point in the body of the curve might be a 4° curve. This is known as a compound curve. It is possible to put any number of segments of different curvature into a compound curve. In other situations, it is necessary following a curve, to have a very short length of tangent track which in turn is followed by another curve in the opposite direction. Such combinations are known as reverse curves, which are illustrated in Figure 4.

An additional method of designating curves, which should be pointed out at this time, is the idea of right hand and left hand curves. Such descriptions always relate to a direction of travel. For instance, Figure 4 shows the direction of movement for a certain train. It can also be seen that this train is moving in an easterly direction. The first curve this train will pass over is a right hand curve. The second curve is a left hand curve. Should a train pass over this track in a westerly direction, the first curve he would reach would be a right hand curve and the second would be a left hand curve.

* TRANSIT USES RADIUS SO IT MAY FIT INTO CITY PLANNING MORE EASILY.

RAILROADS USE DEGREE OF CURVATURE WHICH AIDS IN STAKING OUT CURVES IN ROUGH TERRAIN.

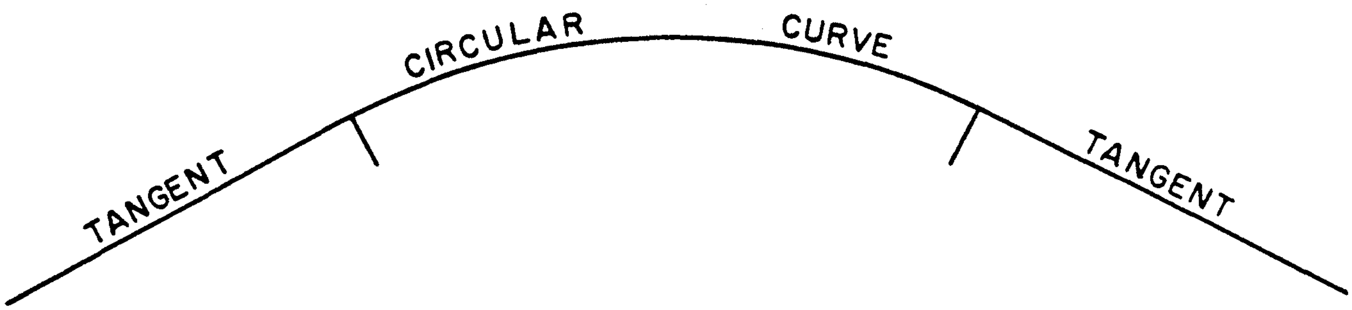


FIG. 1

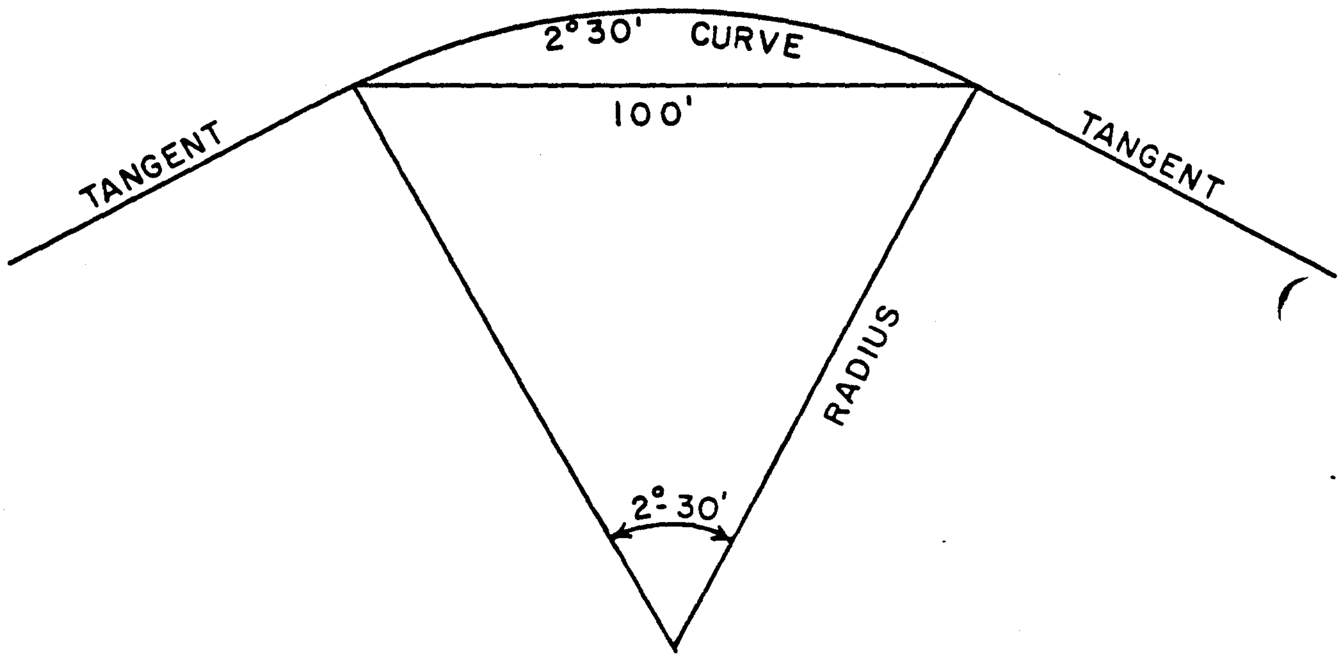


FIG. 2

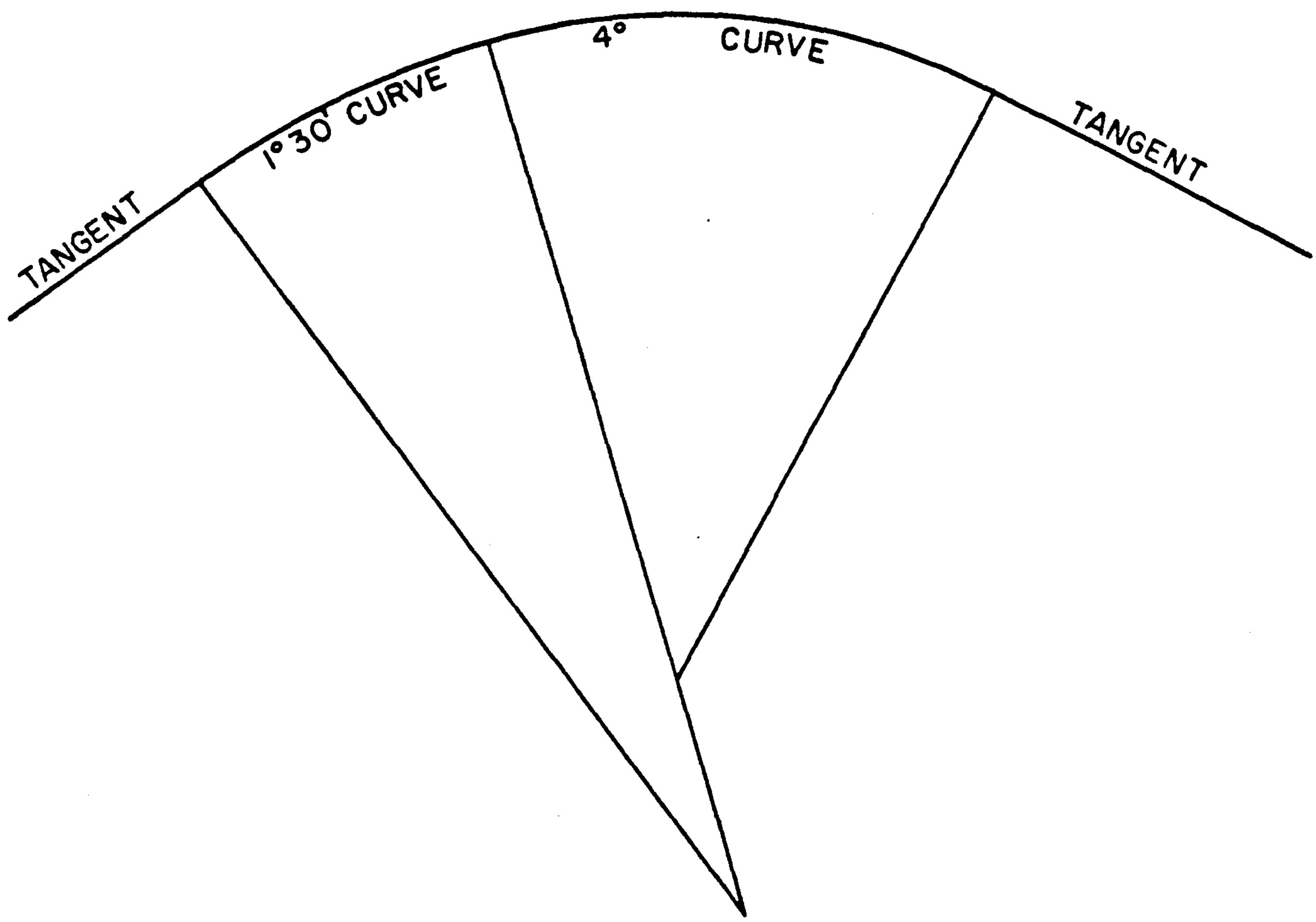


FIG. 3

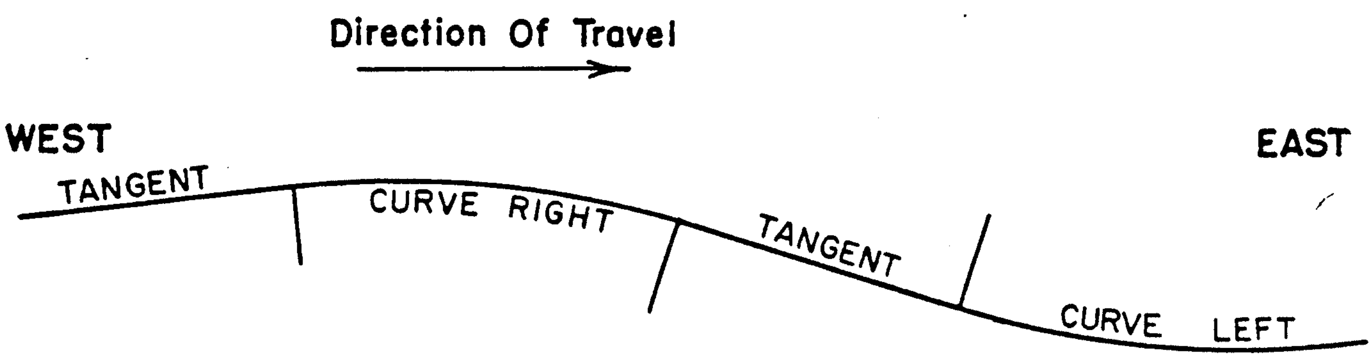

Direction Of Travel
WEST
EAST
TANGENT
CURVE RIGHT
TANGENT
CURVE LEFT

FIG. 4

Next, consider the reactions within a car, and within the track structure, at the point where the car enters a circular curve, as it leaves a tangent. While on the tangent, all wheels were in line with the car body. As the leading car truck reaches the curve, the entire truck must rotate about its center pin, so that the wheels can assume the angle required to travel through the curve. If the full curvature begins right at the end of the tangent, the rotation of the truck must be accomplished in the very brief time, from the instant the leading axle enters the curve, to the instant when the trailing axle enters the curve. This situation is illustrated in Figure 5.

As the rest of the car moves into the curve, the car body begins to be diverted from the straight line in which it was traveling. This causes further rotation between the car and each of the trucks, about the leading and trailing center pins. After the car is entirely in the curve, the wheel angles are similar to those shown in Figure 6. There are frictional forces, involved between the center plates on the car body and the center plates on the trucks. There may be additional friction at the side bearings, between the body bolsters and the truck bolsters. The outer rail of the curve has to deflect the wheels and guide them to their new alinement.

As far as the car is concerned, this can result in a considerable lurch. This can cause an uncomfortable ride in passenger trains, an increase in the possibility of shifted lading in freight trains, and excessive wear on various equipment parts. With regards to the track, the thrust against the outer rail can cause a number of problems. These include excessive wear of the gage side of the rail head, widening of the gage, irregular track alinement and deterioration of the ties, in this vicinity. Because of these problems, use of circular curves immediately next to a tangent is usually limited to tracks designed for slower speeds where such forces are not very great.

EASEMENT CURVES

What is done, is to introduce a segment of curve between the tangent and the circular curve which is called a spiral. The spiral consists of gradually increasing curvature from the tangent to the circular curve. This provides a gradual transition in which the trucks can rotate to the angle required to pass through the curve without a lurch. Excessive thrust against the track structure is avoided. The length of the spiral required, depends upon the speed at which trains will be permitted to operate and the degree of curve. Spirals are used with most curves with train operations at moderate to higher speeds. They are used at both the entering and leaving ends of a curve. They are also used to provide transitions between the various curvatures in compound curves.

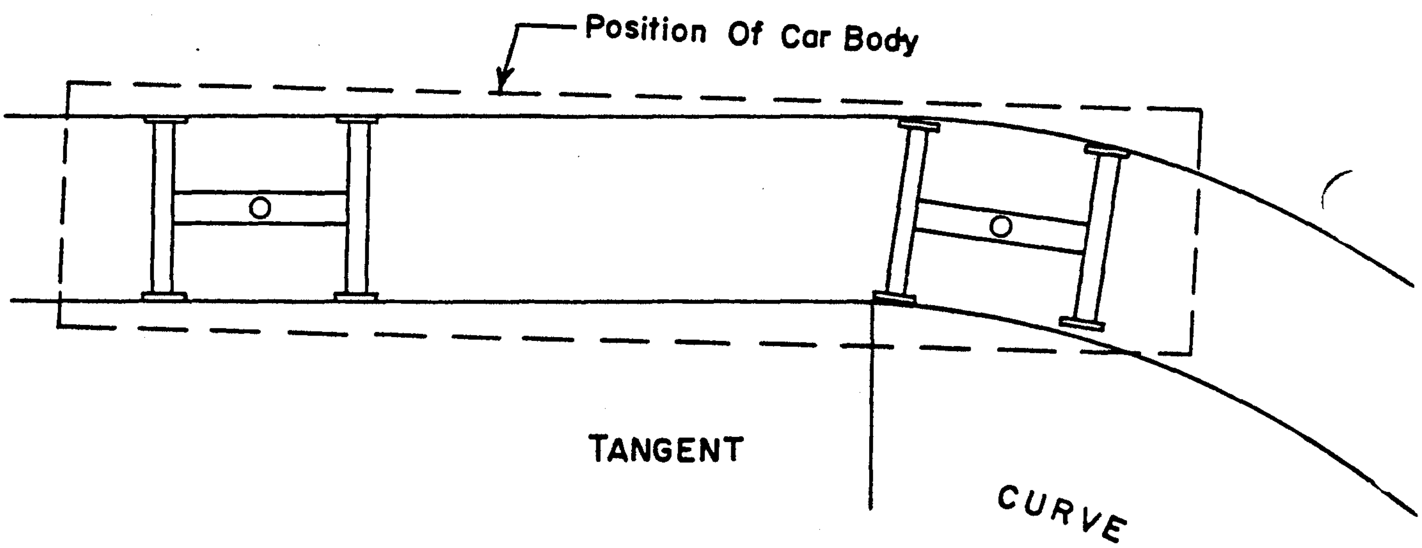


FIG. 5

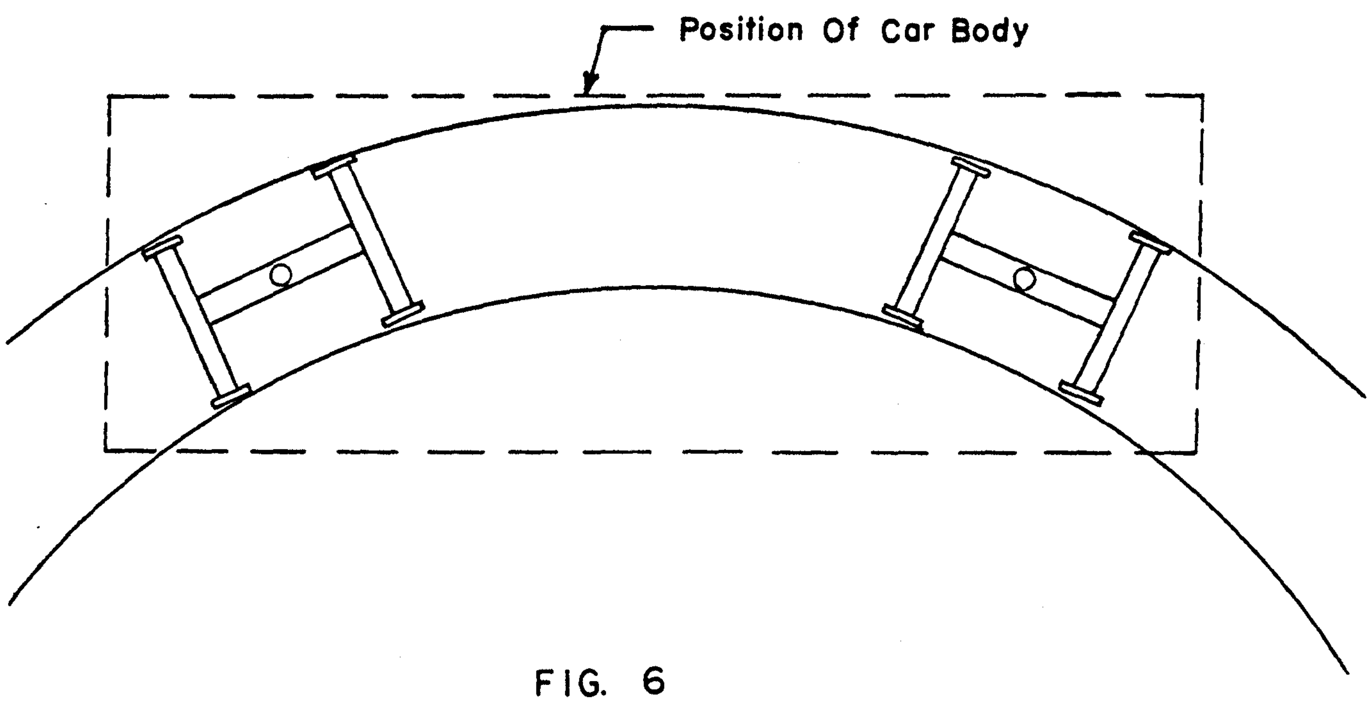


FIG. 6

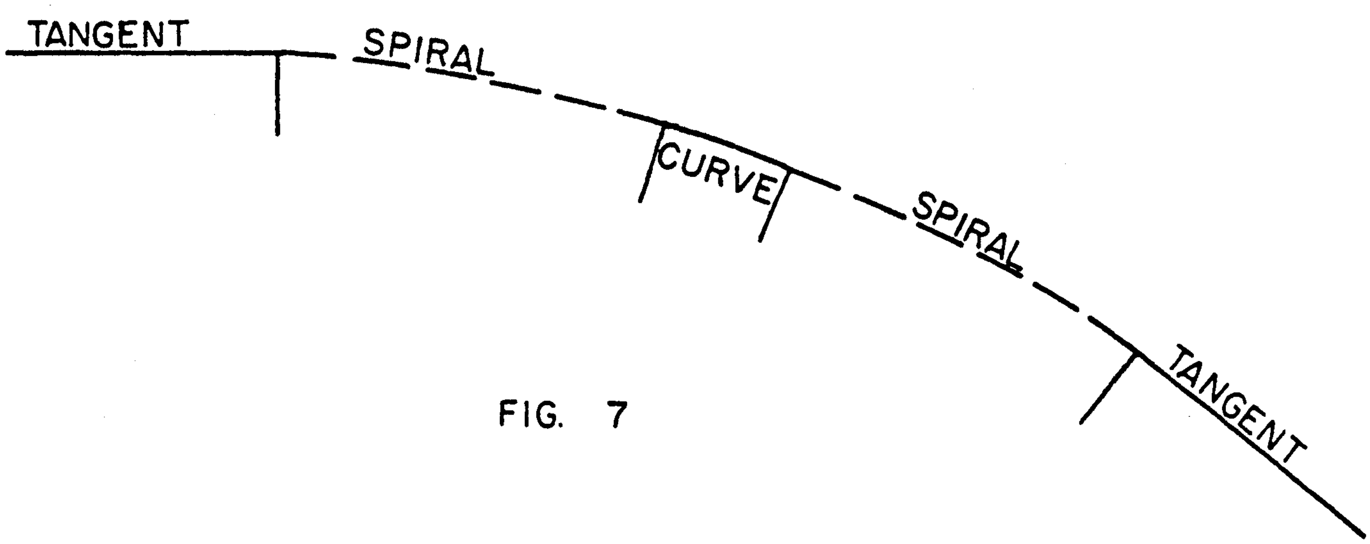


FIG. 7

Figure 7 illustrates a curve with spirals.

Most curves have the track banked so that the outer rail is raised above the inner rail. This banking is properly called superelevation although frequently referred to as elevation. This practice permits a better interaction between the track and the equipment moving over it at substantial speeds. Since curves are so often elevated, the outer rail of a curve is commonly referred to as the high rail. The inner rail is likewise called the low rail. Another advantage of spirals, is that the transition from level track to the full elevation required for the curve, can be made in this area. This is also an important contribution to smooth riding track. Superelevation will be studied in another lesson.

LINE RAIL AND GAGE RAIL

If track always had perfect gage between the two rails, the alinement of both rails would always be the same. Unfortunately, irregularities in gage do exist. Wherever these variations in gage are not uniform, differences in the alinement of the two rails will exist. For this reason, it is the usual practice to designate one of the rails as the line rail. The idea is that whenever work involving alinement is done, it should be based upon the same rail. The opposite rail is then considered as the gage rail. As long as track is reasonably well maintained, the line rail should have the best alinement. Any work undertaken to correct irregularities in the gage should therefore be performed on the rail opposite to the line rail, so that when brought to proper gage, it will have the better alinement.

On a curve, the outer or high rail is always the line rail. Therefore, the inner or low rail is the gage rail. On tangents, the practice varies. Some railroads may designate the north, south, east or west rail as the line rail. On multiple track, it may be the rail closest or furthest from the centerline of the right-of-way. It may not be specified in a particular railroad's standards. If that is the case, work with the same rail throughout the length of the tangent. Any measuring or sighting done with regards to alinement should always be done with the same reference line used for gaging. It should be done on the gage side of the rail head, 5/8 inch below the top of the rail head.

DEFECTS OCCUR IN ALINEMENT

These are the basic principles used in establishing track alinement. If track always stayed on the proper alinement, these principles would be of little importance to you. Such is not the case. Irregularities in alinement do occur, and you need a good working knowledge of these principles to deal with such defects. We will next consider the ways in which alinement defects develop.

First, consider the way in which stresses within the rails affect track alinement. This can best be done by making a comparison. Compare a long steel rail, which may consist of a length of continuous welded rail, or a series of rails connected with joint bars, with another long, slender steel object. Use your tape line for making the comparison. If you exert a pulling force on your tape line, you know that it is capable of resisting a good deal of force before it breaks. You also know that if the pulling forces remain in line with each other, the tape will remain in the same line. When this is done, the tape is said to be in tension. The same thing can be expected with rails which are in tension. The rail will remain in the same alinement, as long as the tensile forces are in line with the rail. If these forces become large enough, track bolts may break. This stress may cause a flaw within the rail to develop into a broken rail. It is unlikely, though, that a defect in line will occur.

Consider what happens when you grasp your tape with both hands and try to push them together. What you are trying to do is to put the steel into compression. As soon as you apply a small amount of compressive force, the tape begins to buckle. All sorts of distortions in its alinement may occur. This is not caused by any lack of strength within the steel itself, it is caused by the shape of the tape.

Long, slender objects have relatively low resistance to buckling, when compressive forces are applied. The comparison between the steel tape and the steel rail is exaggerated; but the principle is the same. If large compressive forces are applied to a rail, it will tend to buckle. When the rails are spiked to the ties, the resulting track reacts to compressive forces in the rail as a unit. This structure is not nearly as slender as a single rail, which increases its stability. Embedding the ties in ballast, increases resistance to buckling further. Still, in relation to their length, railroad tracks are relatively slender. Large compressive forces within the rails are capable of producing lateral displacement of the track, or poor line.

EFFECT OF TEMPERATURE

You should understand how compressive and tensile forces develop within a track. One cause is temperature change. Steel tends to contract or shrink as its temperature is lowered. If it is restrained, so that it cannot contract, a tensile force is built up within the steel. As the temperature of the steel is increased, it will tend to expand. If some restraint does not permit it to expand, a compressive force develops within the steel.

In track with bolted rail, these forces are partially relieved with the expansion and contraction of the rails permitted by the rail end gaps at the joints. The forces are not fully relieved due to frictional resistances at locations such as the joint bars, tie plates and spikes. The exception to this, is some median temperature where the stresses within the rail are about to pass the point between tension and compression. In track with continuous welded rail, expansion and contraction cannot occur. This results in much larger tensile stresses in cold weather and compressive stresses in hot weather.

Changes in temperature are not the only things that cause tension or compression within a track. Rail tends to move under traffic. On tracks where most of the traffic is in one direction, it usually tends to move in the direction in which trains move. The general trend on grades is for the rail to move toward the bottom of the grade. These are generalities and there are many exceptions. Rail anchors are applied to prevent such longitudinal movement. Properly applied rail anchors, in sufficient quantity, in track, well embedded in ballast, can do an excellent job of controlling longitudinal movement. It must be recognized that only a small amount of movement can cause large forces to be built up.

Consider an example of the size of the forces involved. Assume that a length of welded rail is laid out on rollers to minimize friction. Suppose that the length of this rail is about 1440 feet, which is a common length used by many railroads for continuous welded rail. The length of the rail is measured accurately on a winter day when the temperature of the rail is 0 degrees Fahrenheit. The rail is left undisturbed until a warm summer day when the rail temperature is found to be 120 degrees. This is not an unusual temperature for a rail which has been exposed to direct sunlight for several hours. The length of the rail is again measured and found to be more than one foot longer than it was at 0 degrees.

TREMENDOUS PRESSURES BUILT UP

Next, suppose the same rail is laid securely in track and well anchored at a time when the temperature is 0 degrees. As the temperature increases the rail is unable to expand. Since it can't expand, compressive forces begin to develop within the rail. The warmer it gets, the greater the compressive stress becomes. By the time the rail attains a temperature of 120 degrees, the compressive force within a rail of one of the heavier weights in common use can exceed 300,000 pounds. If each rail attains a compressive force this great, the total compressive force in the track could be over 600,000 pounds.

A track subjected to such large compressive forces becomes extremely unstable. The alinement can become distorted due to sun kinks or even sustain severe buckling. Welded rail should not be laid at cold temperatures without being heated or readjusted, as soon as it is warm enough.

Similar conditions can develop through a combination of movement under traffic and temperature changes. This is particularly true of bolted rail. If not properly anchored, bolted rail may move in one direction until it comes against a part of the track structure that is firmly secured. This might be a turnout, a crossing or any location where the rails are well anchored in solidified ballast. If this process continues until there are no rail end gaps over a considerable distance during cold weather, high compressive stresses will develop in hot weather.

Compression within the track structure is only one of the reasons for the development of defects in track alinement. Some line irregularities are caused by compressive forces within moving trains. One example of this, is the sort of thing that can happen to a train when an emergency brake application occurs. Suppose, the train is moving at a constant speed with all couplers stretched. Next, suppose that an air hose bursts, somewhere near the head end of the train. The brakes will apply first on the cars closest to the break in the air line. It will take slightly longer for the pressure to drain out of the air line further back in the train. This will permit the slack in the couplers in the rear portion of the train to run in against the cars on which the brakes are fully applied.

Such a sequence of events happening in a long, heavily loaded train can cause very large compressive forces within the train. These forces can result in a tendency for the train to buckle laterally. There are several things that could happen if these lateral forces are large enough. One or more cars could derail. When the lateral forces are applied by wheel flanges against a rail, the rail might overturn. In other cases, the rail might remain upright, but the rail could slide outward resulting in wide gage. Another possibility is that the track structure would remain intact, but shift laterally. This could leave a small irregularity in the track alinement, or a major distortion.

There are other ways in which train-handling incidents can leave the track structure with line or gage defects. Such incidents can happen through such varied activities as the use of pusher engines or dynamic brake application.

OTHER CAUSES OF LINE DEFECTS

Line defects can also be caused by inability of the ballast or roadbed to support the vertical loads placed on it. For example, some defect in a rail joint may cause excessive pounding, as wheels pass over it. This continued series of impact loads causes a breakdown of ballast support under the joint ties. A low spot in the surface develops. Perhaps the joint begins to pump mud. It is not unusual for the track to develop a line irregularity at this spot. Depending on the position from which he is observing the track, the trained inspector might observe either the line or the surface defect first.

Another situation in which loads become excessive is one in which the two rails do not have the proper cross level with regards to each other. The change in cross level could be gradual, unlike the previous example of the low joint. There might not even be a rough spot noticeable to anyone riding a train. If the cross level creates enough imbalance, then one rail will be receiving such a large part of the total load of each car passing over it, that a breakdown in surface, line or both can occur.

Roadbed instability can be another reason for the movement of track from its proper line and surface. The problem may be due to soils which are incapable of supporting the loads created by rail traffic. It could also be a problem of slippage particularly where tracks are built on hillsides or river banks.

Any of the causes of track misalinement that have been mentioned so far can be expected to occur on either curves or tangents. The movement of trains on curves can cause another kind of line defect, one which does not occur on tangents. Any object moving around a curve would follow a straight line, if there were not a restraining force which keeps it on the curve. The force, which makes the object tend to move outward, is called centrifugal force. In the case of railroad cars and locomotives, the centrifugal force is applied by the wheel flanges against the gage side of the head of the outer or high rail. In most cases, the track structure is strong enough to resist the centrifugal forces applied against it. In those few cases where these forces exceed the strength of the track, several things can happen. The rail could either slide or roll outward. Another possibility is that of the track structure pushing outward at points where the restraint provided by the ballast is weakest. This has the effect of creating kinks or points of sharper curvature.

Considerable attention has been given to the principal ways in which irregularities in track alinement develop. This has been done so that when you are faced with the job of correcting track alinement, you will acquire the habit of looking for probable reasons for this condition. Sometimes it is necessary to correct not only the defective line, but also the condition which has caused it, in order to prevent a reoccurence.

EFFECTS OF MISALINEMENT

The effects of irregular track alinement will next be examined. Severe defects in line can cause the derailment of a train. The speed of the train is an important factor in determining how great the defect can be before derailment can be expected. In other cases, with less severe line defects, such a defect can contribute to the cause of a derailment. The line defect, together with some other defect, in track or equipment, or some incident in train-handling, can result in a so-called combination cause derailment.

Track alinement defects, not severe enough to contribute to the derailment of equipment, can still create maintenance problems. Any condition which causes locomotives and cars to be deflected from the straight line on which they travel, on a well maintained tangent, creates additional stresses on both the track structure and the equipment. Such forces are inevitable, to some extent, on any curve, but they are greater on a curve with alternating sharp and flat spots, than they are on a smooth, uniform curve.

When stresses caused by trains moving over poorly lined track become substantial, they can cause various problems to develop within the track structure. Stresses caused by defects in line can cause the line to become poorer yet. Another condition that can develop is gage widening. Excessive wear on the gage side of the head of the high rail on curves is another possibility. Shortening of the life of ties can be expected.

The stresses caused by poor track alinement can also cause excessive wear on wheels and other equipment parts. Sudden lurches are uncomfortable and, at times, hazardous to passengers and crew members. It is also possible for damage to lading to be caused by such conditions.

While it can readily be seen, that defects in track alinement can cause many serious problems, it must also be understood that track alinement which approaches perfection is seldom economical or practical to attain. Most track always has numerous minor defects in line. Good maintenance practice involves keeping alinement between what is desirable and what is safe.

USE OF LINING SCOPE

Desirable alinement will be considered first. Consider a tangent which is to be lined by manual methods; that is, by a gang using lining bars or jacks. It is possible to set up a telescopic instrument directly over the gage line of the rail, which has been designated as the line rail.

This instrument could be a surveyor's transit, which is seldom used by track foremen, or it could be a track lining scope designed for such work. When setting it up, the point selected should be one which is considered to be on the proper alinement. This can be determined by visual observation before setting up the instrument. After it is set up, and properly leveled, another point is selected, which is considered to be on the proper alinement. The telescope is then adjusted until the vertical hair line intersects that point. Once the instrument is set up in this manner, the lining procedure is to line the track so that the gage line of the rail at all points in between intersects the hair line in the telescope.

Lining track by this method can produce a high degree of accuracy, one which is satisfactory for track of the highest classes. In addition to providing smooth riding track, from an alinement standpoint, this procedure is capable of removing long, gradual bows from the track if that is desired.

Many skilled track foremen have developed the ability to sight a rail and direct a lining gang in a manner which produces track alinement approaching the quality of instrument-lined track. A few foremen have the ability to do so, with little practice, but most improve this skill with experience. It must be remembered to concentrate on the location of the gage line of the rail head and not be distracted by imperfections in the rail. Where possible, it is always desirable to gain experience on lower classes of track, before having to meet the more exacting demands of lining high-speed track. Although most track is lined by mechanical equipment, every foreman should work to develop the skill of lining track visually, as there will be numerous times when this ability is needed.

Mechanical liners may be a single-purpose machine performing this function, or they may be part of a tamper. The line reference may be provided mechanically by a tightly stretched wire or by an electronic beam. The most commonly used principle is illustrated by Figure 8.

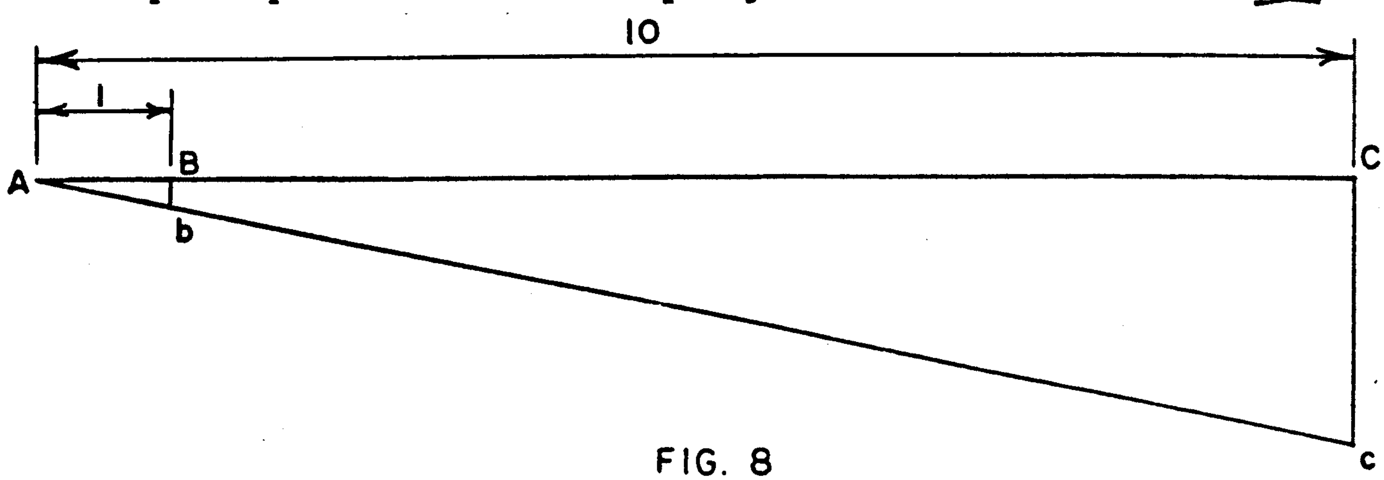


FIG. 8

Point A illustrates the back end of the reference line. When work is in progress, this end of the reference line is on track which has already been lined. It can be assumed to be proper alinement. The line between A and C represents the direction of perfect alinement of the tangent. If the front end of the reference line is on point C when the back end is on point A, then point B, where the lining is done, will be on perfect alinement. But the front reference point which is always on unlined track is frequently on a point not on true alinement. Assume that it is on point c. Then the liner will move the track to point b, rather than point B, at this particular spot in the track. Point b is not on true alinement.

It must be recognized that the front part of the reference line is always much longer than the rear part. Suppose the distance from A to c is 10 times the distance from A to b. This produces an error at b (the distance between B and b) which is only 1/10 the error presently in track at c, (the distance between C and c). In most cases, removal of 90% of the existing line defects will produce excellent track. In a few cases where the existing alinement is so poor, that lining results are still not satisfactory, a second pass can be taken. Again, assuming a 10 to 1 ratio of lengths, 90% of the error will be removed on the first pass and 90% of the remaining 10% error will be removed on the second pass. The result is then 99% accurate.

STRING LINING OF CURVES

Sighting of track alinement on curves is more difficult than on tangents. Usually, it is only possible to detect irregularities which are severe and short in length, such as a kink. The track-lining telescope is of no value on curves. Two very useful tools for lining curves are a length of string and a ruler. The curved line in Figure 9 represents the gage line of the high or outer rail of a curve.

The straight line between points A and C represents a string 62 feet in length. Point b is at the center of the string, 31 feet from point A and 31 feet from point C. If a small knot is made in the center of the string, point b can be located without further measurement. The distance from point b on the string to the gage line of the rail (point B) is called the mid-ordinate. As long as a 62-foot string is used, each inch of distance in the mid-ordinate represents one degree of curvature. For example, if the string is set up in this manner and you measure a mid-ordinate of 5-1/2 inches, the curvature at this point is 5°30'. This is only true if the length of the string is 62 feet and the ordinate is measured at the mid-point of the string.

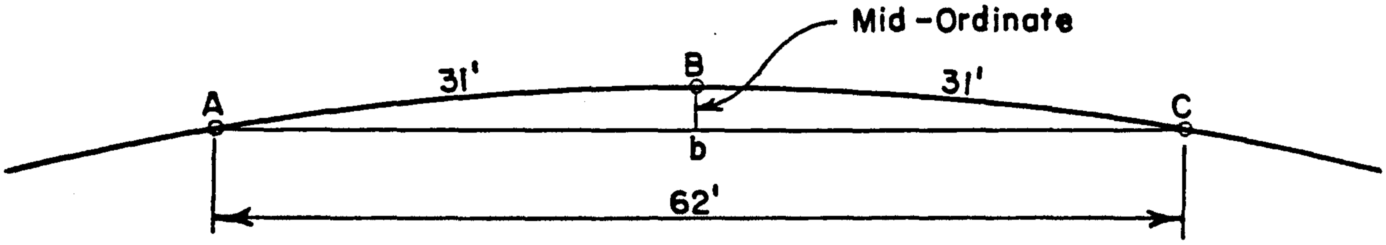


FIG. 9

If the curve is in perfect alinement, the mid-ordinate will remain the same at all points on the curve. In actual practice this seldom happens. The curve can be checked by setting the string at random locations, but a more thorough inspection can be made by measuring 31-foot intervals along the outer rail for the full length of the curve. These 31-foot intervals (called stations) are marked and numbered consecutively from one end of the curve to the other. A set up is made at each station and the mid-ordinate is measured. For example, when measuring station 4, the string will be stretched from station 3 to station 5. The mid-ordinates are all recorded on paper.

You will find that the readings vary. Where there is an above-average reading, the curve should be lined to the inside to reduce sharpness at this point. Where there is a below-average reading, the curve should be lined to the outside. On the spiral, the ordinates should increase uniformly at each station, from zero on the tangent to the average ordinate for the body of the curve.

It is possible to take a set of mid-ordinate readings and make calculations that will provide you with accurate notes on the direction and distance the track should be lined at each station. This work is usually performed by supervisory or engineering staff employees and will not be covered in this course. Even so, by knowing how to measure mid-ordinates, you will be able to identify problem spots and know how to improve the alinement.

String-lining procedures are based on determining the correct alinement at points 31 feet apart. The idea is to first get the track on alinement at these points and then to visually make adjustments between these points. Another advantage of the 62-foot string and 31-foot stations is that it is a convenient distance for reference points. They are not too far apart to permit accurate sighting between stations.

When lining machines are used, the readings taken are not the mid-ordinate but are as illustrated by Figure 8. The basic principle of uniform offsets between the curve and the straight line indicating a smooth curve still applies. The various lining equipment manufacturers specify their own procedures. Usually, one of two general methods is used. One is to run the equipment through the curve, taking a series of readings at fixed intervals such as rail joints. This information is recorded, usually graphically, and a plot made on graph paper to indicate a smooth curve. The distances on the graph paper between actual and desired readings are used as the basis of input to the lining machine, in some cases. In other situations, the machine is set to the curvature indicated by the plot on the graph paper.

The other method requires some advance knowledge of the curve. What is required is the curvature that the body of the curve is designed to, the location of each end of each spiral and the length of the spirals. This information can be fed into the lining equipment from which point the machine will take over the calculations. The same situation regarding referencing described for tangents, applies to curves. If the front reference point is at a point off the true alinement, a small error will be introduced. These errors usually are so minor that they can be ignored.

TOLERANCES IN IRREGULARITIES

The next subject to be considered is that of maintaining safe track from the standpoint of alinement. The FRA Track Safety Standards specify the extent of the irregularity permitted for each class of track as follows:

§ 213.55 Alinement.

Alinement may not deviate from uniformity more than the amount prescribed in the following table:

Class of track	Tangent track The deviation of the mid-offset from 62-foot line[1] may not be more than—	Curved track The deviation of the mid-ordinate from 62-foot chord[2] may not be more than—
1	5"	5"
2	3"	3"
3	1¾"	1¾"
4	1½"	1½"
5	¾"	⅝"
6	½"	⅜"

[1]The ends of the line must be at points on the gage side of the line rail, five-eighths of an inch below the top of the railhead. Either rail may be used as the line rail, however, the same rail must be used for the full length of that tangential segment of track.

[2]The ends of the chord must be at points on the gage side of the outer rail, five-eighths of an inch below the top of the railhead.

It can readily be seen that the FRA standards for alinement are based upon the use of a 62-foot string. Measurements on curves are to be of the mid-ordinate. On tangents a similar measurement is made between the string at its center point and the gage of the rail being checked. The correct name of this measurement on a tangent is the mid-offset. Note, also, the consistency of this standard with the practice recommended elsewhere, that all measurements to the gage of a rail be to a point 5/8" below the top of the rail head. The simplest way to use a string on a tangent would be to place it against the gage side of the rail, which is bowed outward. The rail itself will prevent the string from forming a straight line on the inward bow.

The standard requires that measurements be made on the same rail throughout the entire length of the tangent. Therefore, when measuring a deviation in line towards the gage side, it is necessary to provide some means of keeping the string straight. This can be done by offsetting the ends of the string by placing some sort of blocks between the gage of the rail and the ends of the string. If this is done, the offset distances must be the same at both ends of the string. This offset distance must be subtracted from the total measurement of the mid-offset.

In checking for compliance with the standard, the string should be placed so that the center is at the point where the line defect appears. In Class 4 track, for example, the distance from the center of the 62-foot string to the gage of the rail is not permitted to exceed 1-1/2 inches on tangent track. The tolerances given for mid-ordinates on curves refer to the permitted variation from the proper mid-ordinate for the curve. For example, consider a 7-degree curve in Class 2 track. A 3-inch deviation of the mid-ordinate is permitted. If perfectly lined, the mid-ordinate would be 7 inches. According to the FRA standard, at no point is the mid-ordinate permitted to exceed 10 inches (7" + 3"). Nor is it permitted to be less than 4 inches (7" - 3"). This latter requirement would not apply to the spirals.

TRACK GAGE PROBLEMS

So far this lesson has been concerned with track alinement. The remaining part of it will deal with track gage. Problems involving track gage are due to the gage being either too tight (less than standard) or too wide (more than standard). Wide gage is far more prevalent than tight gage. Wide gage will be investigated first.

The causes of wide gage are very similar to some of the causes of irregularities in alinement, particularly those where lateral forces are placed upon the track structure by moving locomotives and cars. There are several different track conditions that can be caused by such forces and result in wide gage.

Wide gage is seldom a problem on tangent track. In the relatively few cases where it does occur, it can usually be attributed to either extremely poor tie conditions or to some train handling incident, which imposed large lateral forces on the track structure. Since most wide gage occurs on curves, some understanding of the forces which moving equipment places on the track structure will be useful. Centrifugal force has been explained previously. It has also been shown that tracks are superelevated on curves to help counteract the effects of centrifugal force.

A problem arises because the amount of centrifugal force changed considerably as the speed of the train changes. If tracks were superelevated so that when a train moves at maximum authorized speed, the axle loads were evenly distributed between the wheels on the high and low rails, problems might develop with slow-moving trains. Under such conditions an excessively high part of the total axle loads would be placed on the wheels moving on the low rail. One result of this could be a rapid rate of flattening of the low rail head. In the case of jointed rail, surface would tend to break down quickly in the vicinity of the joints.

Certain types of equipment become unstable under such conditions and tend to derail easily. These circumstances make it necessary to compromise between what is desirable for trains moving at maximum authorized speed, and trains moving at low speed, when determining superelevation. Therefore, most tracks have about 3 inches less superelevation that which would produce a balanced condition for trains moving at the maximum permitted speed. This causes a larger part of the axle loads to be transmitted to the high rail by such trains. In most situations, the majority of trains tend to be moving at or close to the maximum speed, and relatively few trains at low speeds.

Another factor is the manner in which trucks tend to negotiate a curve. The leading wheel in the direction of travel tends to attack the high rail at an angle and needs to be constantly deflected by the high rail. This condition usually does not occur with the wheel on the trailing axle. These two conditions, unbalanced superelevation and the angle of attack of leading wheels, create lateral thrusts againt the high rail with each passing wheel.

CURVE RAIL WEAR

One result of these conditions is the gradual wearing away of the gage sides of the rail head on the high rail. This condition of itself is rarely allowed to progress to the point that the track gage is unacceptably wide. It can, however, in combination with other conditions result in unacceptably wide gage. When such wear occurs, the gage side of the rail head becomes sloped. This condition makes the requirement for measuring gage 5/8 inch below the top of the rail head of particular importance.

Another way in which gage becomes wide is through a gradual lateral movement of the rail and tie plate to the field side. This condition also occurs most frequently on the high rail of curves. This is most likely to happen when a large proportion of the ties in the vicinity are in the latter stages of their useful life. As the ties tend to soften due to the effects of aging, the spikes gradually lose their holding power. The spike holes begin to elongate under the repeated lateral thrusts of each passing wheel. Gradually, the whole assembly of rail, tie plate and spikes moves outward. It may occur over a distance of several ties or it may be general throughout the entire curve.

Someone may watch this condition developing very slowly over a period of perhaps several years. This can lead to a false sense of complacency, in the belief that the rate of gage widening will continue to be slow. The problem is that the gradual reduction in the ability of the ties to hold spikes may reach a point where some incident can cause a further widening of the gage to happen, quite suddenly, with resulting derailment of a train. The incident may be the movement of a car, which places abnormally high stresses on the track structure. It may be a harsh run-in of slack, the ties may be further weakened due to being saturated with moisture following a prolonged period of wet weather.

It is also possible for sudden gage widening, due to a spreading movement of the rail and tie plates, to occur at a location where the tie conditions are quite sound. When this takes place, the cause is almost certainly due to some train handling problem or some abnormal equipment condition.

RAIL TIPPING

A gradual widening of the gage can also be caused by a tendency of the rail to cant outward. This usually happens when the tie plates become plate cut on the field side without plate cutting, or with less plate cutting on the gage side. When this happens, the rail tends to be pivoted outward with an increase in gage. This seldom progresses to the point where the condition of itself produces excessively wide gage. It can, in combination with other conditions, result in excessively wide gage. Furthermore, the presence of such a condition indicates the presence of weakened ties which need to be watched carefully. Occasionally, a situation may develop where the rail is canting out of the tie plate seats. This would indicate loss of holding power by the gage side rail spikes, possible intrusion of foreign material onto the tie plate seats, or heaving of the rail due to freezing conditions. Such a situation should be corrected at once.

A situation may develop where a derailment occurs due to a rail rolling outward and it can be established that there was no prior canting of the rail, that there was no lateral sliding of the rail or tie plates and that the derailment occured after the rail rolled outward. In such a case, it is very likely that the forces which caused the derailment were excessive, and the track structure may have been in a condition generally accepted as safe.

The FRA Track Safety Standards for gage are as follows:

§ 213.53 Gage.

(a) Gage is measured between the heads of the rails at right angles to the rails in a plane five-eighths of an inch below the top of the rail head.

(b) Gage must be within the limits prescribed in the following table:

Class of track	The gage of tangent track must be—		The gage of curved track must be—	
	At least—	But not more than—	At least—	But not more than—
1	4′ 8″	4′ 9¾″	4′ 8″	4′ 9¾″
2 and 3	4′ 8″	4′ 9½″	4′ 8″	4′ 9¾″
4	4′ 8″	4′ 9¼″	4′ 8″	4′ 9½″
5	4′ 8″	4′ 9″	4′ 8″	4′ 9½″
6	4′ 8″	4′ 8¾″	4′ 8″	4′ 9″

It can be seen that the allowance for wide gage is more restrictive on tangents than on curves. One reason for this is that wide gage on a tangent is more likely to indicate a poor tie condition than on curves. Also, standard gage on some railroads is specified as being wider on sharper curves, such as 4'--8 3/4" or 4'--9". This is intended to allow freer movement of equipment through the more severe curves.

The minimum gage permitted, in all cases, is 4'—8". The principal hazard in tight gage is the possibility of the wheels of light weight equipment being raised up and possibly derailing. Tight gage in excess of normal tolerances encountered in track maintenance is not very common. It may be due to careless construction or maintenance. Locations where tight gage sometimes tends to develop, are at rail crossings, particularly where the tracks cross each other at a relatively flat angle. This can be traced to forces created by rails running against the crossing and tending to distort major parts of the crossing.

CORRECTING IRREGULAR GAGE

If irregular gage is widespread, it can best be corrected when rail is replaced. If tie plates are to be replaced, incident to the rail replacement, then, regaging will be carried out as a matter of course. Should the process be one of replacing the rail without replacing the plates, it should be determined in advance if regaging is warranted.

If so, all spikes will have to be removed from the tie plates under one rail and the tie plates reset as the rail is brought to gage. This will ordinarily be done under the rail which is not the line rail. On curves, this will be the low or inside rail. In this manner, the better alinement is preserved.

In some cases, regaging must be performed when no rail replacement is anticipated. Depending on the extent of the work involved, it may be a small spot job done with hand tools, or it may be extensive enough to justify the use of much of the same equipment used to replace rail. In any case, all of the spike holes should be plugged before re-spiking is carried out. It may also be desirable, if alternate spike holes are available in the tie plates which were previously unused, to use them, where possible, in preference to the previously used spike holes. In many cases, it is more likely that the timber in these areas will have better spike-holding capability.

Decisions as to regaging to be performed, incident to tie-renewal operations, are not always easy. It is unwise to ignore all wide gage, when ties are being renewed. Much of the value of a new tie is lost when it is installed and spiked, perhaps 3/4 inch to 1 inch wide, only to have the track brought to proper gage a short time later. Future gage-holding capability of that tie will be greatly reduced because of adjacent spike holes. On the other hand, general regaging during mechanized tie-renewal operations can seriously impede the progress of tie renewals. Therefore, minor gage irregularities are frequently overlooked during such operations. The determination as to where to draw the line can vary from one railroad to another or from one class of track to another. Before undertaking such operations, you should find out what the policy is regarding regaging during tie renewals and be governed accordingly.

LESSON 5

EXERCISE QUESTIONS

1. Which of the following curves is the sharpest?

   a. One of 500 feet radius
   b. One of 2000 feet radius

2. Which of the following curves is the sharpest?

   a. A 3°45' curve
   b. A 6° curve

3. What is a curve called which has curvature of 8° near one end and 5° near the other end?

4. Which rail is used as the line rail on curves?

5. Which rail is usually adjusted when regaging a curve?

6. At what point on the line rail are measurements involving alinement taken?

7. At what time of year is track alinement most likely to be unstable?

8. What kind of stress within the rails causes track to be unstable?

9. The ends of a stretched string 62 feet in length are placed against the gage of the outer rail on a curve. At the midpoint of the string the distance between the gage of the rail and the string is measured and found to be 7-1/4 inches. What is the curvature at this point stated in degrees and minutes?

10. A line irregularity is noted in a certain tangent. With the use of a 62-foot string, the maximum mid-offset is found to be 2-1/8 inches. What is the maximum safe speed for freight trains with this condition?

11. At one point in a curve where passenger trains are permitted to operate at 60 mph, the gage is found to measure 4'--9 5/8". Is this condition safe for such an operation?

12. A curve in a track where freight trains are authorized to run 50 mph is designated as a 2 degree 15 minute curve. Mid-ordinates to a 62-foot string are taken at 31-foot intervals throughout the curve. The maximum mid-ordinate was found to be 4 inches. Is this condition safe for this operation?

13. In a certain curve which is designated as a 5-degree curve, the maximum mid-ordinate to a 62-foot string was found to be 7 5/8 inches. What is the maximum safe speed for freight and passenger trains?

14. What is the maximum safe gage on a tangent track where freight trains are authorized to operate at 45 mph?

15. What is an indication that a rail is canting improperly?

Answer the following questions true or false.

16. When regaging track with 8-hole tie plates, care should be taken to respike the same plate holes previously used after plugging the old holes in the ties.

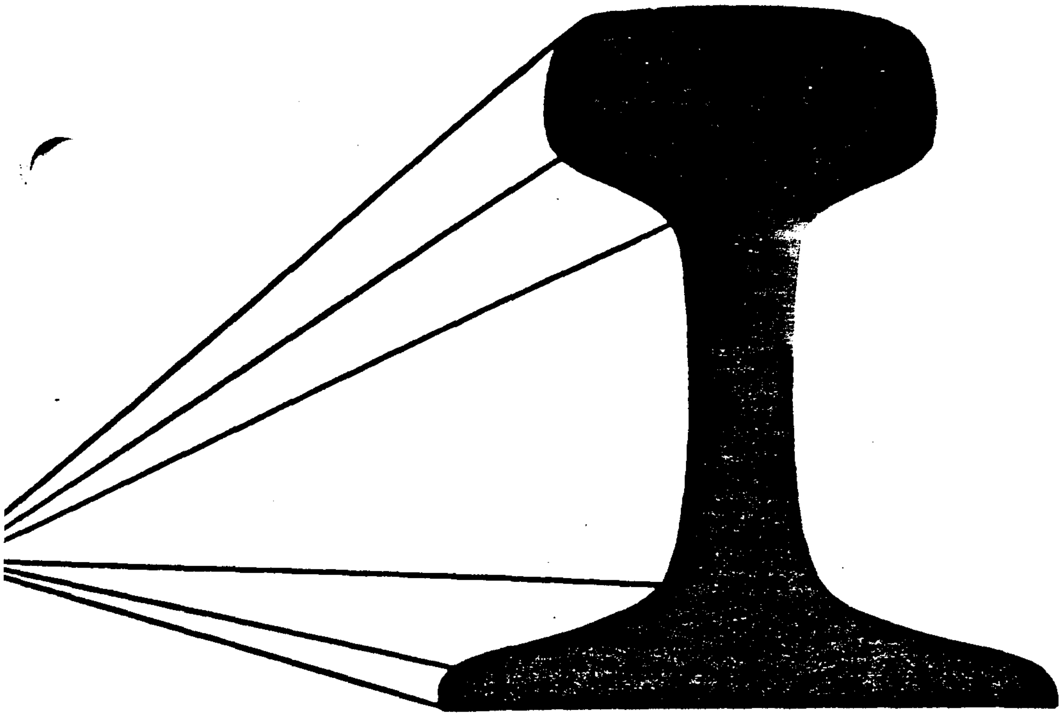
17. When renewing ties with a mechanized gang, the new ties should be installed to the old gage. A follow up gang should correct wide gage later.

18. A curve which is left hand for southward movements is right hand for northward movements.

19. Spirals are best suited to curves with a small degree of curvature.

20. Insufficient ballast can contribute to the development of excessive compressive stresses in a track.

Submit your answers to these questions to The Railway Educational Bureau in the prescribed manner. Be sure to include your name, file number, address, company's name, and lesson number on the upper right hand corner of your paper.



TRACK FOREMAN'S TRAINING PROGRAM

LESSON 6

TRACK SURFACE

The Railway
Educational
Bureau

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LESSON 6

TRACK SURFACE

In lesson 5, attention was directed to those parts of track geometry involving the horizontal location, measurement and maintenance of track. This lesson will examine the vertical placement of track. Where matters of track alinement and gage are involved, the point of reference is always on the inside edge of the rail head---at a point 5/8 inch below the top of the rail. The point of reference concerning track surface is always the top of the rail head.

Ideally, the tops of the rail heads should always provide a smooth uniform surface---free of humps or dips. In addition, the tops of the two rails should have a definite vertical relationship to each other. The tops of the two rails on tangents, should be level with each other. On curves, where the speed and degree of curvature are great enough to justify it, the outer rail should be elevated somewhat above the inner rail.

The loads which are placed upon a track structure by modern rolling stock can be very large. They can be so great that the underlying structure is not always able to sustain them without a partial breakdown in supporting ability. One of the large items in any railroad's maintenance budget consists of those funds which are expended in order to maintain adequate track surface. Millions of dollars are spent each year because the need for good track surface is well recognized by knowledgeable railroaders. Its importance can best be understood through a knowledge of the consequences of poor track surface.

EFFECTS OF POOR TRACK SURFACE

The most serious result of poor track surface is the derailment of locomotives and cars. This can range from minor derailments where little or no damage is sustained, to major catastrophes. Defects in track surface can be the sole cause of a derailment, or they can contribute to a combination cause of a derailment.

Derailments are not the only problem created by poor track surface. Damage to lading and excessive wear on equipment represent part of the problem. Usually, it is very difficult to trace some specific damage or wear to a particular point where track conditions are substandard. Nevertheless, expenses due to such damage are very real.

Another result of poor track surface is accelerated deterioration of the track structure itself. Surface defects can lead to rail damage, shortened tie life and fouling of the ballast. It is believed, by many, that over a long period of time, good track costs less to maintain than poor track.

Speed restrictions are a very real part of the cost of poor track surface. This can be in the form of delayed shipments, increased crew costs or both. If the resources needed to correct defects are not available, this alternative must be used. Yet, it should be recognized that it can mean substantial increases in transportation costs.

FOREMEN'S RESPONSIBILITIES FOR TRACK SURFACE

Track surface irregularities are widespread and can lead to serious consequences if ignored. Most Track Foremen will find a substantial part of their work related to such conditions. This work may consist of looking for and determining the seriousness of such conditions. It may consist of correcting surface defects. Both types of work could be involved, if that is the extent of the foreman's responsibilities.

This lesson will be concerned with the detection of track surface defects, and with the correction of such conditions. Since it is necessary to be able to recognize a track surface problem in order to correct it, detection of defects will be considered first.

FRA TRACK SAFETY STANDARDS

The FRA Track Safety Standards define several different ways in which track surface can be defective. This is done by describing the type of measurement required for each condition. With each such description, permissible limits are given for each class of track. For ready reference, the FRA standards for track surface are:

> Each owner of track to which this part applies shall maintain the surface of its track within the limits prescribed in the following table:

Track surface	Class of track					
	1	2	3	4	5	6
The runoff in any 31 feet of rail at the end of a raise may not be more than	3½"	3"	2"	1½"	1"	½"
The deviation from uniform profile on either rail at the midordinate of a 62-foot chord may not be more than	3"	2¾"	2¼"	2"	1¼"	½"
Deviation from designated elevation on spirals may not be more than	1¾"	1½"	1¼"	1"	¾"	½"
Variations in cross level on spirals in any 31 feet may not be more than	2"	1¾"	1¼"	1"	¾"	½"
Deviation from zero cross level at any point on tangent or from designated elevation on curves between spirals may not be more than	3"	2"	1¾"	1¼"	1"	½"
The difference in cross level between any two points less than 62 feet apart on tangents and curves between spirals may not be more than	3"	2"	1¾"	1¼"	1"	¾"

It should be understood that all of the figures in the this table are minimum safe standards. Any time one of these dimensions exceeds the limit specified for the class of track, speed on the track must be reduced. The speed reduction must be sufficient to lower the class of track to one in which all of the track's dimensions are permitted. If the condition does not meet the requirements of Class 1 track, the track must be removed from service until the condition is corrected.

RUN-OFF AT END OF RAISE

The first set of dimensions refers to the difference in elevation between newly raised track and track which has not been raised. Such transitions are commonly referred to as run-offs. There will be a run-off at the beginning of a stretch of track to be raised. A temporary run-off will be made each time the track is cleared for the passage of a train and at the end of each day's work. Run-offs will be needed on connecting tracks which are not to be raised. If some part of the track structure is not to be raised, run-offs will be needed either side of the unraised section. Such locations might include open deck bridges, road crossings, crossovers, track under overhead bridges or through station platforms. Finally, a run-off will be needed at the end of the raised portion of track. Run-offs are usually of the same length on each rail.

If a run-off is too short, it will tend to give a vertical bounce to each piece of equipment passing over it. If severe enough, such a bounce can cause broken car springs, breaks in various parts of the trucks or the car body. Damage to lading might also result. A short run-off can also lead to train separations. A sudden change in vertical direction can result in vertical slippage of locked couplers between two cars. Particularly, in cases where the two couplers were not well matched as to height on level track, such slippage may result in enough vertical movement for the couplers to become free of each other. This, of course, results in a separation of the train and an emergency brake application. Sometimes such incidents only require the train to be recoupled and started on its way again. In other cases, a severe run-in of the rear portion of the train against the head end might occur and result in a major derailment.

These hazards require that abrupt run-offs be avoided. There are two conditions which determine the length of run-off required. One is the maximum speed of trains operated over the track. This is provided for in the table with different dimensions for each class of track. The other condition is the height of the track raise. This must be calculated. For example, suppose that a raise of 3 inches is being made for Class 4 track. The table shows that 31 feet of run-off is needed for each 1-1/2 inches of raise.

Since the raise is 2 times the amount permitted per 31 feet, the length of run-off must be at least 2 times 31 feet, or 62 feet.

Length and height of run-offs can be checked with a string, a ruler and a tape line. Place one end of the string on top of the rail head at a point which has been fully raised, but near the run-off. Lower the other end of the string until the string is just touching the rail head, along the fully raised portion of track. The point at which the rail head and the string first start to separate is the beginning of the run-off. This point should be marked. Holding the string in the same position, measurements should be taken of the distance between the rail head and the string until the point is located where this distance no longer continues to increase. This is the end of the run-off and should also be marked. The distance between the rail head and the string is the height of the raise. The distance between the beginning and end of the run-off can now be measured to find the length of the run-off.

It is now possible to calculate these dimensions in order to find out the class of track to which the run-off conforms. For example, suppose that by following the procedure just described you have found the length of the run-off to be 53 feet and the height to be 2-1/8 inches. The run-off per 31 feet (R) can be found by using the following formula in which L is the total length of run-off and H is the height of the raise. To simplify calculations, the number 2-1/8 should be converted to a whole fraction which is 17/8.

$$R = \frac{31 \times H}{L}$$

$$= 31/53 \times 17/8 = 527/424 = 1.24 \text{ inches}$$

A run-off of 1.24 inches per 31 feet exceeds the allowance of 1 inch for Class 5 track, but is within the allowance of 1-1/2 inches for Class 4 track. Therefore, the maximum speeds permissible on this run-off are 60 mph for freight trains and 80 mph for passenger trains, (as per paragraph 213.9 of the FRA Standards).

Another situation that must be recognized when making run-offs is the effect of previous run-offs. Consider a part of the track structure of fixed elevation, such as an open deck bridge. If previous track raises have created run-offs adjacent to the ends of this bridge, no additional track raise can be made within the limits of such run-offs. If a new raise of the track is made, the run-offs will have to be made beyond the old run-offs.

DEVIATION FROM UNIFORM PROFILE

The second standard for track surface, refers to the deviation from a uniform profile on either rail at the mid-ordinate of a 62-foot chord. It should be recognized that these deviations or irregularities may consist of dips or humps in the rail. Dips are most common, as most irregularities in surface are caused by a breakdown in underlying support due to the heavy loads imposed on the ballast and roadbed. There are conditions where the deviation will consist of a hump. Such conditions might develop during cold weather in track subject to frost heaving. A hump might result from a general breakdown of surface on each side of a firmly supported point in the track. A hump might also be caused by careless jacking of a track.

The mid-ordinate to the 62-foot chord is measured by placing the string so the center is at the low spot on the rail head (for dips) with the ends tightly stretched and held against the top of rail. The distance between the center of the string and the top of rail is then measured.

For humps, the same procedure is followed, with the center of the string at the high point. The ends of the string should be placed on blocks of uniform height which are placed on top of the rail. The height of the blocks is allowed for in measuring the mid-ordinate.

In cases where the track is on a level grade or on a uniformly ascending or descending grade, these measurements are relatively simple to make. It has been seen that in horizontal alinement, curves are used to connect tangents. In vertical alinement, curves are also used to connect changes in grade. A vertical curve may be in a sag at the bottom of two opposing grades as in Figure 1a. It may also connect the tops of two opposing grades as in Figure 1b. In other cases, the two grades connected may both be ascending or descending, but of different steepness as in Figure 1c.

Whenever profile is being checked on vertical curves, the mid-ordinate to the 62-foot chord, should be other than zero. The procedure is to check mid-ordinates at several points within the vertical curve, find the average, then find out how much the mid-ordinate at the point in question varies from the average. At locations not on vertical curves, the mid-ordinate should be zero. In such cases, the deviation from uniform profile will be the actual reading of the mid-ordinate. This will apply whether the track is a level, ascending, or descending grade.

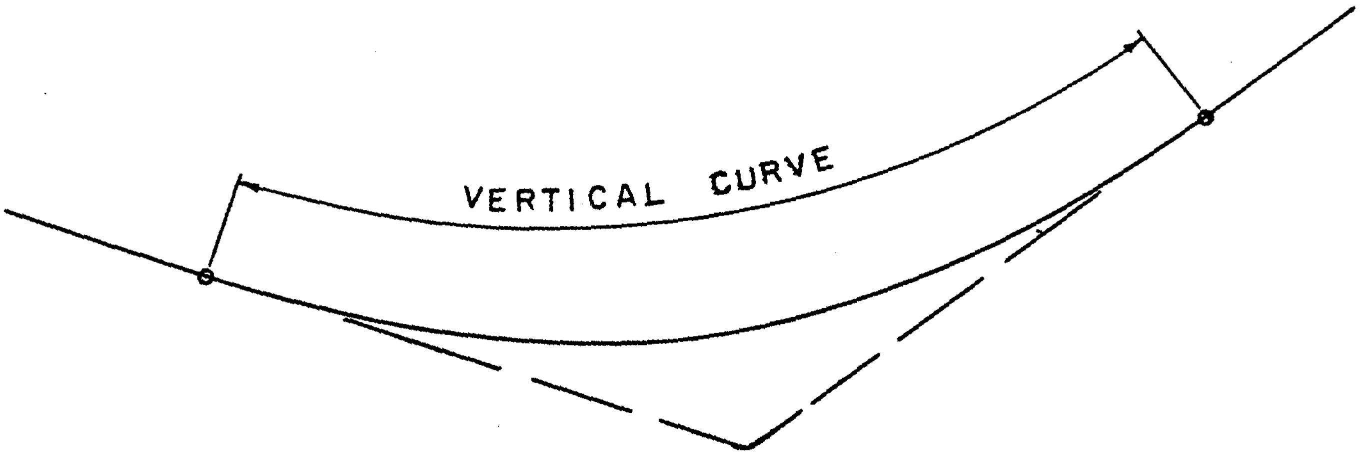


FIG. 1a

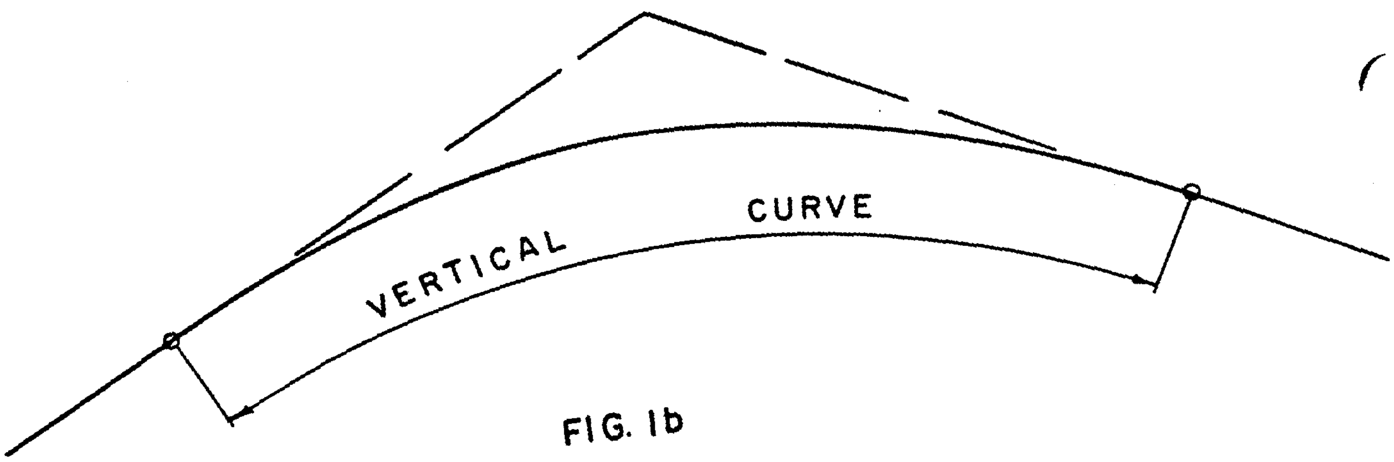


FIG. 1b

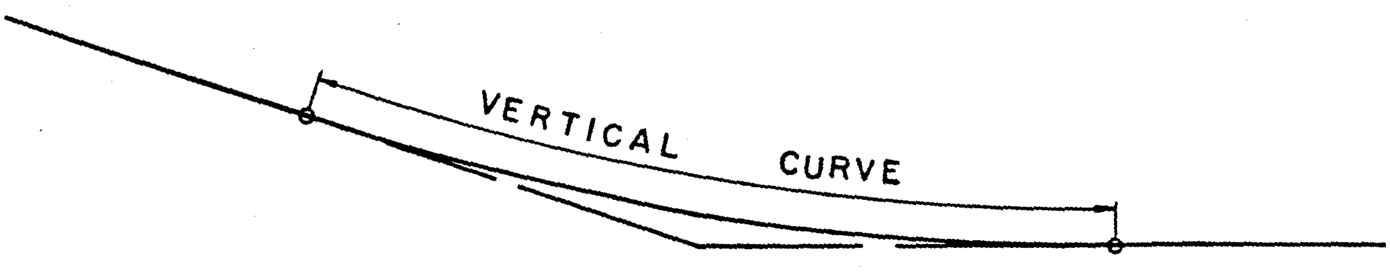


FIG. 1c

One of these dips or humps may develop on both rails at points approximately opposite each other. Should this happen, moving trains will be affected in much the same way that they are by run-offs. The extent of the irregularity and the speed of trains will determine whether the condition is serious.

If such an irregularity in the track surface appears on one rail only, its influence on trains may be quite different. Such a condition is not nearly as likely to cause a parting of locked couplers. It may start a rocking action in various types of cars. This can be the source of a different type of hazard.

GRADES

Since the subject of grades has been introduced, it would be well at this point to find out how grades are rated. A system of measurement is needed because the steepness of the grades on a route can determine how much tonnage a train can haul. The system which is used to measure grades is based on a length of track 100 feet long. The information needed to determine the grade of a track is the amount of vertical rise in a 100 foot length of track. If the track rises one foot in a 100-foot length, it is a one percent grade. If it rises 6 inches (0.5 feet), per 100 feet, the grade is 0.5 percent.

CROSS LEVEL

The remaining standards for track surface are all related to the cross level of the track. Cross level is the difference in height between the two rails of a track at points directly opposite each other.

Cross level is usually determined by the use of a level board. To read cross level, the fixed leg is placed on top of the rail head believed to be higher. The adjustable leg is placed on the opposite rail. The board is then adjusted until the bubble is centered with both legs still on the rail heads. The adjustable leg is then tightened, and the scale on the adjustable leg is read. This is the difference in height of the rails. The scale is normally marked in inches. Fractions can be read to the nearest 1/8 inch. Sometimes it will be found that the rail assumed to be higher was actually the lower one. In such cases, it will be necessary to reverse the level board in order to get a reading.

On tangent track, both rails should be the same height. This is zero cross level.

SUPER
ELEVATION

The FRA standards specify the amount of superelevation required on curves. Superelevation, commonly referred to as elevation, is the cross level on curves which have the outer rail raised above the inner rail. This amount varies with the degree of curvature and the speed permitted on the track. The FRA specifications for elevation are given in the following table:

APPENDIX A—MAXIMUM ALLOWABLE OPERATING SPEEDS FOR CURVED TRACK

Degree of Curvature	Elevation of outer rail (inches)												
	0	½	1	1½	2	2½	3	3½	4	4½	5	5½	6
	Maximum allowable operating speed (mph)												
0°30′	93	100	107										
0°40′	80	87	93	98	103	109							
0°50′	72	78	83	88	93	97	101	106	110				
1°00′	66	71	76	80	85	89	93	96	100	104	107	110	
1°15′	59	63	68	72	76	79	83	86	89	93	96	99	101
1°30′	54	58	62	66	69	72	76	79	82	85	87	90	93
1°45′	50	54	57	61	64	67	70	73	76	78	81	83	86
2°00′	46	50	54	57	60	63	66	68	71	73	76	78	80
2°15′	44	47	50	54	56	59	62	64	67	69	71	74	76
2°30′	41	45	48	51	54	56	59	61	63	66	68	70	72
2°45′	40	43	46	48	51	54	56	58	60	62	65	66	68
3°00′	38	41	44	46	49	51	54	56	58	60	62	64	66
3°15′	36	39	42	45	47	49	51	54	56	57	59	61	63
3°30′	35	38	40	43	45	47	50	52	54	55	57	59	61
3°45′	34	37	39	41	44	46	48	50	52	54	55	57	59
4°00′	33	35	38	40	42	44	46	48	50	52	54	55	57
4°30′	31	33	36	38	40	42	44	45	47	49	50	52	54
5°00′	29	32	34	36	38	40	41	43	45	46	48	49	51
5°30′	28	30	32	34	36	38	40	41	43	44	46	47	48
6°00′	27	29	31	33	35	36	38	39	41	42	44	45	46
6°30′	26	28	30	31	33	35	36	38	39	41	42	43	45
7°00′	25	27	29	30	32	34	35	36	38	39	40	42	43
8°00′	23	25	27	28	30	31	33	34	35	37	38	39	40
9°00′	22	24	25	27	28	30	31	32	33	35	36	37	38
10°00′	21	22	24	25	27	28	29	31	32	33	34	35	36
11°00′	20	21	23	24	26	27	28	29	30	31	32	33	34
12°00′	19	20	22	23	24	26	27	28	29	30	31	32	33

A railroad may use this table or it may prefer to use a different one. If a different one is used, it must provide for slower speeds for any combination of degree of curvature and elevation. Higher speeds are not permitted.

The following are some examples of how this table can be used.

Example 1 - You have a curve with a known curvature of 3°30'. The maximum authorized speed of trains is 50 mph. You are about to resurface the curve, and want to find out the proper elevation. Reading down the left hand column, you find a line for 3°30'. Reading across this line you find a column for 50 mph. Going back to the top of that column, you find that 3 inches of elevation is required for this curve.

Example 2 - You are checking a track with an authorized speed of 35 mph. You find a curve with 1-1/2 inches of elevation with minor variations. The curvature is not known. You take a series of mid-ordinates with a 62 foot string, and find it to be a 5° curve. Checking the table across the 5° line to the 1-1/2 inch column, you find that speeds of 36 mph are permitted on this curve. Therefore, this elevation is satisfactory for the 35 mph speed.

EFFECTS OF IRREGULAR CROSS LEVEL

Before proceeding further with the requirements of the FRA standards, it is necessary to have an understanding of the effects of a change in cross level. This can best be done by examining some of the things that happen to equipment on track with cross level changes. The examples which will be used will be based upon a box car. This will be assumed to be an average size box car, rather than one of the high capacity cars. The first example will be based upon a low spot on one rail. This low spot will be rather short in length, possibly in the vicinity of one rail joint. The track is assumed to be tangent. A level board indicates this spot to be one inch low. A 62 foot string placed on the rail with the low spot also shows it to be one inch low. The box car is placed on this track with one truck directly over the low spot. Since the track is not level, the truck is leaning. The side bearings between this truck and the car body have minimum clearance. This causes the car body to tilt. The height of the car is considerably greater than the distance between rails. Because of this, the one-inch variation in cross level causes the top of the car to tilt about three inches to one side. At the same time the other truck under this car is on level track. That end of the car body is also level. This means that the car body is twisted.

The example just described applies to a car which is not moving. Now, consider what happens to the same car when it moves over the same low spot in the track. As the leading truck moves onto the low spot, the wheels on that rail dip. Since the change in cross level takes place rather abruptly, the tilting of the car body occurs quickly. This brings a considerable amount of weight into motion. It is now pivoting about the wheels on the rail with the low spot. Some restraining force is needed to stop the roll of the car body. This force is in the truck springs. At the point where the maximum tilt or roll occurs, the top of the car body has moved a greater distance than it did when it was on the same low spot, with the car at rest. At the same time, the truck springs on the side to which the car rolled are compressed. There is greater than normal weight on the rails on this side because they are affected by the compressing of the truck springs. Correspondingly, there is a less than normal weight on the wheels on the opposite rail. All of this happens quite rapidly.

The car is continuing to move. In a fraction of a second, the wheels are coming out of the low spot, back to level track. This starts a rolling of the car body in the opposite direction. This tendency is accelerated by the compressive forces in the car springs. The result is that the car body rolls past the center point in the opposite direction, and reverse forces come into action. If this is the only low spot, the car begins to settle down in the vicinity of this truck.

While all this has been taking place, the trailing truck has been on level track. The car body has undergone a twist in one direction and then been quickly twisted in the other direction. Now the trailing truck of this car approaches the low spot. The entire sequence of events happens again at the other end of the car. The severity of the car body roll and of the forces involved depends on several things. They include the dimensions of the surface defect, the speed at which the car is moving, the dimensions of the car, the weight of the loaded car and the average height of the car and load---known as the center of gravity.

Suppose, that instead of one low spot in the track structure there are two similar low spots. These low spots are on opposite rails. The distance between them happens to be about the same as the distance between trucks of the box car. As this car moves over this track, at one point in the sequence of events opposite ends of the car are trying to roll in opposite directions. Suppose, also, that this car is relatively stiff and cannot twist very much. It is difficult to say which way the car will go. It will probably be influenced by the way in which it was tending to rock just before the trucks arrived at these two low spots. The manner in which the car is loaded might have some effect. What could happen is that the car is not fully able to bend to the shape of the track surface. This can result in a loss of contact between the wheels on one of the low spots and the rail head. This would be a momentary situation. If the track is tangent, wheel contact with the rail head will probably be re-established in a fraction of a second, and this incident will not be noticed.

Suppose--that this occurs on a curve, and that the loss of contact takes place on the outer rail. This rail has been guiding the wheels on a curved route by means of a lateral push against the wheel flanges. This momentary loss of wheel-rail contact, or even a lessening of the vertical wheel load on the rail, can permit a wheel flange to begin climbing onto the rail head. Once this happens, the risk of derailment is very high.

This is only one of the ways in which track surface defects can cause a derailment. Assume that there is a series of low joints on both rails. Assume that the distance between the trucks on the box car is about the same length of the rails. This means that both trucks will be on low spots on the same rail at the same time. The entire car body will roll to that side. There will be no twisting of the car body. As the car moves beyond these two low joints, it begins to roll in the opposite direction. Even if there are no more low spots, we know that the car body is going to tend to roll past center. But as the car moves a half rail length, both trucks come to low spots on the opposite rail. Depending on the design of the car and the speed at which it is moving, the reverse roll from the recovery from the previous situation may occur, just as the car responds to a second set of low spots. These two forces combine and cause a more violent rolling action. This is called harmonic rocking. Given such conditions and a continuing series of low joints, this rocking will continue and probably become more violent. Under such conditions wheel lifts occur in many cases. Again, there is greater danger on curves than on tangents, but derailment can take place on tangents as well.

The foregoing descriptions illustrate just two of the ways in which changes in cross level can cause derailments. It would be possible to get into more complex situations where derailment can occur, but it is not necessary. It should be evident by now that a great deal of attention must be given to changes in cross level in order to avoid dangerous situations. It is because of this that the FRA has not one, but several sets of standards to cover cross level defects.

RUN-OFF OF ELEVATION IN SPIRALS

Attention has already been called to the desirability of the rails being level in relation to each other on tangents. The need for the outer rail on curves to be elevated above the inner rail in many cases has also been discussed. The change from zero elevation to the elevation required for curves has not yet been examined. It has been shown that abrupt changes in cross level can seriously affect the ability of equipment to operate without risk of derailment. This necessitates a gradual change in cross level at the ends of curves with elevation. In Lesson 5, the need for spirals at the ends of curves to meet alinement requirements was discussed. Spirals are also valuable from the standpoint of track surface. They provide space for a gradual run-off of the elevation which is needed for the body of the curve.

Railroads may designate the maximum rate at which elevation can be run-off. This is usually based on increments of 31 feet. This may provide for different allowances for various speed ranges. For instance, a certain railroad may have a standard which says that for speeds up to 50 mph., elevation may be run-off at a rate up to 1/2 inch per 31 feet. To apply this, you would have to determine the length of the spiral and the elevation of the body of the curve. You may find that the spiral is of the proper length to run-off the elevation at this rate. For example, if the elevation of the curve is 2-1/2 inches and the length of the spiral is 155 feet, the 1/2 inch per 31 feet will work out properly.

It is more likely that the length of the spiral will be either more or less than needed to fit the increments of run-off. Such conditions are covered by the following statement from the FRA standards:

§ 213.59 Elevation of curved track; runoff.

(a) If a curve is elevated, the full elevation must be provided throughout the curve, unless physical conditions do not permit. If elevation runoff occurs in a curve, the actual minimum elevation must be used in computing the maximum allowable operating speed for that curve under § 213.57(b).

(b) Elevation runoff must be at a uniform rate, within the limits of track surface deviation prescribed in § 213.63, and it must extend at least the full length of the spirals. If physical conditions do not permit a spiral long enough to accommodate the minimum length of runoff, part of the runoff may be on tangent track.

If the spiral is longer than the minimum needed for a complete run-off, the increments per 31 feet are to be reduced so that the full spiral is used for the elevation run-off. Uniform increments are also required. Avoid using 1/2 inch increments for part of the spiral and 1/4 inch increments per 31 feet for the balance of the spiral. Average it out.

If the spiral is not long enough to accommodate the run-off at the specified rate, then the elevation run-off must be started from the point where full curvature begins. The increments are to be reduced through the length of the spiral and extended onto the tangent until the zero point is reached.

Using the example previously given of 1/2 inch per 31 foot increment, with a maximum elevation in the curve of 2-1/2 inches, suppose the length of the spiral was found to be 110 feet. It has been seen that 155 feet is needed for this elevation run-off. In this case, the point of zero elevation would be on the tangent 45 feet ahead of the beginning of the spiral.

MAXIMUM VARIATION OF CROSS LEVEL ON SPIRALS

It is possible that your railroad may not specify the maximum run-off rate permitted. Paragraph 213.63 of the FRA standards specifies the maximum rate of elevation run-off for each class of track under the heading "Variations in cross level on spirals in any 31 feet may not be more than....". Remember, that these are maximum safe increments. These rates of run-off should not be used deliberately, as there would be no tolerance for any irregularities which develop.

DEVIATION FROM DESIGNATED ELEVATION ON SPIRALS

The FRA has another standard for each class of track in reference to the cross level on spirals. This is also found in paragraph 213.63 under the heading "Deviation from designated elevation on spirals may not be more than....". To illustrate this requirement, refer again to the spiral and run-off previously used as an example. At some point in this spiral the designated elevation will be 1-1/2 inches. Assume that this is Class 4 track. The maximum deviation from designated elevation is 1 inch. This standard will have been met at the point where the elevation should be 1-1/2 inches provided the actual elevation is at least 1/2 inch, but not more than 2-1/2 inches.

MARKING SPIRALS AND ELEVATION

It is the practice on some railroads to mark the location of each end of each spiral, at least in the more important tracks. This might be done with permanent markers permanently embedded in the ballast. In other cases the identification might be in the form of markings on the rail web. This procedure would have to be considered as somewhat temporary. Another procedure, sometimes employed, is to affix metal tags to the ties closest to these points. These tags can have the advantage of identifying the amount of elevation required at that particular point. This procedure can also be used to indicate the proper elevation at each 31 foot interval within the spiral.

CURVE RECORDS

Another requirement of the FRA standards involves certain record keeping relative to curves in high speed tracks. This is specified as follows:

§ 213.61 Curve data for Classes 4 through 6 track.

(a) Each owner of track to which this part applies shall maintain a record of each curve in its Classes 4 through 6 track. The record must contain the following information:

(1) Location;
(2) Degree of curvature;
(3) Designated elevation;
(4) Designated length of elevation run off; and
(5) Maximum allowable operating speed

Should you have responsibilities for tracks of these classes, there are times when it will be most helpful to have a copy of these records.

DEVIATION FROM DESIGNATED CROSS LEVEL ON TANGENTS AND CURVES

Maximum variations permitted in cross level on tangents and in the body of curves, are specified in the last two standards of paragraph 213.63. The first of these is the one which is headed "Deviation from zero cross level at any point on tangent or from designated elevation on curves between spirals may not be more than....". As an example, on a tangent in Class 4 track, the actual reading on a level board may not exceed 1-1/4 inches. For an example, on a curve with a designated elevation of 4 inches and in Class 3 track, the actual elevation may not be less than 2-1/4 inches (4"-1-3/4") nor more than 5-3/4 inches (4"+1-3/4").

VARIATION IN CROSS LEVEL ON TANGENTS AND CURVES

The final standard reads "The difference in cross level between any two points less than 62 feet apart on tangents and curves between spirals may not be more than...". Since it is possible to pick many combinations of two points in any 62 foot length of track, a great many differences in cross level can be read. What is needed is to find the maximum difference. This means finding the maximum cross level reading and the minimum cross level reading on a curve. These readings are subtracted in order to find the difference. The distance between two points could conceivably be rather close or it could be any distance up to but not including 62 feet.

In the case of tangents, finding the difference could be somewhat confusing. Suppose that you find a situation within the 62-foot limit where the cross level varies from 1/2 inch (with the north rail low), to 1-5/8 inches (with the north rail low). The difference in cross level is 1-1/8 inches (1-5/8"-1/2"). Next, assume that you find a situation which varies from 1/2 inch (with the north rail low), to 1-5/8 inches (with the south rail low). In this case, the difference in cross level is 2-1/8 inches (1-5/8 + 1/2").

> Example 1 - A 5° curve, with a designated elevation of 2-1/2 inches, has an authorized speed of 40 mph. At one point in this curve the elevation is found to be 1-1/2 inches. At another point 20 feet away, the elevation is found to be 3-3/4 inches. You must determine whether this condition conforms to the FRA standards. First, you should recognize from the speed limit that this is Class 3 track. The permitted deviation from designated elevation is 1-3/4 inches.

The first point has a deviation of 1 inch (2-1/2" - 1-1/2"). The second point has a deviation of 1-1/4 inches (3-3/4" - 2-1/2"). These are both within the allowable deviation from designated elevation. However, these points are less than 62 feet apart, and the difference in cross level must be considered. The difference is 2-1/4 inches (3-3/4" - 1-1/2"). The maximum permitted for Class 3 track is 1-3/4 inches. Class 3 speeds are not permitted. Actually, this exceeds the 2-inch limit for Class 2 track. Speed must be reduced to Class 1 limits until the condition is corrected.

Example 2 - A certain Class 4 track has a 3°30' curve with 3 inches of elevation. Level board readings taken at successive 39-foot intervals are as follows:

3"
2-5/8"
2-1/8"
1-3/8"
2"
2-1/2"
3-1/8"

All of these readings are within the allowable 1-1/4 inch between two points, less than 62 feet apart. However, the 1-3/8 inch reading is 1-5/8 inches less than the designated 3 inch elevation. This exceeds the permitted deviation from designated elevation of 1-1/4 inches. Speed must be reduced to Class 3 limits which permit a deviation of 1-3/4 inches, until the condition is corrected.

INSPECTING TRACK FOR SURFACE DEFECTS

Many Track Foremen have responsibilities for locating track defects within an assigned territory. Usually, the territory assigned is extensive enough to make it impracticable to make the necessary measurements and calculations to positively identify all track surface irregularities. The experienced Track Foreman relies on various observations and on knowledge of the territory. Quite possibly, he may routinely inspect the track from a track motor car or a hi-rail vehicle. If so, he can look for visual indications of surface irregularities. When he sees a condition which looks questionable, he can stop and check it with a level board and, if necessary, with a string.

Possibly, he may occasionally ride a train over his territory. In this way, he can better feel rough spots. These points can be checked later on the ground.

Part of his time may be set aside for walking inspections. This affords an opportunity to get down and sight the rail, looking for irregularities. Suspicious spots can then be measured to establish the severity of the defect. At such times, he may have notes from previous riding inspections of items to check.

He may know of conditions within the territory that require a close check at regular intervals. It may be an unstable roadbed condition. A stretch of track with a troublesome rail joint condition may need watching. Another area may have a history of frost heaving in cold weather. He may be keeping an eye on a muddy ballast situation and its effects on surface.

Knowing that surface is more likely to cause problems on curves than tangents, he may arrange to make a detailed level board check of one or two curves, each time he makes a walking inspection. Since the spirals are the most critical points, he gives these areas the most careful inspection.

Experience is an important factor in a pattern of inspection such as the one just described. This does not mean that it takes many years to acquire such experience. Someone with a desire to learn and a willingness to work at it, can become a competent inspector of surface defects in a reasonable amount of time. Close observations paired with frequent measurements will develop reasonable judgment as to the surface irregularities which may need further attention.

CORRECTING SURFACE DEFECTS

The most common procedure for correcting defects in track surface is that of tamping. There are many ways in which track can be tamped, but they all involve at least three essential operations:

- Jacking of one or both rails
- Some means of referencing, to establish the desired location of the rails
- Tamping or compacting ballast under the ties made loose by the rail jacking operation.

SPOT TAMPING

One type of tamping procedure which is widely used is known as spot tamping. Spot tamping involves jacking the track just enough to remove a specific surface irregularity. Ties are then tamped through the portion of the track which has been jacked.

Spot tamping has several advantages. One of these is flexibility. A spot-tamping operation may proceed with the intention of removing all noticeable irregularities in a stretch of track. The method may also be used only to correct those defects which are considered more critical and farther apart. If the latter method is used, more track can be covered in a day's work. Both methods have their place in maintenance operations. There will probably be times when you, as a Track Foreman, will have to decide which one is proper for the circumstances. On other occasions, this may be a matter of policy, of which you will be informed by a superior officer.

Another advantage of spot tamping is that little or no additional ballast is needed to perform this type of tamping. This contributes to the economy of this type of work. It also minimizes the advance preparations, when the need to correct surface defects develops. The fact that this type of tamping usually requires less manpower and less equipment than other types of tamping also adds to its economy.

SKIN LIFTS

A tamping procedure which attained considerable popularity with the development of the modern tamping machines is usually referred to as the "skin lift". This procedure involves making a general raise of the track. In the process, irregularities in surface are removed. The general raise is usually one inch or less. This amount will be greater in the areas in which low spots existed. General raises of the track structure, regardless of the amount of raise, are frequently called "out-of-face raises".

One of the principal advantages of the skin lift is that every tie is tamped. This permits uniform compaction of ballast under each tie. If settlement occurs under traffic, it should be relatively uniform. This contrasts with the situation that exists in track which has been spot tamped. Some ties will be on an undisturbed bed, and some will be on newly tamped ballast with different compaction, following a spot-tamping job. It is entirely possible that there may be a few loose ties if the wrong locations were selected to begin and end tamping.

Unless there is an excess of ballast in track, it is usually necessary to provide additional ballast in advance of a skin lift. A light application of ballast will be sufficient, if the need is to maintain a similar ballast section to the one which existed prior to the raise.

To obtain maximum efficiency, equipment capable of shaping and leveling the ballast section should be used in this type of tamping operation. Correction of alinement is usually done incident to skin-lift tamping. This may be done by a tamper with track-lining capabilities, or by a separate lining machine. In many cases, two tampers are used in this operation. The lead tamper may have jacking and surface referencing equipment. If so, this machine will bring the track to proper surface, tamping every other tie. The second tamper will then tamp the alternate ties.

The need for additional ballast, and the additional equipment and manpower required, increase the cost of a skin-lift over spot tamping. The advantages of a skin-lift over spot tamping are quality, uniformity, and usually longer lasting results.

HIGHER RAISES

Prior to the development of tamping machines with the capability of effectively compacting ballast with only a small opening under the tie, most out-of-face track raises involved a more substantial lift. The popularity of the skin-lift has reduced the frequency with which such higher raises are made. There are still times when a raise of several inches is desirable. When ballast becomes fouled with foreign material and drainage is impaired, a general track raise that will result in clean ballast under the ties will help considerably. The restored track surface will last longer because of improved drainage around the ties.

Raises of this type require considerably more ballast than skin-lifts. Tamping productivity will be somewhat less than that which is attainable with skin-lifts. This is because of the greater volume of ballast which must be compacted under each tie. Equipment and manpower requirements for such an operation are usually similar to those used in skin-lift tamping. Factors which increase costs are the additional ballast and the additional time it takes to tamp track.

MANUAL TAMPING

Before the development of mechanical tampers, the manual tamping of ties required a tremendous amount of labor. Because modern tamping machines are highly productive, their use is widespread. Yet, there will continue to be frequent situations in which manual methods will be used to surface track. Sometimes, there is a need for a small spot-surfacing job which does not justify moving a tamping machine a considerable distance to correct. In other situations, the urgency of the condition may require immediate corrective action. High density traffic may preclude the use of on-track equipment for operations such as spot tamping.

Manual tamping may be accomplished by use of ballast forks or track shovels, depending on the kind of ballast used. Occasionally, pick tamping may be used. Pneumatic tamping tools, while having the advantage of a power source, might be considered as a manual method. Each tool requires an operator.

In situations where manual tamping is performed, the tools almost always used to bring the track to proper surface are track jacks. Either the small or large-size jacks may be used, depending on the amount of lift that will be made. In a spot-surfacing operation involving a situation such as a few low joints, one or two jacks may be sufficient. In more extensive jobs, additional jacks may be needed.

MANUAL REFERENCING-SPOT TAMPING

Circumstances which justify manual tamping are most likely to be spot-tamping situations. A procedure which is widely used to re-establish proper surface involves sighting of the rail profile. The foreman leans over the rail to be surfaced at a point where the rail is on proper grade. He positions himself so that he is at eye-level with the top of rail, usually to the gage side of the rail. From this position he can judge where the jack or jacks should be placed to correct the low spot. After the jacks are placed according to the foreman's directions, he then observes from the same position during the jacking process. He signals each man when to stop jacking.

After a good rail-head profile has been obtained, the level board is used to check the cross level throughout the jacked area. If the cross level is not satisfactory, each rail should be sighted again, in order to find the source of the problem. When good cross level and good profile have been established, the portion of track raised by the jacks is ready for tamping.

GRADE RAIL

Whenever an out-of-face track raise is made, one rail is designated as the grade rail. Regardless of the means of referencing used, the grade rail is first brought to proper profile. The other rail is then brought to its proper position by use of a level board. On curves, the low or inner rail is always the grade rail. Your railroad may or may not have a system of designating which rail is to be the grade rail on tangents. In any case, you should be consistent in the use of a grade rail throughout the length of the tangent.

MANUAL REFERENCING-GENERAL RAISE

Occasions when it is necessary to manually provide grade referencing for a general raise have become less frequent. Most out-of-face surfacing is done with mechanical tampers with either a wire or electronic device provided for grade referencing.

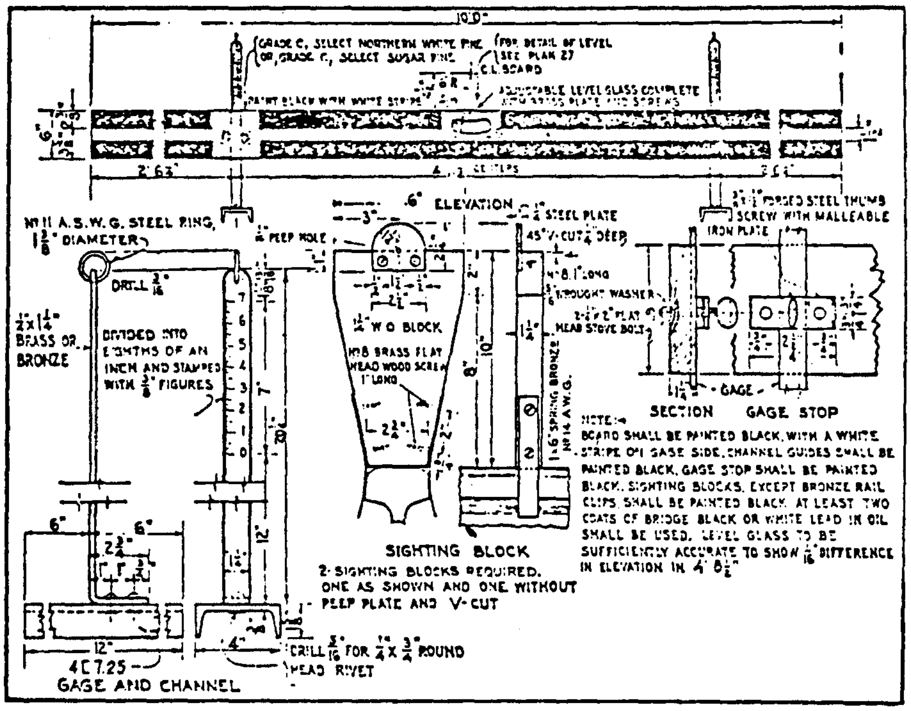
It is possible that you may be faced with an exception to this situation. You should be able to raise a track to a good profile when the need arises. The device which is commonly used to do this is known as a spot board. Figure 2 is a plan of a spot board. The spot board is set up over the grade rail and leveled at a convenient point ahead of the raised track. The usual practice is to avoid low spots as set-up points. A sighting block with a peep hole is placed on the raised portion of the track. A second block is set on the rail head, at the point about to be jacked to the new grade. The peep hole on the sighting block and the top of the forward sighting block are at the same distance above the top of rail. This is the same as the height of the reference line on the spot board when it is set for zero raise. The spot board is raised above this base level by the amount of the raise desired. The procedure is illustrated in Figure 3.

The spot board will provide grades of satisfactory accuracy on level track and on a uniformly ascending or descending grade. It also is quite useful in making run-offs at the start or end of a raise.

When working within the limits of vertical curves, the spot board is less accurate. If the vertical curve is a sag, raises will tend to be too high within its limits. If the vertical curve is a crest, the raises will tend to be too low. The spot board may be adjusted either upward or downward to compensate for this tendency. You should sight the track in advance and mark the ends of vertical curves. In this way, you can adjust the spot board at the right points, rather than waiting until your raise gets out of control. The tendency towards such errors can also be lessened by shortening the distance from the point of jacking to the spot board.

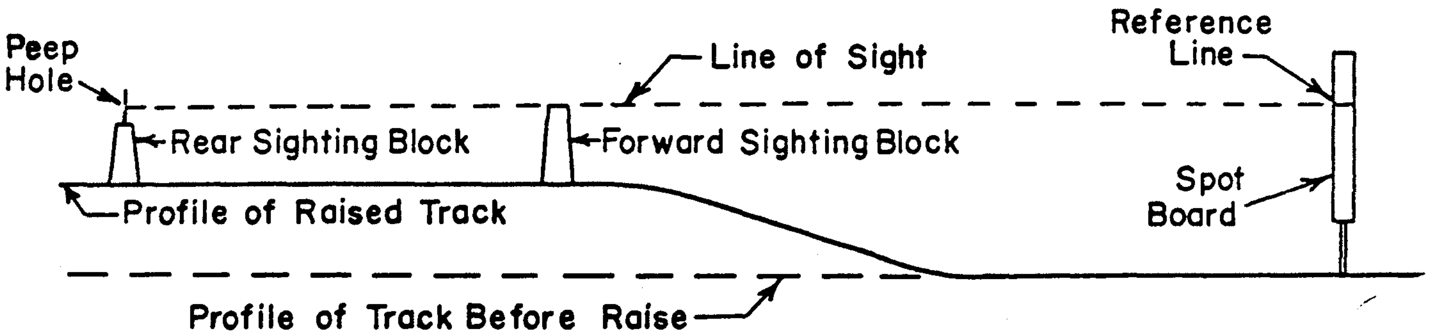
MECHANICAL REFERENCING-GENERAL RAISE

The principles used in the operation of grade-referencing equipment on tamping equipment are very similar to a spot-board operation. Each manufacturer issues instructions covering the operation of his equipment. Regardless of the device used, one rail is set up as the grade rail, and the other rail is brought to position by cross leveling. They all have similar tendencies on uniform grades, on run-offs and on vertical curves. In most cases, the front reference



Plan 30–62—AREA spot board.

FIG. 2



Peep
Hole
Line of Sight
Reference
Line
Rear Sighting Block
Forward Sighting Block
Spot
Board
Profile of Raised Track
Profile of Track Before Raise

FIG. 3

point, corresponding to the spot board, moves constantly. Therefore, this reference point is sometimes on high spots and sometimes on low spots. This can introduce small errors. These are similar to those described in Lesson 5, when lining equipment is used. Usually such errors are small enough to be negligible.

TAMPING EQUIPMENT

There is a variety of tampers in widespread use. Most of them have available an assortment of optional equipment. There has developed areas of specialization in the design of tampers. Many tampers are intended for one particular type of surfacing work. The primary function of any tamper is the compaction of ballast under ties. Even though various optional functions are available such as track jacking, grade referencing and track lining; the basic purpose of a tamper is one of ballast handling. This subject will be dealt with in another lesson.

TRACK SHIMS

Considerable attention has been given to the correction of surface defects by means of tamping procedures. This is the way most surface problems are eliminated. There are times when this is not practical. Such situations occur when surface defects must be corrected in track with frozen ballast.

One type of condition in which this happens is a conventional low spot in the track. It is either undetected or, for some reason, uncorrected, before the ballast becomes frozen. It is determined to be serious enough to warrant prompt correction. In such cases, flat wood shims are installed between the tie plates and ties. The procedure is to remove all spikes through the low area and to jack the rail so as to correct the defect. Shims of different thicknesses will probably be needed in order to bring all tie plates firmly against the rail. It may be necessary to use spikes of extra length to keep the rail firmly secured to the ties.

Another surface problem that sometimes develops in frozen track is the so called frost heave. This may be a spot where the track raises above the proper grade. It may return to its proper position when thawing occurs. If the irregularity is too abrupt while frozen, shims may be needed either side of the frost heave. This does not eliminate the hump, but it can provide a gradual rise and fall. Shims may also correct cross level defects caused by a frost heave.

Once shims are installed in track, they should be checked at frequent intervals. Shims are a temporary expedient and should be removed from track as soon as the condition can be corrected by tamping.

LESSON 6

EXERCISE QUESTIONS

1. What tool is needed to find out how much elevation is in a curve?

2. What tools are needed to find the deviation from uniform profile at the mid-ordinate of a 62 foot chord?

3. Where are vertical curves used?

4. In what part of the track structure are changes in cross level needed?

5. What tool should be used to check the lifts made with jacks when spot tamping track?

6. Which rail is used as the grade rail on curves?

7. When are track shims needed?

8. In a track where the maximum speed is 50 mph, a 3-inch raise is being made. What is the minimum length of run-off needed at either end of the raise?

9. A low spot is checked with a 62-foot string and a ruler. The mid-ordinate is found to be 2-1/2 inches. The track is on a uniform grade. What is the maximum speed at which freight trains may be operated?

10. Elevation is checked with a level board at 31-foot intervals on a spiral and found to be: 0; 1/8"; 1/2"; 3/4"; 1-1/8"; 1-1/4"; 1-1/2".

    Authorized speeds are: Freight trains - 60 mph
    Passenger trains - 80 mph

    Is a slow order required?

11. Level board readings on a tangent are taken at 19-1/2-foot intervals and found to be: 3/4" (East rail low); zero; 1/8" (East rail low); 7/8" (West rail low). For what class of track is this condition acceptable?

12. A 2° curve is located in territory where the authorized speeds are: Freight trains - 50 mph
    Passenger trains - 60 mph
    How much elevation is required on this curve?

13. A curve has a designated elevation of 3 inches. Maximum speed of trains is 45 mph. Level board readings at successive joints (19-1/2 feet apart) are: 3-1/8"; 2-1/2"; 3-5/8"; 3-7/8"; 3". What is the maximum difference in cross level between any two points less than 62 feet apart?

14. Does the condition in question 13 meet the requirements of the FRA standards?

15. By use of a tape line, string and ruler, you find the length of a run-off at the end of a raise to be 68 feet. The height of the raise is 4 inches. What is the maximum speed of freight trains that may be operated on this run-off?

Answer the following questions True or False.

16. A 62-foot string is useful in measuring track surface as well as curvature.

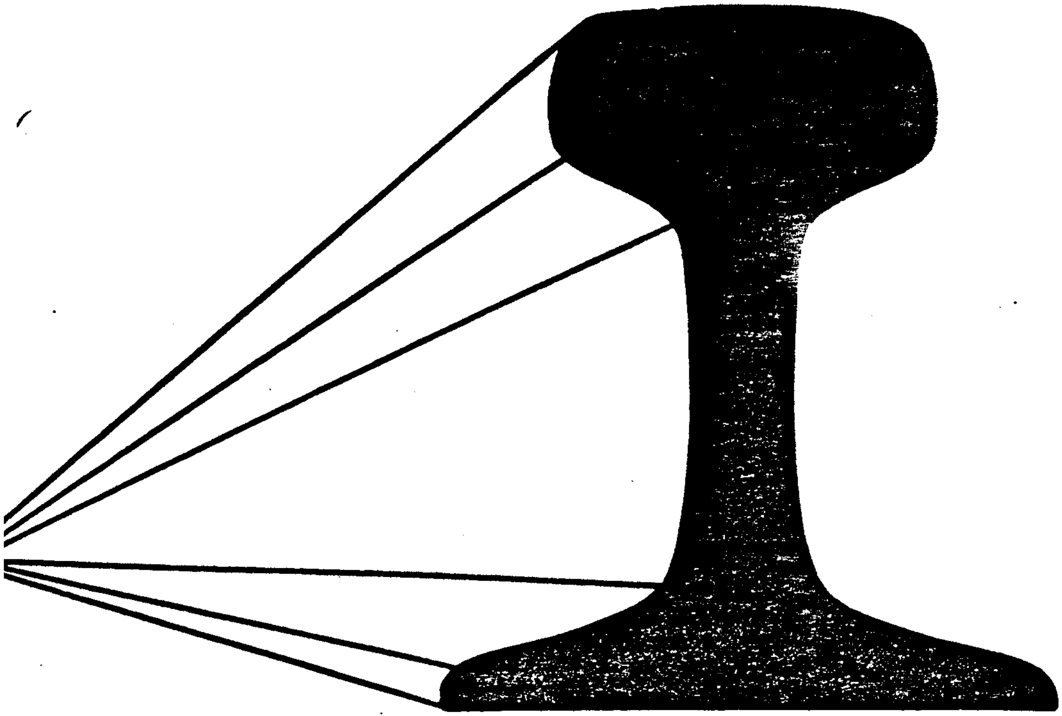
17. The reference point for measuring surface is on the gage side of the rail head, 5/8 inch from top of rail.

18. If a spiral is not long enough for the full run-off of elevation, the run-off should be started in the body of the curve.

19. A "skin-lift" provides a more uniform tamping job than spot tamping.

20. The best way to inspect track for surface defects is to start at one end of the territory with a level board and to check a couple of miles each day until the territory is covered.

Submit your answers to these questions to The Railway Educational Bureau in the prescribed manner. Be sure to include your name, file number, address, company's name and lesson number on the upper right hand corner of your paper.



TRACK FOREMAN'S TRAINING PROGRAM

LESSON 9

RAIL DEFECTS

The Railway Educational Bureau

606 South 75th Street, Omaha, Nebraska 68114

TRACK FOREMAN'S TRAINING PROGRAM

LESSON 9

RAIL DEFECTS

Acknowledgment

Special thanks to the American Railway Engineering Association and Sperry Rail Service Division-Automation Industries, Inc., for their assistance in providing illustrations which will appear in this lesson and to all who contributed to the production of this training program.

LESSON 9

RAIL DEFECTS

It is the steel wheel, rolling on the steel rail, that makes railroads an efficient method of transportation. The relatively small amount of friction developed by the wheel-rail combination permits the hauling of large tonnages with minimal power. This capability has led to substantial increases in the weight placed upon each wheel, some of the larger increases have occurred in recent years. One of the characteristics of the wheel-rail combination is the lack of deformation under load, such as happens with the rubber tire upon a road. This quality of steel is essential to the small amount of friction developed in the movement of rail equipment. It results, however, in very concentrated loads being placed upon both rail and wheel at the point of contact. In this lesson, some of the things that happen to rail as a result of these wheel loads will be examined.

Most newly manufactured rails are installed in heavily used main tracks. Usually, several hundred million tons of traffic will pass over these rails before they are replaced. When the rails are no longer considered to be in suitable condition for the demands of high-speed, main-line traffic, they will probably be relaid on a branch line or in a yard track. This means that most rails have a very long life, before they are finally scrapped.

TREND TOWARD HEAVIER RAIL SECTIONS

Throughout most of the history of railroads, there has been a trend towards heavier rail sections. This has been in response towards even heavier freight cars and motive power. Since the serviceable life of rails is so long, many of the older rails in track were designed for much lighter wheel loads.

Most rails are eventually scrapped because of wear of one or more types. This includes such things as rail-end batter, vertical or horizontal bending, curve wear due to abrading by wheel flanges on the high rail of curves and rail head flattening and lipping.

A smaller number of rails must be replaced before becoming sufficiently worn to justify replacement. This is because of the development of a defect within the rail, which makes it unsuitable for further service. Some types of defects originate with a flaw that is within the rail at the time of manufacture. Most of these flaws are small and remain undetected for many years. Eventually, after a great deal of traffic moves over the rail, the flaw begins to spread. In other cases, a condition develops on the surface of the rail directly related to severe service conditions to which the rail is exposed.

Sometimes cracks originate from some of these conditions on the rail surface. In other situations, a rail cracks or breaks under conditions that make it difficult to determine the cause.

Although some rails break suddenly, in many cases, a defect develops slowly. Some defects can be detected by a well-trained eye before the rail breaks. Others can be located only with special equipment. Some are more dangerous than others; hence, different handling is required. A Track Foreman needs a good knowledge of the different types of rail defects and what to do when confronted with them.

SERVICE FAILURES

Defective rails may be discovered in various ways. One group is called service failures. At its worst, a rail that fails in service is found after is has caused a derailment. In other cases, it may be located because it broke through and caused a signal failure. Some service failures are found by train crews who either see a broken rail or hear the wheels of their train pounding on the break. Others are located by track inspection or maintenance forces before interruptions to traffic occur.

VISUAL DEFECTS

Other rails contain irregularities which are apparent to a trained inspector, even though the rail has not failed. Some of these conditions are considered to be defects because under continued service they may lead to failure.

DETECTED DEFECTS

The other general classification is that of detected defects. This involves the use of special inspection equipment used to locate internal defects. It may consist of a small kit which is used by a man on foot. Other types involve on-track or hi-rail equipment. The most widely known type is the "Sperry Car" which is operated by the Sperry Rail Service. This service is used by a great many railroads. The defects which such equipment locates are similar to those which result in many service failures. Frequently, the detection equipment locates defects which are entirely internal. Internal defects can usually be accurately classified without breaking the rail.

TYPES OF RAIL FAILURES AND DEFECTS

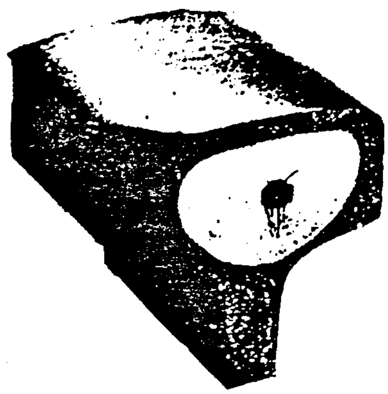
Each of the commonly recognized types of rail failure will be described and discussed. The definitions used are those of the FRA Track Safety Standards. The photographs and diagrams have been provided through the courtesy of Sperry Rail Service and are included in Sperry's Rail Defect Manual.

TRANSVERSE DEFECTS IN THE RAIL HEAD

There are several types of so-called transverse defects which develop in the head of the rail. These defects will generally grow within the rail head until the rail is sufficiently weakened to permit a complete break, under load, across the head, web and base of the rail. The growth of the defect within the rail head may be very slow or quite rapid. These defects may be classified as follows:

TRANSVERSE FISSURE

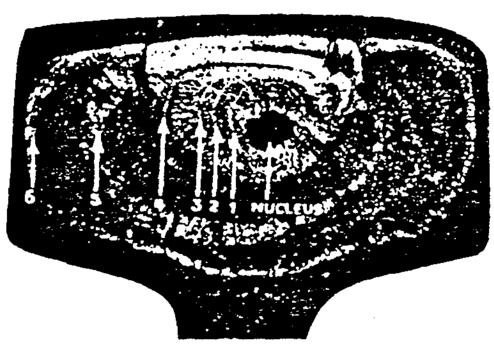
"Transverse Fissure" means a progressive crosswise fracture starting from a crystalline center or nucleus inside the head from which it spreads outward as a smooth, bright, or dark, round or oval surface substantially at a right angle to the length of the rail. The distinguishing features of a transverse fissure from other types of fractures or defects are the crystalline center or nucleus and the nearly smooth surface of the development which surrounds it.



Large transverse fissure, showing normal growth around nucleus.

Courtesy, Sperry Rail Defect Manual

FIG. 1



Transverse fissure, showing rapid growth. Arrows indicate growth rings.

Courtesy, Sperry Rail Defect Manual

FIG. 2

Transverse fissure,
showing sudden growth.

Courtesy, Sperry Rail Defect Manual

FIG. 3

The transverse fissure can be readily identified after a complete break occurs, by the presence of a nucleus within the defect. This nucleus may have been caused by a shatter crack, a small inclusion of an impurity within the steel or a blowhole.

At first, the outward growth from such a defect is usually very slow. After the growth has reached a size equal to about 20 to 25 percent of the area of the rail head, growth usually becomes rapid until a complete break occurs.

Since transverse fissures are caused by defects in the rail at the time of manufacture, the answer to the problem was sought in the rail manufacturing process. The solution was found to be the adoption of the control cooling process. After rolling, the rails are placed in special boxes while they are still hot. The rate of cooling is controlled within specified limits by this procedure. Control cooling of rail was adopted by the steel mills in 1937 and has been highly successful in the prevention of transverse fissures in rails manufactured since that time.

Most railroads still have substantial quantities of rail in track which is not control cooled. Such rail can be identified in two ways. One way is by the absence of the letters CC on the brand which identifies a control-cooled rail. The other way to identify such a rail is by the date of manufacture. Rails manufactured prior to 1937 are not control cooled.

Where a transverse defect is located and positive identification cannot be made as to the type, the possibility that the defect is a transverse fissure must be considered, if the rail is not control cooled. Rails which are known or suspected to contain a transverse fissure are dangerous for three reasons:

1. The defects in the steel which cause transverse

fissures are likely to be found at other locations within the same rail. Protecting a known transverse fissure by the application of joint bars offers no protection against failure elsewhere in the rail.

2. In most cases, there is no visible defect until the rail actually breaks.

3. When the rail does break, which is a complete transverse break across the entire rail, it is highly dangerous.

COMPOUND FISSURE

"Compound Fissure" means a progressive fracture originating in a horizontal split head which turns up or down in the head of the rail as a smooth, bright, or dark surface progressing until substantially at a right angle to the length of the rail. Compound fissures require examination of both faces of the fracture to locate the horizontal split head from which they originate.

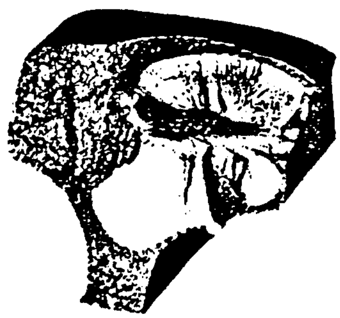


Fig. 21. Compound fissure, showing horizontal separation and several planes of transverse separation.

Courtesy, Sperry Rail Defect Manual

FIG. 4

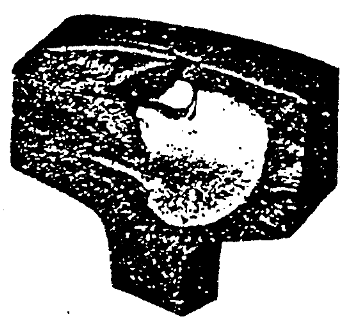


Fig. 22. Compound fissure with very slight horizontal separation.

Courtesy, Sperry Rail Defect Manual

FIG. 5

An internal longitudinal seam, segregation, or inclusion within the rail head, starts the development of a horizontal split head. This horizontal separation, at times, may be very short, as little as 1/8 inch in length. The essential condition for a defect to be classified as a compound fissure is that there be both horizontal and vertical separation. Also, unlike the transverse fissure, there is no nucleus within the defect.

Compound fissures are dangerous for reasons similar to those which apply to the transverse fissure:

1. They can occur at several locations in the same rail.

2. In some cases, there is no visible defect, until the rail actually breaks.

3. When the rail breaks, it is usually a complete transverse break across the entire rail.

DETAIL FRACTURE

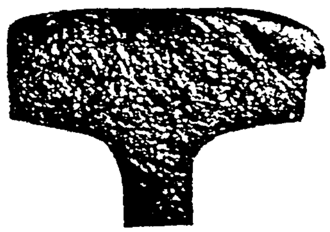
"Detail Fracture" means a progressive fracture originating at or near the surface of the rail head. These fractures should not be confused with transverse fissures, compound fissures, or other defects which have internal origins. Detail fractures may arise from shelly spots or head checks.

Detail fracture from shelling.

FIG. 6

Detail fracture from shelling, with part of shell chipped off.

FIG. 7



Detail fracture originating from head check on gage side (turned rail).

FIG. 8

Courtesy, Sperry Rail Defect Manual

Detail fractures have a transverse growth which may appear to resemble that of the transverse fissure. There are two differences. The defect does not contain a nucleus in the case of the detail fracture. The detail fracture originates at or near the surface, while the transverse fissure originates at an internal nucleus. Shelly spots, head checks and flaking will be discussed later in this lesson in the section on surface defects.

It is possible for a detail fracture to grow quite quickly. Failure often takes place before there is any visual evidence of the defect. Like the fissures, detail fractures lead to a complete transverse break across the entire rail.

ENGINE BURN FRACTURE

"Engine Burn Fracture" means a progressive fracture originating in spots where driving wheels have slipped on top of the rail head. In developing downward they frequently resemble the compound or even transverse fissure with which they should not be confused or classified.

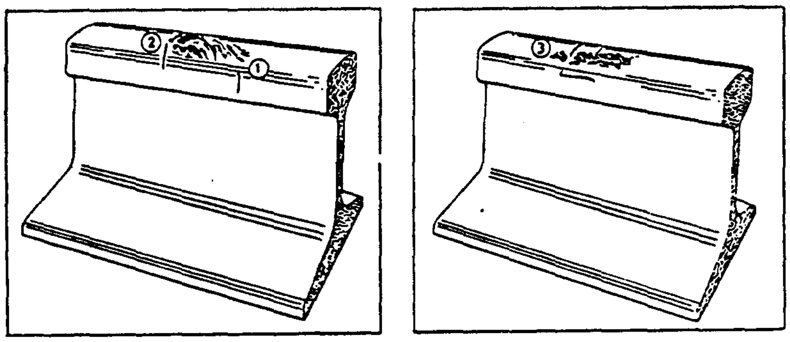
Engine burn fracture, showing small transverse separation.

FIG. 9 Courtesy, Sperry Rail Defect Manual

Many surface defects on the rail head similar in appearance to the rail surface shown in Figure 9, remain in track for long periods of time without developing internal defects. The existence of such a surface defect does not necessarily mean that the affected rail should be replaced. The proper treatment of rails with engine burns caused by slipping drive wheels will be discussed in succeeding lessons.

If severe slippage of engine drive wheels occurs, each driver will create a surface defect on the head of the rail on which it is supported. These defects may be minor or severe enough to require immediate replacement of the affected rails. The slippage causes rapid heating of the rail close to the surface of the rail head. Cooling may also be quite rapid.

This rapid heating and cooling of the surface metal can cause a horizontal separation to occur just under the surface of the rail head. In addition, an irregularity is left in the surface of the rail head. This causes pounding as each wheel moves over the burn. This combination of circumstances can cause growth of the horizontal separation, which can turn downward and form a transverse separation. After the transverse separation reaches a size equal to about 10 or 15 percent of the rail head, growth becomes rapid until complete failure takes place. Although failure sometimes takes place before the defect becomes visible, one or more cracks may be visible on the rail surface in the vicinity of an engine burn, prior to failure. Figure 10 illustrates the appearance of typical cracks which develop on the surface as an engine burn fracture grows.



Gage side　　　　Field side

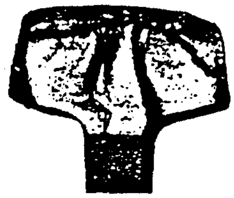
Appearance of engine burn fracture in track.

Courtesy, Sperry Rail Defect Manual

FIG. 10

Sometimes engine burns are welded. The welding process is intended to wash out damaged metal, then build up the low spot in the rail head. Finally, the weld is finished off with a grinder to restore the rail head to a uniform contour.

If this is not done properly, particularly in washing out the damaged metal, separation from the parent metal can remain under the weld. From this a fracture can develop similar to the type found in unwelded engine burns. Figure 11 illustrates a fracture which developed under a welded engine burn.



Transverse separation found beneath a resurfaced engine burn.

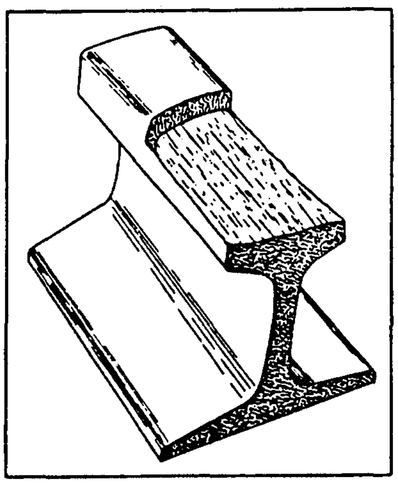
FIG. 11

Courtesy, Sperry Rail Defect Manual

LONGITUDINAL DEFECTS IN THE RAIL HEAD

HORIZONTAL SPLIT HEAD

"Horizontal Split Head" means a horizontal progressive defect originating inside of the rail head, usually one-quarter inch or more below the running surface and progressing horizontally in all directions, and generally accompanied by a flat spot on the running surface. The defect appears as a crack lengthwise of the rail when it reaches the side of the rail head.



General appearance of a horizontal split head.

FIG. 12

Courtesy, Sperry Rail Defect Manual

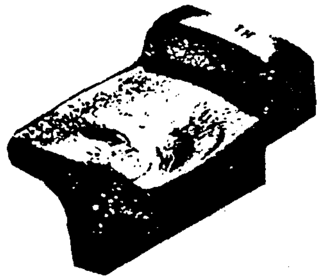


Fig. 32. Horizontal split head with separation extending across most of head.

FIG. 13 Courtesy, Sperry Rail Defect Manual

Horizontal split heads are caused by internal seams, segregation or inclusions within the rail head. The splits develop longitudinally (lengthwise in the rail) in a horizontal plane. They can be short or quite long before the head of the rail breaks out. If the split becomes transverse, the defect is classified as a compound fissure.

Evidence of horizontal split heads is usually visible before failure occurs. In the first stages, a flat spot or dip usually develops on the top of the rail head. There may be a slight widening of the head.

In the second stage, a horizontal crack appears on either the gage side or field side of the rail head. These conditions are illustrated by Figure 14.

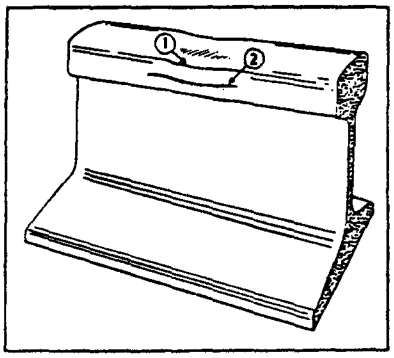


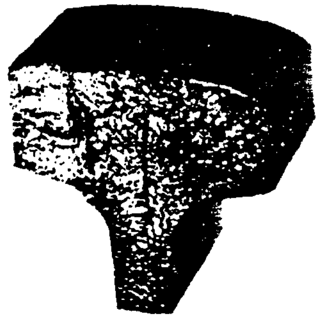
Fig. 33. Appearance of a horizontal split head in track.

FIG. 14 Courtesy, Sperry Rail Defect Manual

Horizontal split heads can occur at different locations within the same rail. Should the upper portion of the rail head break out, the resulting impact on the remaining portion of the rail under a train can cause rapid disintegration. Another danger, which is present when horizontal split heads develop, is that of a compound fissure.

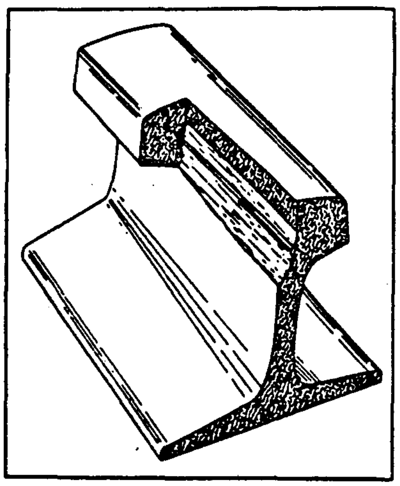
VERTICAL SPLIT HEAD

"Vertical Split Head" means a vertical split through or near the middle of the head, and extending into or through it. A crack or rust streak may show under the head close to the web or pieces may be split off the side of the head.



Vertical split head
with split extending into web.

FIG. 15 Courtesy, Sperry Rail Defect Manual

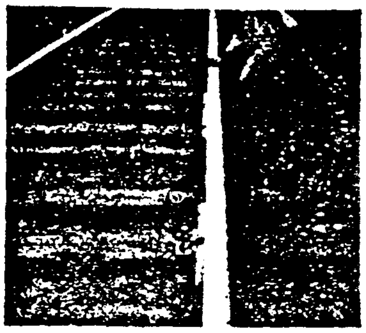


General appearance
of a vertical split head.

FIG. 16 Courtesy, Sperry Rail Defect Manual

Vertical split heads are also caused by internal segregation, seams or inclusions within the rail head. They usually develop rapidly and lengths up to 10 feet are not unusual.

An experienced inspector can frequently detect a vertical split head in track. One symptom is illustrated by Figure 17.



Dark streak
on running surface caused by
dropping of rail head.

FIG. 17 Courtesy, Sperry Rail Defect Manual

At times, widening of the rail head or sagging of one side of the rail head may be noted. When these signs appear, the existence of a vertical split may be further verified by looking under the rail head at the fillets between the head and web. A rust streak or a bleeding crack is further evidence of the presence of such a defect.

Vertical split heads usually grow to a considerable size before such signs are visible. The length of these defects increases the likelihood of severe disintegration of the rail when a piece breaks out of the rail head. If the split is such that a piece breaks out of the gage side, there is danger of a wheel flange climbing onto the rail head or of a wheel falling inside the rail.

WEB DEFECTS

SPLIT WEB

"Split Web" means a lengthwise crack along the side of the web and extending into or through it.

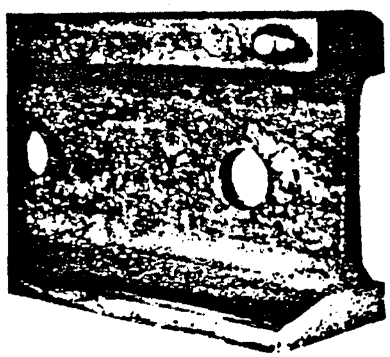
Fig. 41. Section of rail containing a split web.

FIG. 18 Courtesy, Sperry Rail Defect Manual

Split webs may be caused by a seam in the web or by external damage. At times, the cracks may bleed, making the defect more evident. If the rail is not replaced, the defect will grow, turning upward and downward until a complete break occurs.

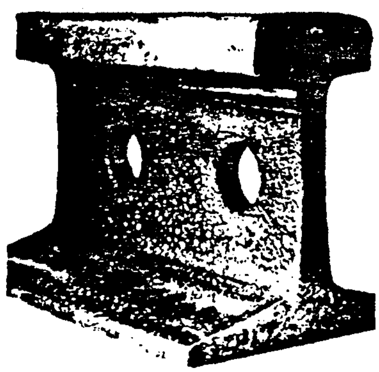
BOLT-HOLE CRACK

Bolt-hole cracks are usually due to stress of the bolt bearing against the edge of the bolt hole. The crack may originate at the point of greatest bearing or at a burr left on the edge of the bolt hole by the drilling operation. The stress of the bolt against the edge of the hole might be caused by inadequate support of the joint, by excessive impact due to rail-end batter, worn joint bars or by misalined bolt holes. Figures 19 and 20 show typical bolt-hole cracks.



Bolt Hole Crack.

FIG. 19 — Courtesy, Sperry Rail Defect Manual



Bolt Hole Crack

FIG. 20 — Courtesy, Sperry Rail Defect Manual

Bolt-hole cracks frequently result in a piece of the rail head breaking off within the limits of the joint bars. Occasionally, the cracks may progress beyond the joint bars and cause a complete transverse separation.

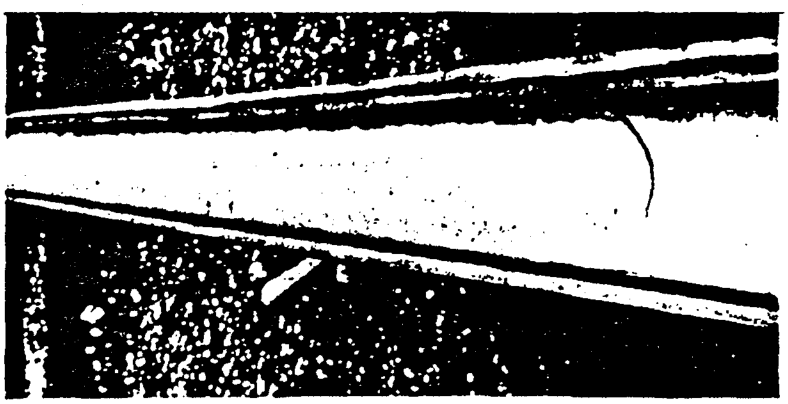
HEAD-WEB SEPARATION

Head-web separations are longitudinal defects at the fillets where the head and web of the rail meet. Rails within highway crossings are sometimes susceptible to this type of defect. This is because of the corrosion which can occur in this critical part of the rail. Rails, that are subjected to off-center loading or excessive speed on curves, sometimes develop this defect. Occasionally, rails which have been transposed will show signs of head-web separation. Figure 21 shows a typical appearance of the defect in the early stages.

Fillet under head of rail polished to show rail strain.

FIG. 21 Courtesy, Sperry Rail Defect Manual

In most cases, where this defect occurs, it develops through most or all of the rail length. Figure 22 shows a head-web separation in an advanced stage, which would have resulted in complete failure in a very short time, had it not been removed from track.



Length of rail containing a head and web separation.

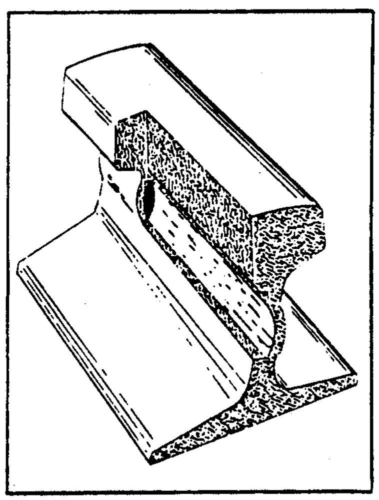
FIG. 22

PIPED RAIL

"Piped Rail" means a vertical split in a rail, usually in the web, due to failure of the sides of the shrinkage cavity in the ingot to unite in rolling.

Piped rail.

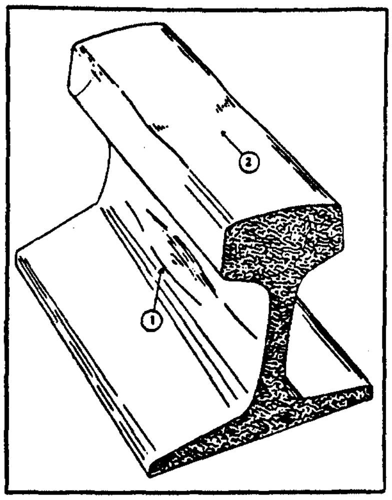
FIG. 23 Courtesy, Sperry Rail Defect Manual



General appearance of piped rail.

FIG. 24 Courtesy, Sperry Rail Defect Manual

Piped rail is not a commonly found defect. Where it occurs, it can cause the rail to break into several pieces. The appearance of a piped rail in track is illustrated by Figure 25. One sign is bulging of the web. Another indication is a slight sinking of the rail head above the pipe.



Courtesy, Sperry Rail Defect Manual

Appearance of
piped rail in track.

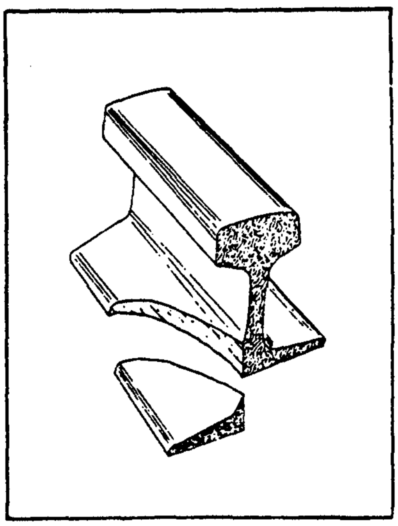
FIG. 25

BASE DEFECTS

BROKEN BASE

"Broken Base" means any break in the base of a rail.

Broken base rails, generally fall into one of two categories. The type illustrated by Figure 26 is sometimes called a half-moon break. This can be caused by poor bearing of the rail on the tie plate, by a seam, segregation or inclusion in the steel or by damage due to a derailment.



Courtesy, Sperry Rail Defect Manual

General appearance
of a broken base.

FIG. 26

The other type of base defect is a transverse fracture. These, usually, start at a nick in the outer edge of the base.

Base defects can cause complete failure in the rail. Transverse fractures, usually, fail suddenly, while the defect is still quite small.

MISCELLANEOUS DEFECTS

ORDINARY BREAK

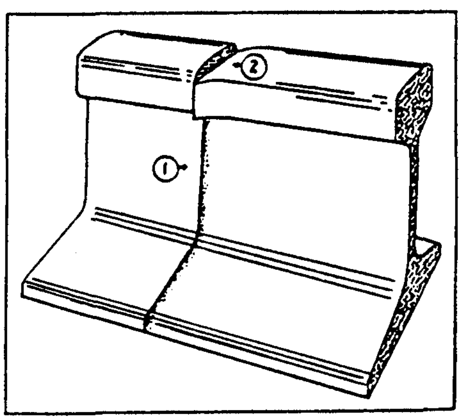
"Ordinary Break" means a partial or complete break in which there is no sign of a fissure, and in which none of the other defects described in this paragraph are found.

This refers to a transverse break which cannot be attributed to a transverse defect in the rail head or to external damage.

DAMAGED RAIL

"Damaged Rail" means any rail broken or injured by wrecks, broken, flat, or unbalanced wheels, slipping, or similar causes.

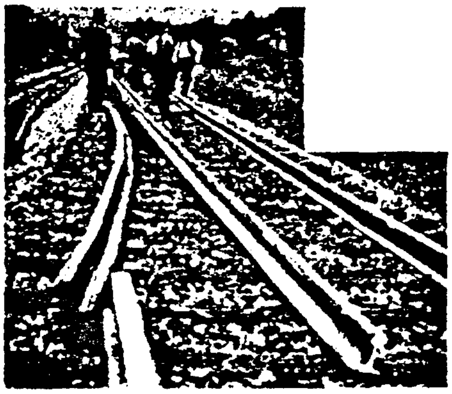
One result of external damage can be a sudden rupture of the rail in the transverse direction. It is similar to the ordinary break, except that the break can be attributed to some event that caused it. Figure 27 shows such a break.



Appearance of a square or angular break in track.

FIG. 27 Courtesy, Sperry Rail Defect Manual

Another type of damage may produce kinking of the rail. This is illustrated in Figure 28.



Kinked rail, removed from track.

FIG. 28 Courtesy, Sperry Rail Defect Manual

Kinked rail is not considered to be serious from the standpoint of possible failure. Continued usage can create maintenance problems.

Another form of damage consists of nicks in the rail. Figure 29 depicts several types of nicks.

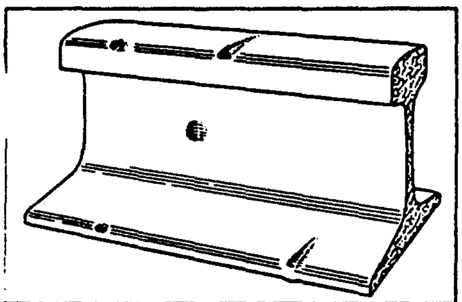


FIG. 29 Appearance of nicked rail in track, showing several common types of such damage. Courtesy, Sperry Rail Defect Manual

Nicks can cause the development of defects. The likelihood of this happening is dependent upon the depth, sharpness, and location of the nick.

Some nicks are caused by trackmen using a spike maul carelessly while spiking, or hitting the rail while adjusting expansion. Other nicks on the head of the rail are caused by broken wheels and these could be serious.

When this occurs, the rail should be examined by a rail inspector to determine whether or not the rails should be replaced.

DEFECTIVE WELD

A defective weld is most frequently a transverse defect; but sometimes, a longitudinal or split web type of defect, which can grow until complete failure occurs. It can be caused by foreign matter on the faces of the rail ends, at the time of welding, by incomplete fusion during welding or by cracks caused by the heating of the rail during the welding process. The defect may be in the head, web, or base of the rail. Figure 30 indicates a typical defective weld.

Courtesy, Sperry Rail Defect Manual

Appearance after breaking of a defective weld caused by an inclusion.

FIG. 30

While cracking can sometimes be detected on the rail surface prior to complete failure, complete fracture often takes place before a defect becomes visible.

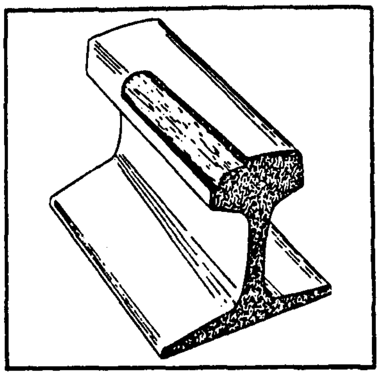
SURFACE DEFECTS

Rails are frequently subject to various forms of surface defects. Their presence does not indicate that the rail contains a dangerous defect. Occasionally, some of them can cause the development of internal defects such as the detail fracture or the engine-burn fracture.

SHELLY SPOTS

"Shelly Spots" means a condition where a thin (usually three-eighths inch in depth or less) shell-like piece of surface metal becomes separated from the parent metal in the rail head, generally at the gage corner. It may be evidenced by a black spot appearing on the rail head over the zone of separation or a piece of metal breaking out completely, leaving a shallow cavity in the rail head. In the case of a small shell, there may be no surface evidence, the existence of the shell being apparent only after the rail is broken or sectioned.

Courtesy, Sperry Rail Defect Manual



General appearance of shelling.

FIG. 31

Courtesy, Sperry Rail Defect Manual

Shelly spots on gage side of rail head.

FIG. 32

Close-up of shelly spot on gage side of rail head.

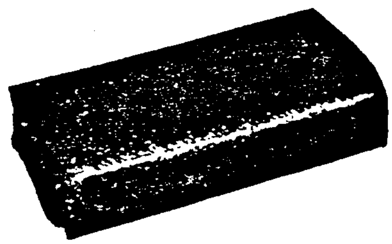
FIG. 33 Courtesy, Sperry Rail Defect Manual

The cause of shelling is not fully understood. It usually appears on curves. Development takes place at the gage corner of the rail head. The hazard, which is associated with shelling, is the possibility of a detail fracture developing.

HEAD CHECKS

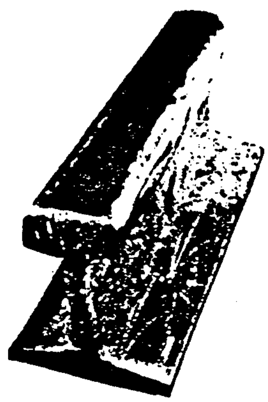
"Head Checks" mean hair-line cracks which appear in the gage corner of the rail head, at any angle with the length of the rail. When not readily visible, the presence of the checks may often be detected by the raspy feeling of their sharp edges.

Head checks are caused by concentrated loading at the gage corner of the rail head. Figures 34 and 35 show head checking in early and advanced stages of development.



Head check on rail surface.

FIG. 34 Courtesy, Sperry Rail Defect Manual



Advanced development of head check, where metal has chipped away between small cracks.

FIG. 35 Courtesy, Sperry Rail Defect Manual

Detail fractures can originate from head checks.

ENGINE BURNS

Engine burns have previously been mentioned in the discussion of the engine-burn fractures. While the possibility of a fracture is the greatest danger of an engine-burn, the presence of an engine-burn in the track can also present other maintenance problems. The irregularity on the running surface of the rail creates an impact stress each time a wheel passes over it. This can produce increasing batter of the rail, track surface defects and accelerated deterioration of the supporting ties.

Many small engine burns remain in track for long periods of time because they are not large enough to create pounding of appreciable amount. Others have the irregularity minimized by grinding off upset metal adjacent to the burn. This can be an effective temporary measure until the burn can be welded or the rail replaced. Depending on the severity of the depression, a slow order may be appropriate, to reduce impact stresses until the condition can be corrected.

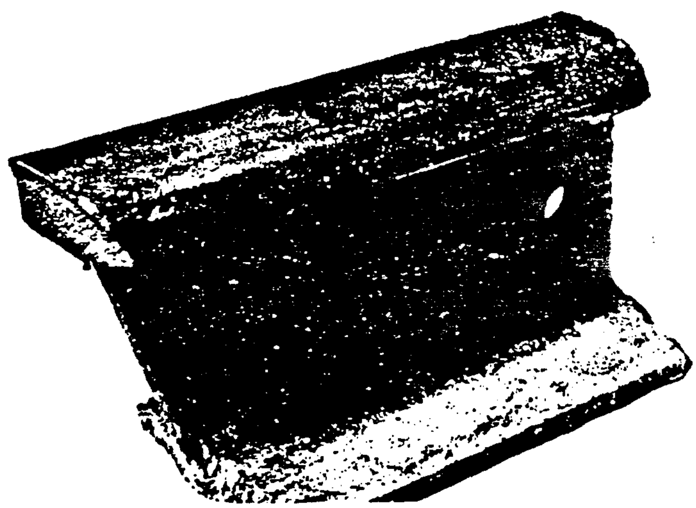
MILL DEFECTS

Mill defects can occur in any part of the rail. They can consist of such conditions as seams, inclusion of foreign material, holes or deformities. The seriousness of mill defects can vary with the type, size and location of the defect. They can cause the development of either transverse or longitudinal defects.

FLAKING

"Flaking" means small shallow flakes of surface metal generally not more than one-quarter inch in length or width break out of the gage corner of the rail head.

Flaking is not as deep as shelling. It usually occurs on the high rail of curves. While flaking is not considered to be a serious defect, it sometimes develops into shelling. A typical flaking condition is shown in Figure 36.



. Section of rail showing flaking.

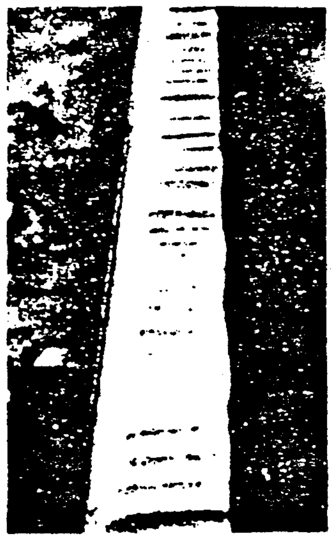
FIG. 36 Courtesy, Sperry Rail Defect Manual

SLIVERS

Slivers can occur on any portion of the rail. They develop in the manufacturing process, when the rail is rolled. They are thin surface defects, usually resembling wood slivers, that can break off. Slivers are not considered to be serious defects, but it is possible for a transverse or longitudinal defect to develop from a sliver.

CORRUGATION

Corrugation consists of a wavy running surface on the rail. It develops over a long period of time and may be caused by extensive braking or sliding of wheels. Although the individual waves are usually a few inches apart, the corrugations may extend over a considerable distance. Corrugations are not considered hazardous, but rail with corrugations is sometimes replaced because of poor riding conditions. Figure 37 indicates a corrugated rail.



Appearance of extremely severe corrugation in track.

FIG. 37 Courtesy, Sperry Rail Defect Manual

CORROSION

Corrosion, which is the rusting away of steel, usually affects the base or web of the rail. It is limited to locations where conditions favor such deterioration. This includes tunnels, grade crossings and tracks which are usually covered, particularly with materials such as spilled coal. Corrosion can severely weaken a rail, permitting a complete break. It usually occurs where the rail is not readily visible for inspection. The condition is, frequently, worst on the bottom of the rail base, making its detection difficult, even when the base of the rail is not covered. Figure 38 shows a rail with base corrosion.

An example of base corrosion.

FIG. 38 Courtesy, Sperry Rail Defect Manual

PURPOSE OF FRA DEFECTIVE RAIL STANDARD

This completes the description of the various types of defects which the FRA requires to be given some attention. It is essential that the action, taken in the presence of any rail defect, will provide reasonable assurance of safety. Some types of defects are much more hazardous than others. It is also necessary not to impose a greater degree of interference to rail traffic than is required in the interests of safety. For these reasons, the FRA specifies a different course of action for each type of defect.

As a result, the FRA standard for defective rails appears to be rather complex. It should be remembered, however, that it is not necessary to memorize the standard. When confronted with a defective rail in track, the Track Foreman should have a copy of the FRA standards readily available, as he should for many other situations during the course of his work. It is necessary for him to know, in advance, how to use the standard. The remainder of this lesson will be devoted to developing an understanding of the proper use of the FRA defective rail standard.

THE FRA STANDARD FOR DEFECTIVE RAILS

213.113 Defective Rails

(a) When an owner of track to which this part applies learns, through inspection or otherwise, that a rail in that track contains any of the defects listed in the following table, a person designated under 213.7 shall determine whether or not the track may continue in use. If he determines that the track may continue in use, operation over the defective rail is not permitted until ---

(1) The rail is replaced, or;

(2) The remedial action prescribed in the table is initiated.

Defect	Length of defect (inch): More than	Length of defect (inch): But not more than	Percent of railhead cross-sectional area weakened by defect: Less than	Percent of railhead cross-sectional area weakened by defect: But not less than	If defective rail is not replaced, take the remedial action prescribed in note—
Transverse fissure			20		B
			100	20	B
				100	A
Compound fisssure			20		B
			100	20	B
				100	A
Detail fracture			20		C
Engine burn fracture			100	20	D
Defective weld				100	A. or E and H
Horizontal split head	0	2			H and F
	2	4			I and G
Vertical split head	4				B
	(Break out in railhead)				A
Split web	0	½			H and F
Piped rail	½	3			I and G
Head web separation	3				B
	(Break out in railhead)				A
Bolt hole crack	0	¼			H and F
	½	1½			I and G
	1½				B
	(Break out in railhead)				A
Broken base	0	6			E and I
	6				(Replace rail)
Ordinary break					A or E
Damaged rail					C

NOTE:	REMEDIAL ACTION
A	Assign person designated under §213.7 to visually supervise each operation over defective rail.
B	Limit operating speed to 10 m.p.h. over defective rail.
C	Apply joint bars bolted only through the outermost holes to defect within 20 days after it is determined to continue the track in use. In the case of classes 3 through 6 track, limit operating speed over defective rail to 30 m.p.h. until angle bars are applied; thereafter, limit speed to 50 m.p.h. or the maximum allowable speed under §213.9 for the class of track concerned, whichever is lower.
D	Apply joint bars bolted only through the outermost holes to defect within 10 days after it is determined to continue the track in use. Limit operating speed over defective rail to 10 m.p.h. until angle bars are applied; thereafter, limit speed to 50 m.p.h. or the maximum allowable speed under §213.9 for the class of track concerned, whichever is lower.
E	Apply joint bars to defect and bolt in accordance with §213.121(d) and (e).
F	Inspect rail 90 days after it is determined to continue the track in use.
G	Inspect rail 30 days after it is determined to continue the track in use.
H	Limit operating speed over defective rail to 50 m.p.h. or the maximum allowable speed under §213.9 for the class of track concerned, whichever is lower.
I	Limit operating speed over defective rail to 30 m.p.h. or the maximum allowable speed under §213.9 for the class of track concerned, whichever is lower.

(b) If a rail in classes 3 through 6 track or class 2 track on which passenger trains operate evidences any of the conditions listed in the following table, the remedial action prescribed in the table must be taken:

Condition	Remedial action: If a person designated under §213.7 determines that condition requires rail to be replaced	Remedial action: If a person designated under §213.7 determines that condition does not require rail to be replaced
Shelly spots.. Head checks.. Engine burn (but not fracture). Mill defect...	Limit speed to 20 m.p.h. and schedule the rail for replacement.	Inspect the rail for internal defects at intervals of not more than every 12 months
Flaking ..... Slivered ..... Corrugated .. Corroded	....do......	Inspect the rail at intervals of not more than every 6 months.

LEARNING THAT A DEFECT EXISTS

Part (a) of section 213.113 requires that a decision be made each time it is learned that one of the defects listed in part (a) exists in track. One of the alternatives is to remove the track from service until the defective rail has been replaced.

If this is undesirable from an operating or maintenance standpoint, the standard makes provision for the temporary operation of trains or equipment under restricted conditions. These restrictions vary within the severity of the defect. It is entirely possible that the person making the decision, may determine that the defect is unsafe for any type of movement.

The person, referred to by the standard, who must make the decision on the handling of the defect, may be properly qualified Track Foreman.

TRANSVERSE AND COMPOUND FISSURES

The handling of transverse fissures and compound fissures may be considered, jointly, since the protection required for each is the same. For these defects, if less than 100 percent of the rail head cross-sectional area is weakened, operating speed must be restricted to 10 mph until the defective rail is removed. If the entire rail head is weakened, operation can only be permitted under the direct supervision of a qualified man. This places considerable responsibility on the man supervising the operation. He must first decide whether it is safe to move a train over the defect. If he determines that it can be done, he must decide the conditions under which the train movement is to be made. It would probably be at a very slow speed, certainly, not more than 10 mph. Provision might also be made for continuous communication, between the man observing the defective rail and the train crew.

DETAIL AND ENGINE-BURN FRACTURES, DEFECTIVE WELDS

These types of defects, may be considered as a group, since the specified action is the same for all of them. In the case of a small defect, in which less than 20 percent of the rail head is weakened, the rail may remain in track provided joint bars are applied to the defect, within 20 days of the time the defect is discovered and the decision is made to keep the track in service with the defective rail remaining in place. The joint bars are to have only the end holes bolted. Until the bars are applied, if the speed limit exceeds 30 mph, it must be restricted to 30 mph over the defect. After the bars are applied, the defective rail may remain in track, indefinitely, and the track may be restored to authorized speed provided it doesn't exceed 50 mph.

In the case of larger defects, in these categories, involving at least 20 percent but less than 100 percent of the cross-sectional area of the rail head, joint bars may be applied in the same manner, but it must be done within 10 days. Furthermore, the speed must be restricted to 10 mph, until the bars are applied. After the bars are installed, the restriction may be removed, except for the 50 mph maximum.

In situations where the complete rail head is affected, immediate operating requirements may be met, by using a qualified employee to supervise operation, in the same manner, as prescribed for fissures. This must be continued until the defective rail is replaced or until joint bars are applied. In this case, at least two bolts must be installed on each side of the defect (except Class 1 track with jointed rail, which requires one bolt either side of the defect). After this is done, the track may be restored to normal speed, provided it does not exceed 50 mph.

HORIZONTAL AND VERTICAL SPLIT HEADS

Similar handling is specified for each of these types of defects. When a split head is detected, not over 2 inches in length, operation is permitted to continue, provided the speed does not exceed 50 mph. The rail must then be inspected 90 days later.

Split heads over 2 inches in length but not exceeding 4 inches, may remain in track provided the speed does not exceed 30 mph. The rail must then be inspected 30 days later.

Split heads over 4 inches in length must have the speed restricted to 10 mph.

Split heads that break out in the rail head require that the operation be supervised by a qualified employee under the same conditions that apply to major transverse defects.

SPLIT WEB, PIPED RAIL, HEAD-WEB SEPARATION

When any of these defects are detected which do not exceed 1/2 inch in length, the operation may continue provided the speed does not exceed 50 mph. The rail must be inspected 90 days later.

Such defects which exceed 1/2 inch in length, but are not larger than 3 inches, may remain in service provided the speed does not exceed 30 mph. The rail must then be inspected 30 days later.

When any of these defects exceeds 3 inches in length, speed must be reduced to 10 mph.

If such a defect develops to the point where it breaks out in the rail head, operation may continue under the supervision of a qualified employee under similar conditions to those specified for other defects.

BOLT-HOLE CRACK

When a bolt-hole crack is detected which does not exceed 1/2 inch in length, the operation may continue provided the speed does not exceed 50 mph. The rail must be inspected 90 days later.

When a bolt-hole crack exceeds 1/2 inch in length, but is not more than 1-1/2 inches in length, the operation may continue provided the speed does not exceed 30 mph. The rail must be inspected 30 days later.

When a bolt-hole crack exceeds 1-1/2 inches in length, speed must be reduced to 10 mph.

When a bolt-hole crack breaks out in the rail head, operation may continue under the supervision of a qualified employee under similar conditions to those specified for other defects.

BROKEN BASE

When a broken base is detected which is not over 6 inches in length, the operation may continue provided the speed does not exceed 30 mph, and provided joint bars are applied with at least two bolts on each side of the defect (except Class 1 track with jointed rail, which requires one bolt either side of the defect).

If the length of the defect is more than 6 inches, the rail must be replaced before further operation is permitted.

ORDINARY BREAK

When such a break occurs, the operation may continue under the supervision of a qualified person, under similar conditions to those specified for other defects. If joint bars are applied with at least two bolts on each side of the defect (except Class 1 track with jointed rail, which requires one bolt either side of the defect), operations may be resumed with no further restrictions.

DAMAGED RAIL

These defects may remain in track provided joint bars are applied to the defect within 20 days of the time the defect is discovered and the decision is made to keep the track in service with the defective rail remaining in place. The joint bars are to have only the end holes bolted. Until the bars are applied, if the speed limit exceeds 30 mph, it must be restricted to 30 mph over the defect. After the bars are applied, the defective rail may remain in track indefinitely and the track may be restored to authorized speed provided if it doesn't exceed 50 mph.

SURFACE DEFECTS

Surface defects are covered by part (b) of section

213.113 of the FRA standard. This standard does not apply to Class 1 track, nor does it apply to Class 2 track on which passenger trains do not operate. It does apply to Class 2 track on which passenger trains operate and to all higher classes of track.

The application of this standard is based on the judgment of the qualified employee inspecting the track. That judgment is to be based on a determination as to whether the surface defect is severe enough to require replacement of the rail. If it is determined that any of the surface defects listed in the standard do require replacement, the speed must be restricted to 20 mph, and the rail must be scheduled for replacement.

If there are shelly spots, head checks, engine burns (but not fractures) or mill defects present, which do not require the rail to be replaced, the rail must be inspected for internal defects at intervals of not more than every 12 months. This requires the use of electronic equipment. A visual inspection will not meet this requirement.

USING THE FRA STANDARD

It has taken several pages to explain the requirements for handling defective rails, which the FRA has consolidated onto two small charts. These charts are most useful for ready reference on the job, once you learn how to use them. This can be accomplished by carefully studying these explanations and constantly referring to the appropriate chart as you study them. You should do this until you fully understand everything on the charts, without having to refer back to the explanations. The charts will then be valuable to you for use on the job, when you are faced with a defective rail, and need to make a decision regarding it.

LESSON 9

EXERCISE QUESTIONS

1. What is the general name for rail defects which break across a rail from the gage side to the field side?

2. What type of internal defect sometimes develops from a shelly spot?

3. What type of transverse defect has a well-defined nucleus within the defect?

4. What type of transverse defect sometimes develops from a small horizontal split head?

5. What type of defect is the control cooling process, which is used in the manufacture of rail, intended to prevent?

6. On what part of a rail does flaking occur?

7. If a horizontal split head 3 inches in length is detected, what is the maximum speed permitted over this defect?

8. If a bolt-hole crack 2 inches in length is located, what is the maximum speed permitted over this defect?

9. If fully bolted joint bars are applied to an ordinary break, is a speed restriction required?

10. Is it permissible to apply joint bars to a small transverse fissure in order to raise the speed restriction above 10 mph?

11. A broken base was found in a rail 4 inches in length. The foreman placed a speed restriction of 30 mph on the track. Did this comply with the FRA standards?

12. In the process of repairing a grade crossing in Class 4 track, a foreman found the base of the rails to be corroded. He planned to replace them as soon as rails of suitable length could be obtained. What else should he do?

13. If a vertical split head breaks out on the gage side, what hazards exist, other than that of further breakage?

Answer the following questions either TRUE or FALSE.

14. Even though there is a complete transverse break in a

(Exercise questions continued on next page)

rail, it is not always possible to tell if it has a transverse or compound fissure while it is still in track.

15. After joint bars are applied to an engine burn fracture, speed must be restricted to 30 mph.

16. The restrictions that must be placed on bolt-hole cracks are the same as those for split webs.

17. Vertical split head defects frequently attain a length of several feet.

18. Vertical split heads can only be located by a detector car, if they have not cracked out.

19. Detail fractures may be caused by corrugation.

20. Where rail is corroded, it must be inspected with a detector car at least once every 12 months.

Submit your answers to these questions to The Railway Educational Bureau in the prescribed manner. Be sure to include your name, file number, address, company's name and lesson number on the upper right hand corner of your paper.

Grades, Curves, Ballast, Ties, Rail

Track Building No Job for Amateurs; Each Component Has Role in Final Product

Crossties is indebted to Burlington Northern News for the article on track building no job for amateurs; each component has role in final product by Thomas J. Lamphier, President, Transportation Division, Burlington Northern, which appears on the following pages.

By Thomas J. Lamphier
President, Transportation Division

If I were asked to teach a class on railway track construction and maintenance, I'd start with the first precept of the railway civil engineer — "Never forget that the tracks of all American railroads are too narrow." They were built to a gauge of four feet, eight and one-half inches. But if we had to do it all over again we'd probably build them with the rails at least six feet apart.

The Russians built their railroad system to a five-foot gauge — but for the wrong reason. They wanted to make it more difficult for an invading army to bring up supplies from a neighboring country. In doing that, the Russians were able to obtain some advantages in car and locomotive design.

But, though track gauge varies, the principles of track construction are much the same the world around, and all track has the same components — a roadway constructed with suitable grades and curvature, ballast, ties, rail, angle bars, tie plates, rail anchors and spikes. These are what make a track structure work.

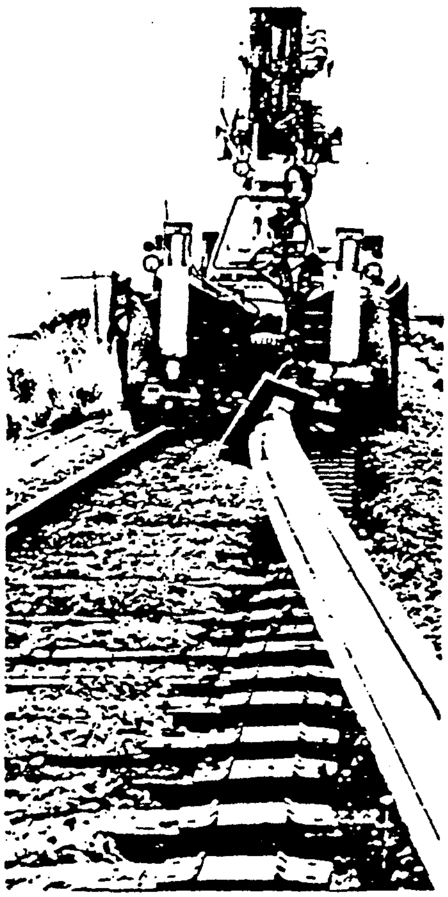
Unlike a bridge that can be designed to meet specific stress, a railroad track in engineering circles is an indeterminate structure. That is, it is subject to undefinable or unknown forces, and there are not enough equations that can relate the unknowns to each other.

Let's take track from the bottom up, starting with the road bed. The grades and curvature of each roadway ultimately determine the economics of the guidance system. If grades are too steep, you pay in fuel costs. If curves are too sharp, maintenance costs rise — particularly the cost of rail renewal. The roadway should be constructed with appropriate soils and with adequate drainage.

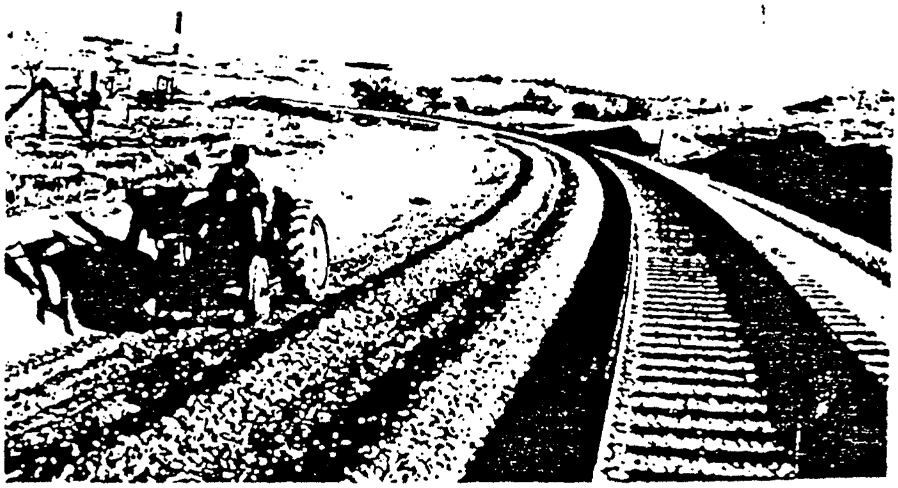
The next element is ballast, which helps to hold the rail and tie in line and surface and provides drainage for the track structure. Every conceivable type of material has been used to perform this function, including natural earth, cinders, pit run gravel, quarry waste, blast furnace slag, precious metal slag, and crushed rock. We still use gravel on light-traffic branch lines and it is perfectly adequate, but we consider the best ballast for our main lines to be crushed rock.

The ballast under the tie is consolidated by tamping machines to provide a dense, stable column of ballast 30 inches wide. The tamping heads of the machine are dropped simultaneously on both sides of each rail and on both sides of each tie. The downward pressures exerted by the tamping heads penetrate the ballast, vibrating and squeezing the particles to form that 30-inch wide column under each rail.

This is important. If the ballast becomes fouled, or if it is of inferior quality so that the relative density in



Setting welded rail in place.



New track serves coal mine in Wyoming. Tractor operator seeds banks along right of way.

he center or ends exceeds that under he r 'he ties will break either in c or under the rail. This can e a serious condition if it extends ver a long stretch of track. However, ve control this problem by using rushed rock ballast and by eriodically cleaning and retamping t.

High quality ballast is not plentiful nd thus commands a high price. Among the features we look for in a allast material are hardness and oundness. Our tamping machines nd heavy train loads put ballast nder high stress, so the material also nust offer good tensile and compres- ive strengths and be able to resist brasion.

It also must resist freezing, thawing nd the natural acids that exist in round waters. The final product nust consist of chunky pieces of rock, vith rough, angular surfaces that nterlock when vibrated and squeezed nder the tie by the tamping nachine.

The best ballast is produced from ranite, basalt and dolomite, al- hou necessity we sometimes use stone and blast furnace slag certain lines. Currently BN uses bout three million cubic yards of bal- ast annually and maintains a fleet of ,400 specially-designed cars to dis- ribute it around our system.

Now let's look at ties — which hold he rail to a gauge of four-feet, eight nd one-half inches and distribute he weight of trains to the ballast and subgrade.

On Burlington Northern our main ine tie is seven by nine inches by ight feet, six inches long. This length has been found through years of test- ng to provide the desired level of sup- ort. The BN standard for ties is to lace 3,250 under each mile of rail.

We obtain our ties from the south- rn hardwood forests in Kentucky, Arkansas and Missouri, northern hardwoods from Wisconsin and Min- esota, and softwoods from Montana, daho, Washington and Oregon. The hardwood ties are virtually all oak nd gum and the softwoods are pine, arch and fir.

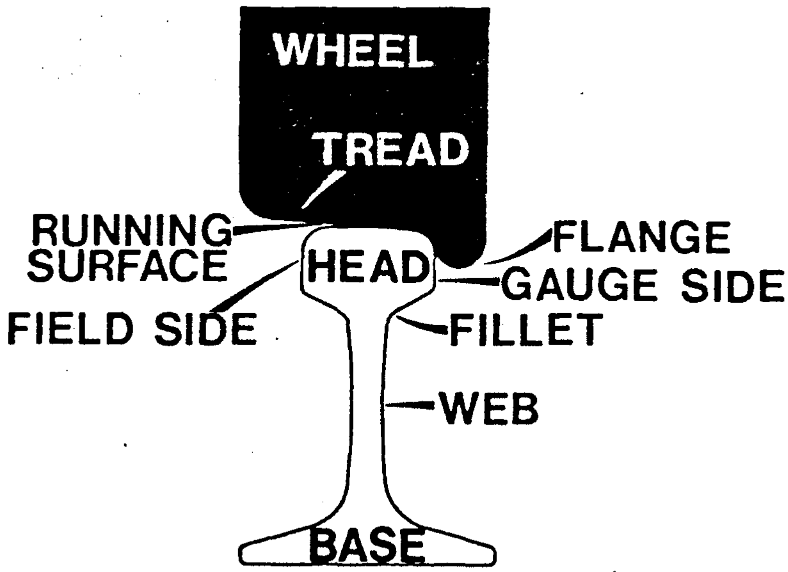
BN 's green ties and air-dries p to one year, depending on ecies. It's possible to speed this rocess by kiln-drying, but the capital osts are high and we are satisfied with the economics of air-drying. Our green tie inventory at the present time is about 3.5 million, which is about a one-year supply.

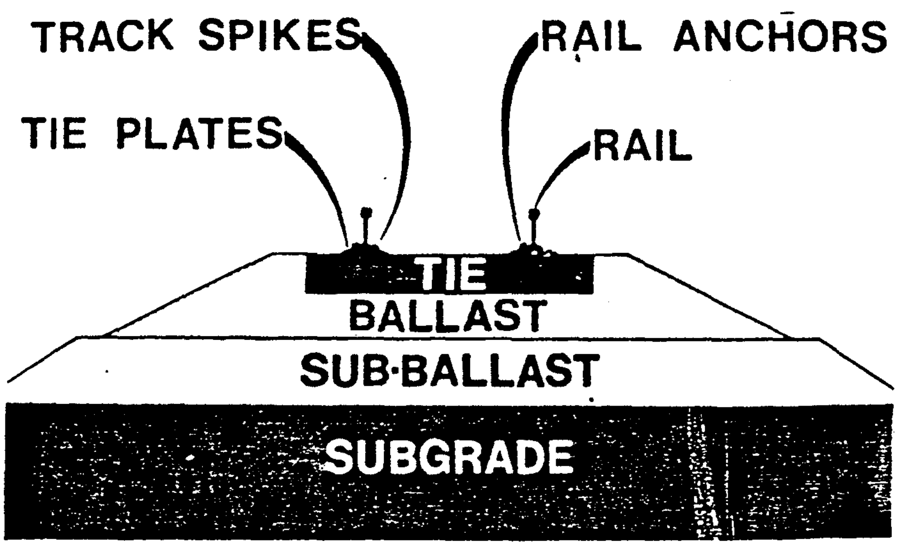
The main track component, the rail itself, serves as both a guide path and a running surface for the flanged wheels of cars and locomotives. A rail is a rolled steel product made to careful specifications as to dimensions and its chemistry and metallurgical characteristics. The shape of rail hasn't changed appreciably since the introduction of steel for rails in the 1870s. However, back then rail was extremely light by today's standards, weighing 40 to 60 pounds per yard. Weight increased as cars and locomotives became larger and heavier and today the standard rail for BN main lines is 132-pound.

Rail derives its stiffness from the metal in the head and the base. The web, which functions as the connector, is designed to accommodate and resist both the vertical forces and the horizontal forces put on it as flanged wheels are guided around curves and along tangent track.

Burlington Northern depends on three suppliers for almost all its rail — Colorado Fuel & Iron at Pueblo, Colo., U.S. Steel's mill at Gary, Inc., and the Bethlehem Steel mills at Steelton, Pa., and Lackawanna, N.Y. Specially heat-treated or alloyed steel rail of a hardness greater than common rail is placed on sharp curves.

The importance of special rails becomes clear when you consider that our regular 132-pound rail, which is





entirely satisfactory on a tangent, can be worn out in two to three years on a sharp curve of a high density line.

The function of the tie plate is to provide a seat on the tie for the rail and to reduce wear of the tie by spreading the load. Most original track construction was innocent of this component and, since their introduction, these plates have been made larger and heavier as cars and locomotives have become larger and heavier.

On BN we use a seven and three-quarter-inch by 14-inch tie plate, which has a shoulder on each side of the rail. The standard spiking pattern requires four spikes per tie plate, with two railholding spikes and two-plate holding spikes. The function of the spike is to hold the rail in gauge, not hold it down as some believe. The rail-holding spikes are driven at the base of the rail and tie plate-holding spikes are driven at the outer edges of the plate.

Rail anchors are used to prevent the longitudinal movement of rail. This restraint is necessary on most main and branch lines and is required absolutely on welded rail and in unit coal train territory.

Actually, a railroad track is an elastic structure that is built to bend and deflect under load. It is important that track components allow for this resiliency and elasticity. If we built track too rigid, we'd introduce all kinds of problems associated with excessive wear and over-stress of components.

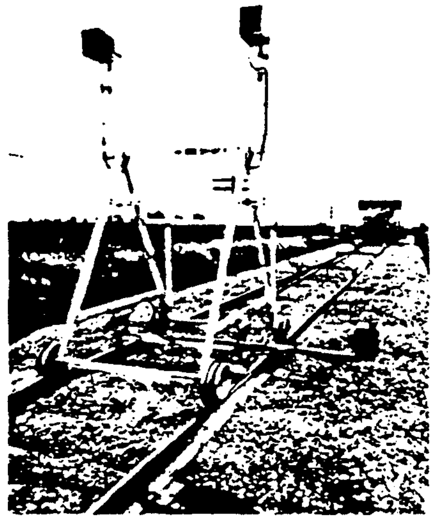
For many years now rail has been rolled in 39-foot lengths. Beginning in the late 1950s, we began welding these into strings approximately 1,440 feet long. This eliminates most of the joints and greatly increases rail life. About 5,000 miles of BN main line are laid with welded rail.

The welding process now in use is called electric flash butt welding. This is a process in which a high voltage electrical current is arced across the rail ends until the rails can be fused. This process is dependable and produces a high quality weld.

Now that we looked at construction of a modern track, the next step is keeping it in condition appropriate for the traffic imposed on it.

Maintenance of the railway track structure consists of several basic functions — restoration of the railroad grade itself, which is referred to as bankwidening, restoration of bridges and culverts, renewal of the ties, replacement of worn rail, replacement or cleaning of the ballast and the constant removal of imperfections in the line and surface through the use of tamping machines that also line the track. Rail and ties generally are replaced on some type of cycle basis. For example, we would like to renew worn ties in a given segment of track every five to seven years.

Rail replacement is based on inspection, considering physical wear and reviewing the record of rail failures over a period of time and the gross tons that have passed over the rail. New ballast, or ballast-cleaning



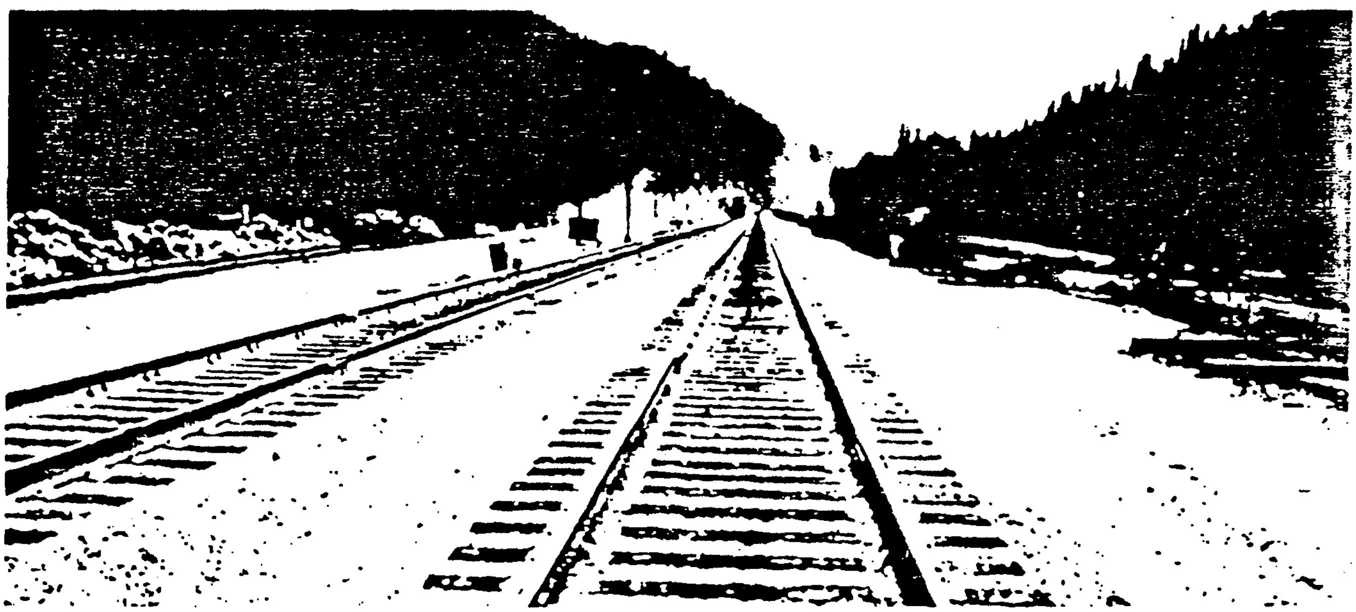
Electronic track liner levels and aligns tracks.

programs, usually are based on inspection of the track for signs of the ballast becoming fouled, as indicated by pumping joints, or a high level of moisture in the track structure.

In addition, incidental maintenance work is carried out, such as spraying the track to prevent weed growth, cutting brush on the right of way, cleaning culverts and waterways, and maintaining fences, switches and grade crossings.

Where it once took 150 full-time section workers to maintain 45 miles of track, now we do it on a cycle basis with only five people using machines.

That's what I'd tell students about constructing and maintaining track. Welcome to the world of modern railroading.



SECTION 02450

GENERAL TRACK CONSTRUCTION

PART 1 - GENERAL

1.1 DESCRIPTION

A. The Work specified in this Section consists of track construction procedures and requirements that are common to both standard direct fixation and ballasted track, and to direct fixation and ballasted special trackwork, including laying and fastening continuous welded rail, joining rail, anchoring rail, rail grinding, final alignment, inspection, and cleanliness of the site.

B. All materials required for track construction, unless specified as COMMISSION furnished materials, will be furnished by the Contractor.

C. The Contractor may propose, in writing to the Construction Manager, alternatives for performing the Work specified herein. These alternatives may be used in lieu of the procedures specified herein only if written acceptance of these alternatives has been received from the Construction Manager.

D. Trackwork Definitions - The following abbreviations and terms, with their coinciding definitions, represent the standard glossary of trackwork terms for the COMMISSION and supplement the definitions contained elsewhere in the Specifications and in the AREA Manual for Railway Engineering. In the event of a conflict between the AREA definition and a definition contained herein, the definition contained herein will apply.

1. Adze - To cut into the top surface of a tie to provide proper bearing for a tie plate.

2. Approach Slab - A concrete slab located at interface of ballasted track with embedded or direct fixation track to provide a transition from embedded or direct fixation track to ballasted track.

3. Ballast - An integral part of the ballasted track structure, composed of crushed stone, in which ties are embedded.

4. Bonded Joint - A rail joint that uses high-strength adhesives in addition to bolts to hold rail together. The bonded joint may be insulated or non-insulated. (standard)

5. Bumping Post - A device attached to the rail, designed to stop a rail vehicle at the end of a track. A sliding type of friction arrestor is designed to slide along the track before it brings a rail vehicle to a complete stop.

3.2 PREPARATION

A. Establish track alignment based on the Contract Drawings and monuments established by the Construction Manager and the following:

1. Track gauge is four feet, 8 1/2 inches between rails measured 5/8 inch below top of gauge side of rail for tangent track and curves with a radius equal to or more than 500 feet. Curves with radii less than 500 feet but equal to or more than 250 feet shall have a track gauge of four feet, 8 3/4 inches. Curves with radii less than 250 feet shall have a track gauge of 4 feet, 9 inches.

2. Alignment of tangent track is based on the center line of track, equidistant between the gauge sides of the running rails.

3. Alignment of curved track is the center line of track with the high rail located 28 1/4 inches measured from the Profile Grade Line in the plane of the rails. Gauge transitions shall be made with the inside rail.

4'-8½"
2'-4¼"
24
28¼"

4. Alignment of track utilizes station equations which must be adherred to.

B. Set top of rail and superelevation based on the Contract Drawings and the following:

1. Obtain superelevation by maintaining the inside rail at the required profile grade line indicated and raising the outside rail above the inside rail.

2. Start superelevation at the point of tangency and increase uniformly to full superelevation of the outside rail at the junction of the spiral with the circular curve.

3. Use metal tags to mark the beginning and ending points of superelevation and locate at 1/4-inch increments between the beginning and ending points for curved track. Attach metal tags stamped with the superelevation in 1/4-inch increments from zero superelevation to maximum superelevation for each end of the curve at points approximately one foot inside the outer rail. Face metal tags to read in ascending order.

C. The basic geometric data is as indicated. Any additional geometric data required by the Contractor will be the Contractor's responsibility.

D. Tolerances - Allowable deviation from indicated geometric design for trackwork installation as indicated in Exhibit 2.

3.3 LAYING CONTINUOUS WELDED RAIL

A. General

1. Unload and lay continuous welded rail in a manner which will prevent damage to the ties, rails, and structures.

2. Prepare and submit rail laying records which provide weight, mill brand, rolling year, and heat number of end rails in rail string; date and time of placing rail string; length of rail string; air and rail temperature; stationing of both ends of rail string; weather conditions; and rail end gap to nearest 1/16 inch.

3. Place CWR string on ties or direct fixation rail fasteners. Arrange ends of opposite rails to be more than ten feet apart when measured along centerline of track.

4. Install rail with ~~rail stamping~~ branding on the field side of the track.

B. Cutting and Drilling of Rails

1. Cut rails square and clean by means of rail saws or abrasive cutting disks. Flame cutting will not be permitted. Do not cut rails for installation of standard or bonded joints within 14 feet of a shop weld. Cut rail end, in which a pulling hole has been drilled, one inch from hole, away from rail end and perpendicular to rail; discard portion containing hole.

2. For joining rails with standard joints, drill and space bolt holes in rail in accordance with AREA Manual for Railway Engineering, Volume 1, Chapter 4.

3. For joining rails with bonded standard joints, drill and space bolt holes in rail to provide no gap between rail ends.

4. For joining rails with bonded insulated joints, drill the bolt holes in the rail to provide the gap for the insulated end post between the rail ends.

5. Drill holes perpendicular to rail web using template as drilling guide. Do not use the joint bar as a drilling guide. Drill to be used must be approved by the Construction Manager.

6. Collect and remove from site all drilling particles.

C. Beveling of Rail Ends - Bevel rail ends at standard bolted joint locations in accordance with current AREA Standard Plan No. 1005-40. Bevel rail ends in bonded joints in accordance with the manufacturer's written specifications.

D. Hardening of Rail Ends

1. At bolted and bonded joints, harden rail ends of standard strength rail. Joint bars and associated insulating materials shall be removed from rail ends during the end-hardening process.

2. Use approved end-hardening procedure and the qualified personnel to perform the end-hardening on the rails, as indicated in Paragraph 1.5 herein.

E. Determining Rail Gap

1. Calculate rail gap, by the formula: G = 0.000078*L*(t-T)+Q. (* means multiplication) where:

   G = gap, in inches

   t = Optimum anchoring temperature in degree F; between 80 and 90 degrees F if rail will be anchored at-grade or aerial; between 65 and 75 degrees F if rail will be anchored in subway.

   T = temperature of rail at the time of laying in ^{o}F.

   L = Length of rail in feet (one-half the sum of the length of the two rail strings adjacent to the joint).

   Q = Zero inches if joint will be bonded standard type, end-post thickness if joint will be bonded insulated type, and 1/8 inch if bolted standard joints.

2. Negative values indicate that the rail length is too long and the rail must be cooled to zero stress level.

3. Determine rail temperature by placing thermometer on shaded side of rail base next to web and allowing thermometer to remain there until no change in temperature is detected, but for not less than five minutes. Use AREA standard rail thermometer as specified in AREA Manual of Railway Engineering, Volume 1.

4. If rail gap is wider than 1 1/2 inches, insert a dutchman equal to rail gap G minus 1/2 inch after rail has been aligned with abutting rail to prevent damage to rail ends during laying, ballasting and other operations requiring passage of on-track equipment over rail joints. Remove dutchman before anchoring rail, and if rail temperature would cause rail gap to close.

F. Initial Fastening of Rail

1. Clean contact surfaces to allow for full bearing of the rail seat.

2. Prior to using on-track equipment, temporarily anchor rail to gauge on every fifth fastener, or tie if rail is either on tangent or on curves with a radius larger than 1,900 feet and on every third rail fastener or tie if rail is on curves with a radius of 1,900 feet or less.

G. Anchoring CWR

1. Install rail anchoring devices when the rail is within the permissible anchoring temperature range of 65 degrees F to 75 degrees F in subway or 80 degrees F to 90 degrees F in at-grade track. Anchor opposite rail only when its temperature is within 5 degrees F of the previously anchored rail's temperature at the time of its anchoring.

2. Prior to joining CWR strings, adjust the CWR strings for the zero thermal stress temperature, vibrate to relieve internal rail stresses, and fully anchor. Join CWR strings when the rail gap is at the specified gap. If the rail gap is not within the recommended tolerances for joining CWR strings, unanchor the CWR strings for 300 feet on each side of the rail gap, and readjust each CWR string to within the specified zero thermal stress range. Reanchor the CWR strings before installing the rail joint. If the recommended rail gap cannot be obtained in this manner, cut a section of rail from the end of one of the CWR strings and insert a rail not less than 14 feet long to ensure the recommended rail gap. If the Contractor elects to use an artificial means of adjusting the rail for anchoring, the method and equipment proposed must first be reviewed and accepted by the Construction Manager.

3. Zero thermal stress in CWR may be achieved by heating, cooling, or pulling the rails, or a combination thereof. When zero thermal stress is obtained, anchoring shall begin immediately. The stress within the rail shall remain with the specified zero thermal stress range until the rail is fully anchored. Once zero thermal stress has been obtained, maintain the correct rail gap during installation of joint bars. Vibrators used for relieving internal rail stresses shall be of a type acceptable to the Construction Manager and shall not damage the CWR.

4. Record the rail temperature and the information listed below at the time of rail anchoring.

   a. location by station, track designation, and rail;

   b. date and time;

c. air temperature, rail temperature, and approximate weather conditions;

d. rail gap at time of anchoring to nearest 1/16 inch; and

e. adjustment applied (type and end movement).

Record the rail temperature every 30 minutes during the anchoring process. If the rail temperature deviates from the specified zero thermal stress range, cease anchoring until the rail temperature returns to within the specified range.

H. Joining Continuous Welded Rail

1. Remove dutchman if one has been inserted in rail gap.

2. Join CWR strings in the yard area with bonded standard joints except where indicated.

3. Join CWR strings in the mainline area with thermite welded joints.

4. Cut CWR where insulation joints have been shown in the Contract Drawings and join together with bonded insulated joints.

5. Join strings together by either pulling rail ends together, vibrating rails, or heating rails, or a combination thereof.

6. Do not locate the center of standard joints or bonded standard joints within the following locations:

   a. Not closer than ten feet from bonded standard joint in opposite rail.

   b. Not closer than 14 feet from the center of shop welds, bonded standard joints, or standard joints in the same rail.

I. Final Alignment and Track Inspections

1. The Construction Manager will make a survey of the track prior to acceptance. The final horizontal and vertical alignment, gauge, cross level, and superelevation shall be within the specified tolerances shown on Exhibit 2 "Track Construction Tolerances".

2. Track deviations, as disclosed by the survey, which exceed specified tolerances shall be corrected by the Contractor at no additional cost to the COMMISSION.

J. Rail Grinding

1. After the completion of trackwork to its final alignment and elevation, grind all mainline CWR, including that installed under Contracts R01-T01-C140 and R01-T01-C325, in a continuous operation. Inform the Construction Manager before starting to

grind rail, and obtain from the Construction Manager written approval to operate rail-grinding equipment over the completed track.

2. Grind top and gauge side of running rail head with a high-speed rail-mounted grinder capable of removing a minimum of 0.001 inch and a maximum of 0.002 inch per pass. Make a minimum of three separate passes. Remove not less than 95 percent of rust, mill scale, and surface irregularities from top of rail head with successive passes of rail grinder. Use rail grinder with grinding wheels not smaller than ten inches in diameter and control downward pressure to permit grinding more metal per pass at high spots and bridging at low spots less than ten inches in length. Rail grinding equipment shall fit within the clearance in envelope specified in Exhibits 6 and 7.

3.4 FIELD QUALITY CONTROL

Conduct a field weld quality control program to test for internal defects in field thermite welds. The testing shall be performed by an individual experienced in conducting ultrasonic and induction testing, and the test program shall be conducted in conformance with Section 02456, "Welding of Rail".

3.5 CLEAN UP

A. Remove loose debris, track materials, clusters of rail grinding particles and spilled concrete. Cut exposed stirrups and tie wires flush with the concrete surfaces. Remove from the site at no additional cost to the COMMISSION.

B. Sweep clean any concrete trackway and wash down with water.

C. Examine all drainage inverts, pipes, sumps and other conduits for spilled concrete, rail grindings, ballast material, and other debris. Remove all such obstruction at no additional cost to the COMMISSION.

END OF SECTION

SECTION 02452

BALLASTED TRACKWORK CONSTRUCTION

PART 1 - GENERAL

1.1 DESCRIPTION

The Work specified in this Section consists of construction of ballasted track on at-grade sections as indicated.

A. Ballasted track construction shall consist of supplying, placing and compacting ballast; distribution of concrete ties; laying track; road crossing trackwork at Wardlow street and Spring Street in Long Beach, anchoring and destressing rail; final lift, line and dress of track and other operations as specified herein.

B. Running rail and concrete ties complete with clips, shoulder spacers and rail seat pads will be furnished by the Commission. Sub-ballast will be placed under previous contracts by others, except in the Satellite Yard.

C. All other materials required for ballasted track construction shall be furnished by the Contractor.

1.2 RELATED WORK SPECIFIED ELSEWHERE

Section 02450 General Track Construction

Section 02455 Materials Furnished by the Commission

Section 02456 Welding of Rail

Section 02457 Ballast

Section 02458 Track Appurtenances & Other Track Material

Section 02460 Ballasted Special Trackwork - Main Line

1.3 QUALITY ASSURANCE

Test results as specified in Section 02450, General Track Construction, shall be submitted in accordance with the requirements of Section 01300, "Submittals".

PART 2 - PRODUCTS

2.1 BALLAST

Ballast shall conform to the requirements of Section 02457 "Ballast".

2.2 OTHER TRACK MATERIAL

Other track material not specified in this Section that is required for the complete installation of ballasted track shall be as specified in Section 02458, "Track Appurtenances and Other Track Material".

PART 3 - EXECUTION

3.1 PLACEMENT OF INITIAL BALLAST

A. Prior to placement of initial ballast layer the Contractor shall check the subballast to check conformance with Section 02200, "Earthwork" and report discrepancies to the Construction Manager.

B. The initial layer of ballast shall be uniformly distributed over the finished subballast and compacted before concrete tie distribution operations commence.

1. Subgrade fouled or disturbed by the Contractor's operations shall be repaired and recompacted by the Contractor at no additional cost to the Commission.

3. The initial layer of ballast shall be limited to a total compacted depth that will establish the top of rail at least 4 inches below final grade.

4. Each lift of ballast within the initial layer shall be uniformly spread and compacted with not less than four passes of either a self-propelled, pneumatic-tired roller or vibratory compactor. Each compacted lift within the initial layer shall not exceed a depth of 4 inches.

5. The self-propelled, pneumatic-tired roller shall have a gross weight of 10 to 15 tons, and the vibratory compactor shall have a weight of not less than 10 tons and shall be capable of applying a dynamic load of not less than 18,000 pounds at 1300 to 1500 cycles per minute.

6. The compacting equipment selected by the Contractor shall be subject to inspection and acceptance by the Construction Manager.

3.3 PLACEMENT OF CONCRETE TIES

The Contractor shall transport the ties from the storage site to the work area, where the ties shall be distributed and properly spaced on the initial layer of ballast.

A. Concrete ties shall be spaced at 30 inches for both curved and tangent track, measured at the center point of the tie. Ties shall be laid normal to the center line of track or as shown on the Contract Drawings. Ensure that the bottom surface of the ties has full bearing against the ballast.

B. Unnecessary handling, redistribution, and reloading of ties shall be avoided.

C. Ties shall be lifted and supported during storage, transportation, and placing in such a manner as to prevent damage. Ties shall not be dropped to the roadbed. Ties damaged as a result of improper handling by the Contractor and rejected by the Construction Manager shall be removed and replaced with undamaged ties.

D. The cost of replacement ties and the cost of removing the damaged tie and transporting and installing the replacement tie shall be at the Contractor's expense.

3.4 LAYING RAILING AND ANCHORING

Laying rail, installing bonded joints, and anchoring of CWR and jointed rail in ballasted trackwork shall be as specified in Section 02450, "General Track Construction", and as modified herein:

A. Fastener seats shall be cleaned and prepared, so as to remove all loose foreign material, for placement of the rail pads, CWR strings and jointed rail.

B. Rail shall be placed on the concrete ties before placing final ballast and field welded in accordance with the accepted Contractor's Drawings submitted under Section 02450 and shall not be dragged over the fastener seats.

C. Welded rails shall be installed and anchored to produce zero thermal stress as specified in Section 02450, "General Trackwork Construction" and Section 02456, "Welding of Rail".

D. Bonded joints shall be installed as specified in Section 02463, "Bonded Joints".

E. Final rail destressing and anchoring of ballasted track shall proceed when the track has been completely ballasted to prevent tie movements due to thermal expansion or contraction and when the track has been raised, tamped, and rail clips and fasteners cleaned.

F. Rail anchoring in ballasted track shall be accomplished by installing rail clips in accordance with the fastener manufacturer's recommendations and as specified in Section 02450, "General Trackwork Construction" and Section 02456, "Welding of Rail".

3.5 SURFACING AND ALIGNING

A. After skeleton track has been installed, ballast shall be placed in the tie cribs and shoulders of the track structure to restrain movement of the ties due to temperature changes in the CWR.

1. Ballast shall be unloaded in quantities which will fill the tie cribs and provide an adequate amount of ballast for the initial track raise, and a surplus to continue to hold the track after the initial track raise.

2. Track surfacing shall be done by methods which will prevent undue bending of the rail, straining of the joints, and damaging the tie shoulders and clips.

3. The amount of track lift shall neither exceed nor endanger the horizontal and vertical stability of the track.

4. The track shall be raised so that a final raise shall not be less than one inch or more than 3 inches when bringing the track to the final surface.

5. The top of the ballast section shall be trimmed one inch below the base of rail.

6. After the track has been raised, aligned and swept, the rails shall be anchored within the specified zero thermal stress range.

7. Ties and fastening devices damaged during the surfacing operation shall be removed and replaced with new ties and fastening devices at no additional expenses to LACTC.

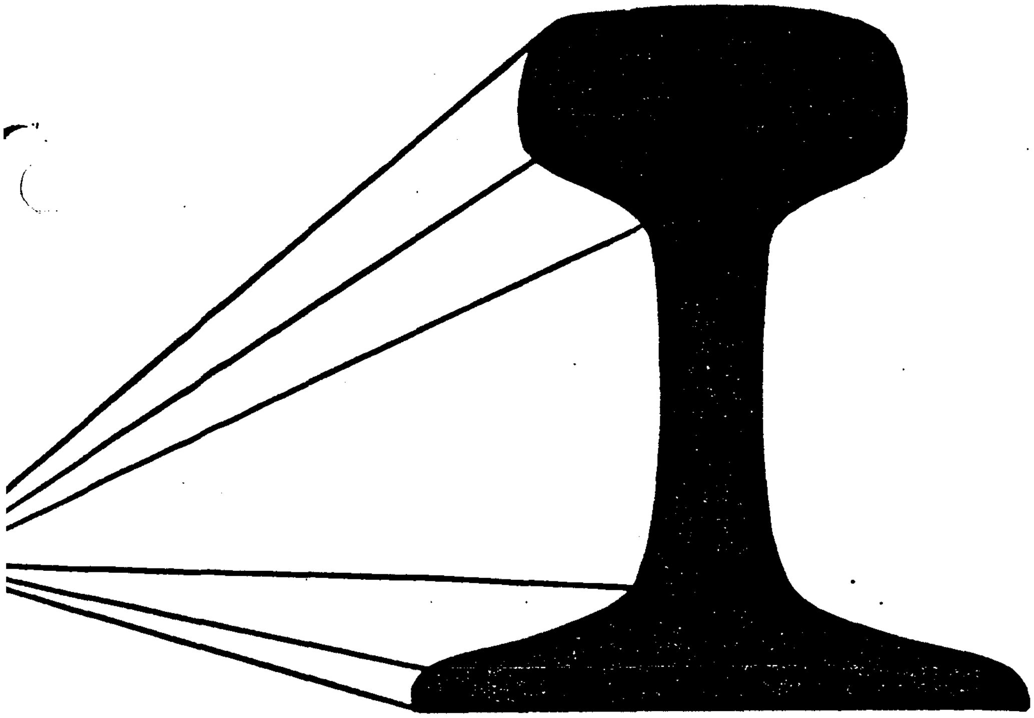
8. Surfacing shall be discontinued when the ambient temperature is more than 5 degrees Fahrenheit above the anchoring temperature.

B. Tamping shall be done with a squeeze-vibratory type power tamper acceptable to the Construction Manager. Control of the power tamper's tamping cycle shall ensure the maximum uniform compaction of ballast along the track. The ballast shall be tamped on both ends of the tie from points 15 inches inside the rail centers to the ends of the tie. Tamping will not be permitted at the center of the ties outside the above stated limits, but the cribs shall be filled with ballast in this area. For each tile, tamping shall proceed simultaneously inside and outside both running rails both sides of the tie.

1. The Contractor, at his own expense, shall remove at random a maximum of one percent of the ties so that the Construction Manager may inspect the compaction of the ballast beneath the ties to determine the tamping variables of each piece of tamping equipment, and for spot checking of the production work.

C. Rail alignment shall be in accordance with the requirements of Section 02450, "General Track Construction".

1. Final surfacing and aligning of the track shall be completed after the track has been initially surfaced and aligned, anchored, and joined together by field welds, or bonded joints. The final surface and alignment of track shall be within the



TRACK FOREMAN'S TRAINING PROGRAM

LESSON 10

RAIL LAYING

The Railway Educational Bureau

1809 Capitol Ave., Omaha, Nebraska 68102

LESSON 10

RAIL LAYING

Each year, hundreds of thousands of new rails are laid in track replacing rails that are no longer suitable for use in those tracks. The rails which are removed from track because they contain defects such as those described in lesson 9 are a small part of the total. Most rails are replaced because of wear. The most common types of wear are those that develop in joints and on curves.

Unlike defects which usually occur at random, these types of wear normally affect all consecutive rails in a stretch of some length. Replacement of rails in a continuous stretch lends itself to techniques far different from those suitable for replacement of a single rail.

New rails are usually installed in important main tracks. Many of the rails which are removed from these tracks are suitable for reuse at other locations. Rails which have been removed because of wear in the joint area can have the ends sawed off. This process is called cropping. Rail which is cropped can be drilled with new bolt holes, and then reused as jointed rail. Instead of drilling them, the cropped rails can be welded into lengths of continuous welded rail. In some cases, curve-worn rail is suitable for reuse in lower class tracks. The total amount of rail, both new and second hand, which is laid in stretches to replace worn rail, is very large. Because of the importance of this track-maintenance function and the high degree of specialization frequently used, this entire lesson will be devoted to the replacement of rail in existing track as a continuous stretch.

The techniques which are widely used in replacing rail, bear a great deal of resemblance to the assembly line methods used in many manufacturing plants. The principal difference is that instead of the work passing by men and equipment stationed at fixed locations, in rail-laying operations, the men and equipment must continually advance to the next unit of work.

The greatest part of the physical work is performed at the time the old rail is removed from track and replaced with either new rail or relay rail of a better quality. There is work that must be performed in advance of this operation and there is work which must follow it. The efficiency with which the replacement operation is carried out and the quality of the final job, depend to a large extent on the effectiveness of these other phases of the job. The entire process of replacing a stretch of rail can be considered in four phases. They are:

Planning

Preparation

Installation

Follow Up

PLANNING

RAIL REQUIREMENTS

In many cases, part of the planning of a rail-renewal project will be carried out by supervisory personnel other than Track Foremen. In most cases, one or more Track Foremen will do at least a portion of the planning. They will frequently be called upon to develop information for supervisory personnel to use in their part of planning the job.

Once it has been determined that a certain section of track is to have the rail replaced, it is necessary to determine the extent of the project. Each end of the job must be established and identified on the ground. The distance to be covered and the quantity of rail required have to be determined. On short jobs, the distance may be found by direct measurement. On longer jobs, the limits are sometimes referenced to nearby fixed points for which engineering stations or mile-post plusses are known, and the distance is calculated.

Physical features within the limits of the project need to be identified and considered in the plans. If the steel is to be replaced in turnouts and other special trackwork, the necessary material must be provided. Extra footage of rail must be available. If such installations are to be skipped, compromise joints will be needed if there will be changes in the rail section.

New rails are grouped into various classifications at the mill. The means of identification and usage recommended by the A.R.E.A. are listed in the following table. This may conform to your railroad's practice, but you should find out if there are any differences.

Class of Rail	Standard Length Feet	Color or Design	Use
No. 1-low carbon	39	Uncolored	Any track
No. 1-high carbon	39	Blue end	No restriction Preferably curves
No. 1-"A" Rails		Yellow end	Any track
No. 1-short lengths		Green end	Any track
No. 2	39 or under	White end	Any track
X-Rayls	39 or under	Brown end	Where designated b chief maintenance officer

Sometimes, when the project consists, primarily, of replacing curve-worn rail, only one of the two rails will be replaced. At times, special heat-treated rail will be used on some or all of the curves.

In some situations, grade crossings may be skipped. This raises the question of whether compromise joints will be required. If the rail is to be renewed through crossings, and jointed rail is being used, extra length rails may be needed to avoid rail joints within the crossing. Crossings, bridges, station platforms and other physical features may require advance planning of material distribution procedures.

OTM REQUIREMENTS

In addition to determining the quantity of rail which will be required, and identifying problems that may be encountered in distributing the rail, it will be necessary to determine the quantities of the various fittings that will be required. The standard track fittings to be used, usually classified as "other track material", and, frequently, abbreviated as "OTM", will be largely affected by two conditions. They are:

Will jointed rail or continuous welded rail be installed?

Will the tie plates be replaced, or will the same plates be reused?

If continuous welded rail (CWR) is to be installed, the joint bars, bolts, nuts and nutlocks will not be required. It is necessary to determine the procedure that will be used to connect each string of CWR. Conventional joints may be used, adhesive-type joints or thermit welds. If either of the latter two systems will be used, it should be determined whether the installation will be made immediately, or if conventional joints will be needed temporarily. The requirements for insulated joints and compromise joints will have to be determined, regardless of whether jointed rail or CWR is to be used.

The number of rail anchors required will have to be decided. This will be dependent upon your own railroad's standards and policies. More anchors will be required for CWR than for jointed rail. Where jointed rail is used, more anchors may be required on single track than on double track. The anchor pattern to be used must be established so that the total quantity needed can be calculated. It must also be determined whether part or all of the rail anchors presently in track can be reused. If the rail section is to be changed to one of a different base, the anchors will all have to be replaced. Anchors which show signs of slipping should not be reused.

If the rail to be installed has a different base width than the rail to be replaced, the tie plates will have to be replaced. Under some conditions, tie plates will be replaced even without a change in rail section. This may be done where it is desired to install larger tie plates, where the existing plates are severely worn or where the cant of the rail is to be changed (see lesson 1). If the tie plates are not to be replaced, it may be necessary to have a small quantity of similar plates available to replace missing or broken tie plates. Tie-plate requirements are usually determined from an estimate of the number of ties in track within the limits of the project.

Spike requirements are based on the pattern at each tie plate. At the minimum, two rail-holding spikes per plate will be used. At times, an additional gage-side rail-holding spike may be used on curves. Sometimes one or two plate-holding spikes are installed. A decision will be needed on the anticipated reuse of spikes presently in track. Spikes may not be suitable for reuse because of throat cutting from abrasion, corrosion or severe bending. Sometimes it is decided to use new spikes for rail holding and to reuse the best of the old spikes for plate holding.

Tie plugs will be needed to insert in all holes from which spikes are pulled. The type of plug required will depend upon whether the plugging operation is to be manual or mechanized. If a tie-plate-gager is to be used, gage studs will be needed for this operation.

All necessary turnout material will have to be provided. Usually, each railroad has a standard bill of material for each size turnout, which lists all of the components required.

The following tables will be useful in estimating quantities of material required for a rail-renewal project.

Length of Rail Used	No. of Rails per Mile, One Side	No. of Rails per Mile, Both Sides	No. of Bolts per Mile, 4 Hole Joint	No. of Bolts per Mile, 6 Hole Joint
39 Ft.	135	270	1080	1620
36 Ft.	147	294	1176	1764
33 Ft.	160	320	1280	1920

No. of Ties per 9 Ft.	No. of Ties per Mile	No. of Tie Plates per Mile	Number of Spikes per Mile			
			2 / plate	3 / plate	4 / plate	5 / plat
	2708	5416	10,832	16,248	21,664	27,080
22	2978	5956	11,912	17,868	23,824	29,780
24	3249	6498	12,996	19,494	25,992	32,490

No. of Rail Anchors per Rail Length	No. of Rail Anchors per Mile of Track		
	39 Ft. Rail	36 Ft. Rail	33 Ft. Rail
8	2160	2352	2560
10	2700	2940	3200
12	3240	3528	3840
16	4320	4704	5120
20	5400	5880	6400
22	5940	6468	7040
24	6480	7056	7680

SUPPLIES

In addition to the track materials which will be used, a variety of other supplies will be required. This list can vary, but a list of supplies frequently required includes:

Gasoline
Diesel fuels
Lubricants
Creosote or other wood preservative
Wood shims for temporary run-offs
Oxygen
Acetylene
Welding steel
Bituminous paving
Fuel for rail heaters
Rail joint lubricant
Rail expansion shims
Grinder for adzer bits
Extra gringing wheels
Paint for marking temperature on rails

DETERMINING OPERATION

While there are a great many similarities in methods used to install jointed rail and CWR, there are some substantial differences. These will have to be recognized throughout the planning process.

When the replacement rail is to be laid on the tie plates presently in track, without adjustment of the plates, the process is substantially simplified. However, even when the tie plates are not to be replaced, it is sometimes necessary to remove and re-install the plates under one or both rails. This is made necessary to correct gage, alinement or improper cant of the tie plates due to plate cutting. The ties are adzed to provide a proper seat for the tie plates while the plates are removed from the ties. If the tie plates are to be reused, the track must be inspected early in the planning stage and these needs identified.

ANTICIPATING DIFFICULT CONDITIONS

The preliminary inspection should be conducted so as to identify conditions likely to interfere with the smooth flow of the work. Any locations where there is excess ballast present that would interfere with the progress of the work, should be noted. This also applies to foreign materials such as spilled lading or wash-ins.

Close clearances or guard rails may restrict the efficiency of equipment. Hazardous locations such as bridges or tunnels may require special arrangements for the protection of employees and the proper progress of the work.

The effect of rail traffic on the progress of the job should be predicted, and the work scheduled in the most practical manner. The situation at grade crossings should be considered, and the best way of handling traffic determined.

Some of the problem situations which will be noted may be overcome by advance preparation. It may be possible to eliminate the condition before installation of rail begins. In other situations, it might be possible to handle the condition more effectively by allocating equipment or manpower to deal with it as the work progresses. Sometimes there is no easy solution to a problem, and productivity of the operation will of necessity be reduced. If this is anticipated in advance, at least the scheduling of the work will be more realistic than a plan based on guesswork.

GANG ORGANIZATION

Much rail laying is done by special gangs organized for this purpose. These gangs usually have a well developed table of organization for personnel. In most cases, they are provided with a full range of mechanized equipment. The supervisors assigned to these gangs are specialists and are and are well qualified in their organizational assignments for varying conditions.

At other times, rail is laid by forces who are not specialists in this work. This may consist of more or less, local forces that are temporarily borrowed from other assignments to undertake a particular rail-laying project. The job may require combining all available forces within a reasonable distance. The forces which can be made available may or may not be sufficient to form the most desirable organization for the job at hand. The equipment which can be made available may be the ultimate in rail-laying efficiency, or it may only provide for mechanization of some of the operations. It is the latter situation which most Track Foremen are likely to be confronted with at some time. The following procedure is more likely to apply to this type of operation. The planning of specialized rail laying organizations is usually performed at higher levels of management.

Make a list of the various operations that will have to be performed during the replacement of rail. Some variations in these operations occur depending on such situations as CWR or jointed rail, gaging or "on the plates", conventional joints or field welds. List these operations down on the left side of the paper. Leave space for three additional columns. In the next column, list the equipment available to perform each of the operations. If no equipment is available for a particular operation, indicate "None" opposite that operation. In the third column, show the equipment operators required for each operation. In the fourth column, show the number of trackmen or laborers needed for each operation.

The list may look something like the following, which only includes a few operations:

Operation	Equipment	Machine Operators	Trackmen
Pull Spikes	2 Spike Pullers	2	
Remove Rail Anchors	None		1
Remove Bolts & Joint Bars	1 Power Wrench	1	1
Load Scrap	1 Scrap Loader	1	1

When the entire list is completed, the manpower equirements can readily be seen. Each operation should be reviewed to see if the capabilities of the force and equipment is reasonably balanced between operations. It would not be well balanced if, for example, three high production spike pullers were used and only one man was available to manually insert tie plugs.

It might very well be that the force required exceeds the force available. In this case, a revised plan will be needed. Usually, this will involve assigning the available manpower to "front end" operations to remove the old rail and prepare for installation of the replacement rail. This part of the work will then have to be terminated early enough to permit reassigning the same men to "rear end" operations. This type of procedure results in a considerable loss of productivity. It does permit the installation of rail with a limited force when there is no other alternative.

It is also possible, by planning the force requirements, that you may find that there is more force available than that which is needed for a well-balanced operation. This permits making decisions in advance so that manpower is not wasted. Under such conditions, it might be desirable to assign part of the force to related operations. Turnouts programmed for steel renewal might be progressed with a separate gang, so that the rail-laying operation is not delayed by this work. Loading of material might be progressed behind the rail gang, while the track is removed from service. There could be other unrelated work which could be carried out advantageously because of availability of the track for maintenance work.

The list which follows, describes items of work typical of rail-renewal projects. No single job is likely to include all of these items, as they cover variable situations. The list should provide a useful reference, should you be called upon to take charge of a rail-laying operation.

→ Open grade crossings
→ Thread CWR from shoulder to center of track
Remove rail anchors
Pull spikes
Remove nuts
Remove track bolts
Remove joint bars
Load scrap OTM
Remove old rail
Remove tie plates
Punch spikes with broken heads through ties
Set tie plugs
Drive tie plugs
Remove crib ballast (to protect adzers and permit installation of rail anchors)
Adze ties
Apply preservative to adzed surface of ties
→ Place new tie plates
→ Gage tie plates
→ Set new rail in plates

Apply lubricant to joint area
Install joint bars, bolts, nutlocks, and nuts
Heat or cool rail
Vibrate rail for thermal adjustment
Apply rail anchors
Drill spike holes
Set spikes
Drive spikes
Drill bolt holes, as needed
Install insulated joints
Weld joints, as needed
Make field welds or install adhesive joints
Grind welds
Surface loose ties
Restore grade crossings
Install turnout material
Replace ballast removed from cribs

SCHEDULING

Once the force and equipment assignments have been worked out, it should be possible to make a reasonable estimate of the productivity that can be anticipated. From this, and knowledge of the track usage time that can be obtained, a schedule can be prepared. The schedule should include sufficient time for advance unloading of material and other preparatory work and for follow-up work, as well as the installation of the rail.

A good schedule is needed to insure the following:

All items of material and supplies to be available when needed.

Equipment to be available when needed.

Arrangements made for diversion or rescheduling of trains on proper dates.

Force assignments, by dates

Arrangements for rescheduling service to shippers

Arrangements for detour of highway traffic at grade crossings.

PREPARATION

Preparation includes the items of physical work which must be done in advance of the actual installation of the rail.

DISTRIBUTION OF RAIL

One important phase of this work, is the distribution of the rail. If CWR is involved, special cars are required to transport it. Uusally, specialized equipment is provided adjacent to the rail-carrying cars to expedite the unloading. This may include a winch to being the unloading process, and threaders to guide the rail from the train to the intended position on the ground.

The normal procedure is to push or pull the train out from under the rails guiding the rails to a position on the shoulders. In the case of multiple-track territory, rail will be distributed in the inter-track areas. Two rails are distributed at the same time, one to either side of the track. As the ends of the strings of rail are reached, the train is stopped and these rails are connected to the next rails to be unloaded. Special splice bars are usually provided to facilitate a quick connection of the rail ends. This procedure results in rail being unloaded without overlap or gaps between rails.

Less elaborate equipment sometimes makes it necessary to use a crane to hold onto one end of a string of CWR, while an engine coupled to the other end of the train load of rail pulls the train out from under the rail which is being restrained.

Some railroads install a short rail between each string of CWR which is called a buffer rail. The purpose of this is to facilitate any future adjustment in the expansion of the string of CWR, by removing the buffer rail. A longer or shorter buffer rail can be installed after the adjustment is made.

The considerable differences which exist in the design of transporting and unloading equipment for CWR, make it impracticable to establish firm procedures for unloading it. Each railroad normally issues instructions applicable to its own equipment. Any Track Foreman anticipating assignment to this work should become familiar with these instructions in advance. It is possible to point out certain conditions that are likely to develop during the course of unloading CWR:

If there is a defect within the rail or a weld, stresses which develop during the unloading process may cause it to break. Resulting movement of the free ends can be unpredictable.

A change of direction in movement of the train for even a very short distance may cause severe buckling of unrestrained rail.

Sudden starts or stops can cause considerable sway of free ends of rail.

Reaction time of personnel to signals may or may not be as quick as you anticipate.

All of these conditions should emphasize the fact that a careless unloading operation exposes the personnel to serious hazards. A foreman who understands these potential hazards will make sure that all employees are in a safe position during the unloading process. When rail is unloaded properly, the procedure is a safe one. It is only when safe practices are not understood or enforced, that the potentional for injury exists.

Various types of construction can present obstacles when unloading CWR. If it is intended to install the rail through crossings, trenches should be dug through the paving on either side of the track. The rail can then be placed in the trenches, which can be temporarily backfilled until the rail is installed.

Turnouts and crossovers will usually make necessary the cutting of at least one of the rails. This is usually done with an acetylene torch to avoid excessive delay. The rail is cut longer than anticipated, so an exact cut to fit can be made as the rail is installed.

Special provision may be necessary to support the rail at locations such as bridges. This may involve the placing of outriggers between bridge ties. Rail must be restrained when the possibility of lateral movement caused by vibrations from traffic exists.

CWR is subject to the same termperature changes when stored adjacent to a track as it is after installation in the track. Care must be taken to insure that the ends are by-passed, so that a substantial increase in temperature will not cause buckling, with possible fouling of the track.

Unloading of jointed rail presents a different series of circumstances. The most common procedure is to use a work train in which cranes mounted on flat cars are placed adjacent to gondolas loaded with rail. A well-trained gang can unload rail with this equipment, without the necessity of stopping the train to spot each rail. If there is any question as to the skill of the crane operator or the ability of the engineman to control the train in the required manner, all men in the cars and on the ground should be required to get well clear before each rail is handled.

At times, this work is done with a locomotive crane handling a carload of rail. Since the same operator controls the movement and the lifting, very smooth handling is possible. In other operations, the cars of rail are placed on a side track and a smaller on-track crane distributes the rail throughout the length of the job. This is more suitable to smaller jobs and remote locations where the cost of work train operations is excessive.

DISTRIBUTION OF OTM

On some jobs, all OTM is distributed in advance throughout the length of the rail stretch to be renewed. This may be done by unloading material from a work train. Some of it will be unloaded manually; other items such as kegs of spikes or bolts might be unloaded with a crane.

In some instances, there is a trend away from this practice. Some or all of the OTM may be carried to the point of work each day by the rail-renewal equipment. There are several reasons why this may be done:

- Increased theft and vandalism in some areas
- The tendency to unload too much material in advance, leading to loss or the need to recover the excess
- Development of special material-handling equipment, such as spike carts and rail anchor carts
- Elimination of the need for joint OTM because of CWR

When this latter practice is followed, provision must be made for the material to be at the tie-up point for the rail-laying equipment, for it to be readily accessible for transfer and for adequate trucking capacity within the equipment line up. The material which is least suited to this type of handling is tie plates, because of the weight and numbers involved. The best procedure for each operation will have to be determined.

PREPARATION OF RAIL

At locations such as turnouts and insulated joints, some advance measuring and cutting of rails may be desirable, in order to avoid delay while rail laying is in progress. Short rails may be provided for this purpose to avoid waste of rail. If shop-prepared stock rails are not provided, it may be advantageous to bend and drill them in advance.

When jointed rail is being installed, it is usually desired to maintain joint stagger within specified limits. On curves, a greater length of rail is required on the outer, or high rail than on the inner, or low rail. In order to maintain stagger of the joints on a curve, it is customary to insert one or more short rails on the low-rail side. The total difference in rail length depends upon the degree of curvature and the length of the curve. If short rails of suitable length are available, cutting of rail can be avoided.

EQUIPMENT CHECK

Permanently assigned rail gangs usually have regular operators assigned to the equipment who are familiar with the condition of the machines. The intermittent rail-laying organization is more likely to be assigned equipment which has not been in use for extended periods, or which has been assigned to a succession of operators. When these conditions exist, it is advisable to have each machine checked out in advance by a mechanic or reliable operator.

INSTALLATION

The ideal situation during the course of a rail-renewal project is for each operation to progress at a uniform rate of speed. No single operation would be delaying the operations which follow, nor lag behind those which precede it. In practice, this is seldom attainable. There will probably be one operation which is limiting the overall productivity of the entire force. This is sometimes referred to as a pace operation. If the addition of another machine or more manpower to that operation, significantly increases productivity, such action may be justified. If some other operation becomes the pace operation with very little change in productivity, the additional force or equipment may not be justified.

The problem is complicated by changing physical conditions within the track. On one occasion, progress might be delayed by an unusual number of throat-cut spikes, from which the heads break off, leaving the shanks of the spikes in the ties. Another time, frozen ballast may delay a ballast cribbing operation. A large number of grade crossings can be the controlling factor.

There are other ways in which even the best planned jobs can encounter bottlenecks. A key machine operator may report off sick. A machine may break down. Rail traffic requirements may reduce anticipated track usage time. A sudden downpour may slow operations with a half mile of rail torn out.

All these and many more possibilities become the rail gang foreman's responsibility. He must constantly adapt the resources at his disposal to expected and unexpected situations. He constantly strives to improve productivity while maintaining a high level of quality in the work.

There are numerous items that require frequent checking to assure the quality of the finished job. One of these is the gage of the track. Tie plates must be checked to be sure that no part of a tie plate shoulder is under the base of the rail. Field side shoulders on the plates should be snug against the edge of the rail base and square to the rail.

All specified spikes should be installed and fully driven. Any spikes which have been bent should be either straightened and driven or replaced. Rail anchors should be checked to be sure that the required number are installed, that they are fully set on the base of the rail, and that they bear against the sides of the ties. In the final job, every tie against which anchors are applied, should have the same anchor pattern on both rails.

All joints should be inspected. Bolt holes must be drilled as required, never burned with a torch, and bolts inserted in the proper number. Occasionally, joint bars may be applied with an improper cant, not bearing properly against the upper and lower fishing areas of the rail ends. Any mis-matched rail ends must be corrected by welding. Bolt tension should be periodically checked with a hand wrench.

It is of utmost importance to get the proper thermal adjustment of the rail as it is installed. The A.R.E.A. recommends the following rail-end gaps in jointed rail for various temperatures:

33-Ft. Rail 100 Joints per mile		39-Ft. Rail 135 Joints per Mile		78-Ft. Rail 68 Joints per Mile	
Rail emperature Deg F	Expansion Inches	Rail Temperature Deg F	Expansion Inches	Rail Temperature Deg F	Expansion Inches
elow -10	5/16	Below 6	5/16	Below 35	5/16
- 10 to 14	1/4	6 to 25	1/4	35 to 47	1/4
15 to 34	3/16	26 to 45	3/16	48 to 60	3/16
35 to 59	1/8	46 to 65	1/8	61 to 73	1/8
60 to 85	1/16	66 to 85	1/16	74 to 85	1/16
Over 85	None	Over 85	None	Over 85	None

Your railroad's practice may conform to this table, or a different table may be used due to temperature ranges in your area.

When installing CWR, it is the usual practice to make a permanent record of the temperature at which each length of rail was anchored. These temperatures are to be rail temperatures, not air temperatures. This is found by placing a rail thermometer on top of the rail base, not in direct sunlight, and leaving it there for several minutes. If the temperature is not within the specified range, the anchors will have to be removed at a later date, when the rail temperature is within this range, and the rail expansion readjusted. Many CWR installing gangs have rail heating and a few have rail cooling equipment which brings the rail within the specified range before it is anchored. Constant use of the rail thermometer is necessary to monitor this operation.

The rail gang foreman must know his company's standards for the location and stagger of insulated joints, and must see that they are installed accordingly. When jointed rail is being installed, he must see that the joint stagger is maintained within specified limits.

FOLLOW-UP

After the rail is installed, there will be various items of work to be done before the job can be considered to be complete. Some of these things may be at least partially completed, while the installation of the rail is in progress. When manpower and equipment availability permit, this can be desirable, by taking advantage of track usage available to the rear of the rail-laying force.

LOADING RAIL

The practices involved in the handling of the rail removed from track vary between railroads. Many railroads remove the joint bars while the rail is still in track, roll the individual rails onto the shoulder, then load them into gondolas with a crane after the rail gang has completed work at this location. Sometimes the rails are inspected and graded on the ground. The rails may be separated by grades during the loading process.

Other railroads do not remove the joint bars. Instead, they have developed techniques for loading strings of jointed rail onto CWR trains. When this is done, the strings are transported to a central plant where they are dis-assembled, graded and sorted. The latter procedure permits welding of rails into strings of CWR in the same order in which they were previously laid in track. This results in welding relatively well matched rails together. When this procedure is used, the Track Foreman responsible for loading the rail may have little or no responsibility for grading the rail.

If the rails are loaded singly, it is more likely that rails will be graded prior to loading. Varying degrees of separation may be required as the rail is loaded, depending on each railroad's policy. Items of concern in the grading of rail for reuse are:

Vertical wear on the rail head

Horizontal wear on the rail head (curve cutting)

Surface defects (engine burns, corrugations, etc.)

Corrosion

In addition, the rails may have been recently tested with a detector car. Rails with internal defects may not have been changed out, in anticipation of the rail-renewal project. Rails with such defects should be disposed of separately. If the defects are in the joint area, and the rails are to be cropped, the defect should not restrict the use of the rail.

The following table shows the A.R.E.A.'s recommendation for classifying rail. Your railroad's classifications may be the same as this, or they may be different. You should determine this, and also become familiar with the method used by your railroad for marking rails to indicate the grade to which they are classified.

RECOMMENDED RAIL GRADING CLASSIFICATIONS

Rail Weight	Maximum Rail Wear-Inches Top	Gage	General Rail Use & Rail Condition
Class 1			
140	1/4	1/2	Main Line use - Very minor
132-131	3/16	1/2	
122	5/32	7/16	engine burns and corrugation
115	1/8	3/8	
112	1/8	1/4	
100	1/8	1/8	
90	1/8	1/8	
Class 11			
140	3/8	3/4	Branch Lines - Small engine
132-131	5/16	3/4	
122	5/16	3/4	burns and corrugation
115	5/16	3/4	
112	5/16	1/2	
100	3/16	1/4	
90	1/4	3/16	

Class lll

140	5/8	7/8	Light Branch Lines - Medium
[illegible]-131	7/16	7/8	
[illegible]	1/2	7/8	engine burns and corrugation,
[illegible]	3/8	3/4	
112	3/8	3/4	may be pitted and show some
100	1/4	1/4	
90	5/16	5/16	oxidation.

Class lV

140	3/4	1	Yards.
132-131	9/16	1	
122	11/16	1	Any burns not mashed or
115	1/2	7/8	
112	1/2	7/8	fractured.
100	7/16	7/8	
90	3/8	3/8	

DISPOSITION OF OTM

Practices will differ between railroads in the manner in which the various items of other track material removed from track are handled. Some railroads will emphasize maximum sorting by the forces picking up this material. Scrap may be separated from materials which are reusable. Separations might be made between those items which can be reused in their present condition, and those which must undergo some sort of reclamation process before they can be reused. For example, spikes which can be reused if they are straightened, could be kept separate.

In other situations, there may be a central inspection and sorting facility available, and the policy may be to load all OTM without any inspection or separation. It will be necessary for you to determine your railroad's policy in this matter. Reclaimable material which is erroneously put in a scrap pile can represent a major waste of funds.

RESTORING GRADE CROSSINGS

Installation of rail through grade crossings requires at least partial opening of the crossing. In addition, if CWR is being installed, there may have been trenches provided through the paving for the temporary storage of the rail when it was unloaded. Normally, restoration of the crossing surface will be a high-priority item in the follow-up schedule. They will frequently have to be restored the same day that the rail is installed.

RETIGHTENING TRACK BOLTS

Track bolts frequently become loose after rail traffic has operated over the newly laid rail for awhile. This may become noticeable after a few days or a few weeks, depending on the density of traffic. This is first noticeable by a loss of tension in the nut locks. If the bolts are not retightened, the nuts will work off the bolts, and the entire joint may become disassembled.

In most cases, one retightening of the bolts will be sufficient, as the joint bars will have become fully seated by the traffic prior to the retightening. Future tightening of the bolts may then only be needed at the relatively long intervals found in normal maintenance.

TRACK SURFACING

Track surfacing, incident to rail renewals, can take various forms. The extent of the need may vary with the class of track, and the condition of the track surface prior to the rail renewal.

In some rail-laying gangs, a tamper is provided as part of the equipment. This tamper could be used for conventional spot tamping or it might be used only to tighten up loose ties at locations where low joints existed in the old rail.

At other times, surfacing may be carried out after completion of the entire rail-laying operation. This could take the form of spot-tamping or of a general raise. In any case, any ballast removed from the tie cribs should be restored to the cribs promptly, so that there is no loss of longitudinal restraint of the rails.

When general rehabilitation of the track is desired, it is customary to replace the rail first, then renew defective ties and to finish up with a general track raise. This sequence brings the track to proper gage before new ties are installed, so that they are not weakened by respiking. By installing ties before raising track, uniformly compacted tie beds are retained.

LESSON 10

EXERCISE QUESTIONS

1. Where is heat-treated rail used, when it is provided?

2. Are more rail anchors usually needed on jointed rail with traffic predominately in one direction or with a single-track operation?

3. What is the recommended way of unloading CWR where highway crossings are present?

4. What are two conditions to look for in the placement of tie plates under the rail?

5. What is the proper way to use a rail thermometer?

6. What two measurements are commonly used in grading rail for reuse?

7. It has been decided to install cropped rail in a certain stretch of track which is 2-1/2 miles long. The rails are all 36 feet in length. Six hole joints will be used. How may track bolts will be needed?

8. CWR is to be laid in a track which has 22 ties per 39 feet. Every second tie is to have rail anchors on both side of the tie. How many rail anchors per mile will be needed?

9. Rail is to be installed in a stretch of track two miles long. This track has 22 ties per 39 feet. One mile of this track is tangent and you have been instructed to use 2 spikes per tie plate in this area. The other mile is curved and you have been told to use 4 spikes per tie plate. How many spikes will you need for the two mile stretch?

10. You are grading 115-pound rail, using A.R.E.A. classifications. A rail which has vertical (top) wear of 1/4 inch and horizontal (gage) wear of 5/8 inch, is of what class?

Answer the following questions either TRUE or FALSE.

11. A short rail which is inserted on the low side of a curve to adjust rail joint stagger is called a buffer rail.

12. When it is necessary to cut CWR during unloading, use of an acetylene torch is permitted.

(Exercise questions continued on next page)

13. CWR can buckle while it is laying on the ballast shoulders, before installations.

14. Track bolts should be checked about 3 or 4 months after rail is installed to see if they need retightening.

15. It is usually advisable to renew defective ties in advance of a rail-renewal job.

16. Adzing is necessary to correct improper rail canting caused by plate cutting of the ties.

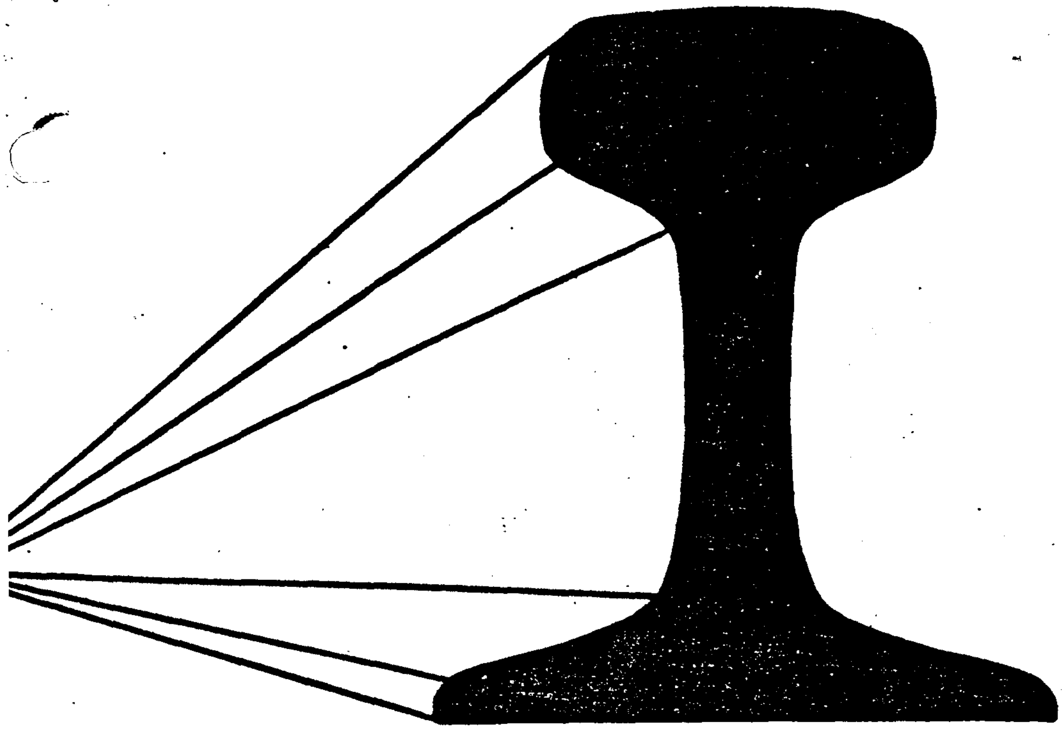
17. It takes a greater length of rail to go around the outer or high rail of a curve, than it does to go around the low or inner rail of a curve.

18. When tie plates are being renewed, the new plates are usually distributed from a cart which is part of the gang's equipment consist.

19. When renewing turnouts, the stock rails must be drilled and bent in a shop.

20. Burning of bolt holes with a torch is not permitted in yard tracks.

Submit your answers to these questions to the Railway Educational Bureau in the prescribed manner. Be sure to include your name, file number, address, company's name and lesson number on the upper right hand corner of your paper.



TRACK FOREMAN'S TRAINING PROGRAM

LESSON 20

TRACK CONSTRUCTION

The Railway Educational Bureau
1809 Capitol Ave., Omaha, Nebraska 68102

LESSON 20

TRACK CONSTRUCTION

The greatest part of the work performed by most Track Foremen consists of the maintenance and inspection of tracks and roadway. This is so because the vast extent of the facilities in existence makes the total amount of care required very great. Nevertheless, there is an extensive amount of new track construction underway at most times.

New track construction is performed in a wide range of situations. A construction project may consist simply of a turnout which is installed in existing track, leading to a spur track which serves an industrial plant. Sometimes these installations become rather extensive, with several turnouts and side tracks being constructed to serve an industrial park or a large industry.

A different construction situation involves the installation of a track parallel to an existing track. This may consist of a double-tracking a single track line. It could also be in the form of installing an additional passing siding or lengthening an existing siding to handle increased traffic demands.

Some construction projects are in the form of new terminal facilities. A new yard may be built or an existing one modernized for various purposes. These may include the establishing of more favorable grades for switching, providing additional or longer tracks for increased capacity or installing automatic switching facilities for improved efficiency. Terminal facilities also include tracks for shops and equipment servicing installations, piggy-back terminals and other special freight handling facilities.

New track construction is sometimes in the form of construction of a new line. This may be a branch built to reach potential new sources of freight traffic, such as a new mine or industrial plant. Sometimes main line routes are relocated to reduce grades or curvature or to shorten the line. Relocation might also be necessitated by some form of new construction, such as a dam.

This lesson will acquaint you with problems which you are likely to encounter in a variety of new construction situations, and suggest ways for dealing with them. The discussion will be limited to track construction. Construction of the roadbed for new tracks is most often done by other than track forces. This lesson will assume that a properly graded roadbed and sub-ballast have already been provided. It is at this point, the Track Foreman's responsibilities usually begin.

DETERMINE WHAT IS TO BE DONE

When given an assignment to construct track, there are several things you should determine before starting the job. This will apply to any job, large or small, although it may not be necessary to get into as much detail on a small job. Among the things you should know are the size of the job and any deadlines that must be met. Knowledge of such conditions may affect the way a job is progressed. The force to be assigned might be determined by such considerations. A need to provide rail service to a facility by a certain date may result in a decision to place a track in service for slow speed operation before all work is completed, such as final lining and ballast dressing.

You must know the standards to which the track is to be constructed. This will include the type, size and spacing of ties. Also the type of tie plates to be used and the spiking pattern. You must know the rail section to be used, whether new or relay rail will be installed and whether welded or bolted. The number and type of rail anchors, as well as the anchoring pattern, must be determined. It is necessary to know the type of ballast that is specified as well as the depth of ballast under the ties and the standards for shoulder and crib ballast.

It is essential that you understand the references provided for establishing alinement and grade, as well as turnouts and other special trackwork. The limits of spirals and curves must be indicated. You also need to know the amount of superelevation to be provided for each curve.

You will also need to know how the materials are to be delivered, the equipment that will be available for handling material and constructing track and the force that will be assigned. As you determine these things, it is advisable to take notes. Few people can remember all the details, and you may not have need for all of the information until the job has been in progress for some time.

PLANNING THE JOB

If there is more than one track or turnout to be built, consideration should be given to the sequence in which they are to progress. Completion of one part of the job may enable another part to be done more efficiently. There might be a need to get a certain part of the facility in service as soon as possible.

There are two basic methods that can be used to construct track or switchwork. One procedure is to assemble all parts of the track structure in place. The other method is to use pre-assembled panels. The panels may be built close to the job site or at a remote location where facilities are provided for such work. The advantages and disadvantages of each system will be considered.

When track or switchwork is built in place, less handling of the material is required. If the material is delivered by carload, maximum capacity is realized from the cars, either by weight or volume. Sometimes, the material can be unloaded right at the point of installation--if there is a parallel track. In this situation, no additional handling is needed. This type of construction can be carried out with material handling equipment of relatively light capacity.

One of the disadvantages of this procedure is the relative inconvenience encountered in obtaining proper tie spacing. The spacing procedure starts from one end of the job. The location of each tie must be manually measured and adjusted, in relation to the preceding tie. In addition, the tie ends must be alined manually. The location of the line rail in relation to tie ends must also be manually adjusted. Ties must be squared at right angles to the rails. When ties, tie plates and rail are brought to the correct relative positions and are ready for spiking, the bed on which the ties rest may cause difficulty. The ties usually will not be on a bed that is smooth enough for tie, tie plate and rail to fit snugly in all cases. Many of the ties will have to be nipped in some manner in order to provide a snug fit that will permit proper spiking.

An advantage of in-place construction, where jointed rail is used, is that no further adjustment of joint locations is required after the various parts are assembled.

Construction of panels is done most efficiently when a jig is provided. Jigs can provide for the proper spacing between ties and prevent the spiking of ties at an improper angle. They can control the alinement of tie ends. Location of the line rail and its tie plates can be made easier. Spiking can be accomplished without the need for nipping ties.

A well-designed panel construction facility can also provide for efficiency in handling of materials. The facility can be located adjacent to tracks that can be used for carloads of ties, rail and other track material (OTM). It may be appropriate to handle material directly from the cars to the panel under construction, or to stockpiles adjacent to the panel jigs. Depending on the location of the facility in relation to point of installation, the completed panels may be loaded in cars, on flat-bed highway trailers or flat-bed on-track trailers.

Track can be constructed relatively quickly by the panel method, particularly when a stockpile of panels is kept on hand. With proper equipment, panels can be set in place and connected with considerable speed. The ballasting, surfacing and lining operations are the same regardless of the method of assembling the track.

Disadvantages of panel construction include the need for equipment capable of handling fully assembled panels, the need for rehandling of material, the need for staggering rail joints after the panels are in place or replacing jointed rail with CWR. The economies of one method relative to the other can vary from one construction project to the next. The choice should be based on an evaluation of conditions that will be present on each project.

BALLASTING

Ties may be placed directly on the sub-ballast. Ballast is then unloaded and the track is raised and tamped. There may be several cycles of ballast unloading, raising and tamping, depending on the depth of ballast to be placed under the ties.

This process can be minimized by placing most of the required depth of ballast on the sub-ballast before proceeding with the other phases of track construction. This depth of ballast can be brought within about two inches of final grade. This procedure requires the use of off-track equipment for hauling and unloading the ballast. Care should be taken to avoid rutting the surface of the sub-ballast with tires. The ballast should be graded and compacted with a roller before placing ties on the surface. When this is done, the ballast that is unloaded after installation of the track, is limited to that required for a light raise and that required for the cribs and shoulders.

DISTRIBUTING TRACK MATERIALS

Where a track construction project consists of building a track parallel to an existing track, there is an important advantage for material distribution efficiency. Ties, rail and OTM can be unloaded from cars which are handled by a work train or locomotive crane on the in-service track. If track panels are used, they can be distributed in the same manner. If CWR is to be installed, this may be unloaded in the normal manner along each side of the in-service track. It can then be moved laterally to the alinement of the new track by a crane of Speed-Swing with a rail threader attachment. The principal limitation to the effectiveness of these procedures may be restricted availability of track usage time because of the demands of rail traffic.

An entirely different situation prevails when there is not an adjacent track from which to unload the materials. There will usually be a location near the end of existing track where carloads of track materials will be placed for unloading. If the size of the project is extensive, the unloading site may be advanced as the work progresses. Materials may be moved forward from the unloading site by used of trucks. Sometimes they are banded into groups of various sizes for ease of handling. Other track material can also be distributed by truck. On smaller jobs, such material is sometimes delivered from a central storage point in this manner. With proper planning, it may be possible to distribute it at the point of installation without further handling.

When material is distributed by trucks or other off-track equipment, careful planning is necessary to determine the most efficient way to use the equipment, while avoiding damage to the roadbed. If there is no parallel access road or suitable terrain for the operation of equipment, it may be necessary to use the roadbed for delivery of materials. Should this be done prior to placement of the sub-ballast, it may be necessary to regrade the surface and compact it after material distribution is complete. An irregular top surface of sub-ballast is very undesireable, as it can lead to the formation of water pockets. If part of the ballast is placed before materials are distributed, it will have to be graded and compacted. Operations will have to be restricted to equipment capable of operating effectively on such a surface.

Long back-up movements should be avoided, where possible. This will often make it necessary to distribute ties and OTM to one side of the roadbed. On large projects, entrance and exit points at crossroads or turning points for equipment should be considered. In this manner, through movement of equipment can be planned, without one vehicle impeding the progress of others.

This distribution of rail usually requires other techniques. On small projects, it is sometimes practical to haul rail on long, flatbed highway trailers. This method has serious limitations, though. The loads may be in excess of the legal length on highways. Additionally, trackbeds may not be suitable for the use of this type of equipment when heavily loaded.

Bolted rail is often unloaded as it is installed in track. With this type of operation, the ties and OTM are positioned for some distance in advance of the work. An on-track crane is used for rail handling at the point of work. This may be a locomotive crane coupled to a carload of rail on the trailing end. A smaller, on-track crane towing suitable flat trucks loaded with rail can also be used. The crane must be pivoted 180 degrees after each rail is lifted from the equipment on which it is loaded. The rail is then placed where it is to be installed in track. The work force applies a pair of joint bars and spikes it to a sufficient number of ties to permit the crane and the load of rail to operate over it. Meanwhile, the crane is rotated again to pick up another rail. When this rail is brought forward, it is placed on the side of track opposite to the previous one. The joints are usually staggered opposite the center of the rail on the opposite side. The work moves forward in this way, in half-rail-length intervals. When the load of rail has been installed, the progress of the work is interrupted until a new load is obtained. This may involve a return trip for the crane to a storage point. Some operations are organized with support equipment to bring supplies of rail forward to the crane working at end-of-track.

If CWR is to be installed, entirely different techniques are needed. The strings of rail are usually dragged forward with suitable off-track equipment, such as a bulldozer, to which they are attached by a cable or chain. Consideration will have to be given to the manner in which the strings of rail will be unloaded from the train. If there is no urgency to complete the unloading of the train so that it can be promptly returned to the welding plant, the problem is simplified. The train might be placed immediately adjacent to the end-of-track. The off-track equipment can then pull each string of rail from the train in turn and take it forward to the point where it is to be installed.

Often it is necessary to unload the rail train as quickly as possible. This can usually be done faster with a work train engine. There may be a problem in this instance to provide enough ground space for the storage of an entire train load of CWR close to the end-of-track.

PLACEMENT OF TIES

Ties may be distributed along the roadbed in advance of the spacing and alinement operation. This distribution may be by banded bundles or as loose ties. It is also possible to organize a project so that each tie is placed in its proper position as it is unloaded. The placement of ties must be done in accordance with the spacing which is specified and the alinement to which the track is to be built. Spacing is sometimes specified in terms of the number of ties per rail length. The following table will enable you to readily convert commonly used spacings to inches:

No of Ties Per 39' Rail	Distance Between Ties-Center to Center
24	19 1/2 inches
22	21 1/4 inches
20	23 3/8 inches
18	26 inches

In addition to placing the ties so that the proper spacing is obtained, it will be necessary to place them on the proper alinement. Since the length of ties is permittted to vary slightly from the standard, placing them on the proper alinement is usually done by lining the ties so that one end is a uniform distance from the centerline. This will produce a situation with all the tie ends a uniform distance from the rail on one side, and with a slight variation from the opposite rail to the tie ends on the other side of the track. Your company may have a standard which specifies the side of the track that is to have uniform tie alinement. Figures 1, 2 and 3 indicate a system of tie delivery and placement that was devised for a large project on the Canadian National. In this case,

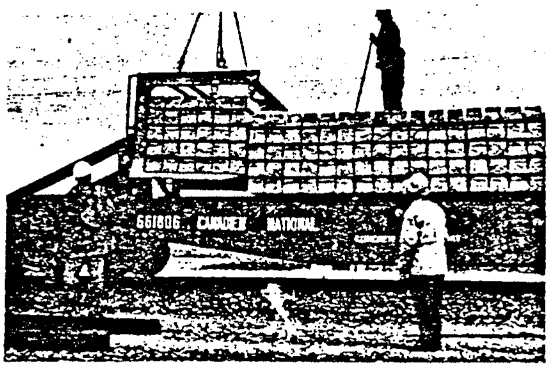


Fig. 1 *Special equipment for unloading concrete ties in groups of 30.*

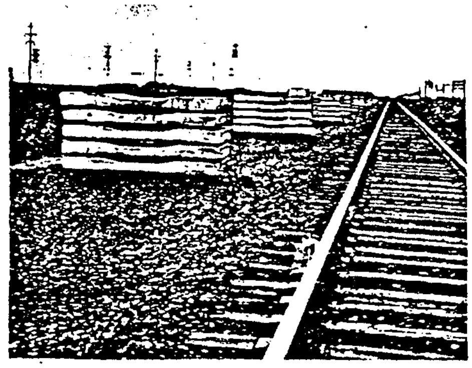


Fig. 2 *Stacks of 30 concrete ties distributed at proper intervals.*

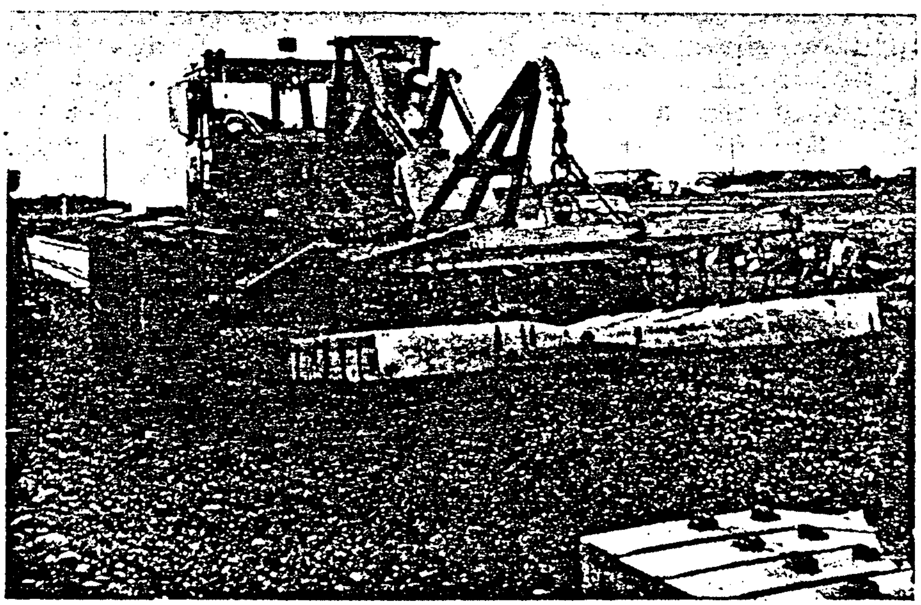


Fig. 3 *Specially equipped Speed Swing for distributing concrete ties in groups of six.* (Photos courtesy of Railway Track and Structures)

the ties being installed are concrete. Regardless of the type of ties, various systems can be devised where the project is large enough to warrant special consideration.

Care must be taken throughout the tie placement process to avoid disturbing any line or grade stakes that are present. This must also be observed during subsequent stages of the construction. Line stakes may be placed on the centerline, or they may be offset a fixed distance to minimize the possibility of being disturbed. Either way, it will be necessary to perform some arithmetic to determine where the tie ends should be in relation to line stakes. Grade stakes may be placed close to a rail or offset so that a level-board is needed to determine the relative elevation of the stake and rail.

If a track is being constructed parallel to an existing track, the alinement is sometimes determined by measuring at intervals from the existing track, to establish predetermined track centers.

INSTALLATION OF TIES PLATES AND RAILS

Concrete ties have pre-positioned fastenings for the rail. There are no tie plates to install. There are no measurements required in order to locate the first rail installed (line rail) the proper distance from the tie ends. A similar situation can be produced with wood ties, if the ties have been pre-plated at a central location. More often, this is not the case. It is usually necessary to establish the first rail installed a fixed distance from the end of each tie. A good way to do this is to make a simple jig that will permit the field edge of each tie plate to be placed the correct distance from the tie end. This distance will depend on the size of the tie plate and the length of the ties.

Once the first rail is installed and spiked in its proper position on the tie plates, the location of the opposite rail and its tie plates is determined by use of the track gage. In the installation of rail on both sides, care should be exercised to get the field side shoulder of all tie plates snug and square with the base edge of the rail. The number of spikes installed in each tie plate should be the same as indicated in the specifications.

ADJUSTMENT OF RAIL

Jointed rail should be installed with rail end gaps suitable for the rail temperature that exists at the time the rail is installed. This spacing is obtained by placing shims of the proper thickness between the rail ends. The desired range of expansion gaps may be stated in the specifications for the job. If not, your company may have a suitable table of expansion gaps in its maintenance standards. If the expansion gaps are not specified in either of these sources, it is suggested that the following table, recommended by the A.R.E.A., be used.

33-Ft. Rail 160 Joints per Mile		39-Ft. Rail 135 Joints per Mile	
Rail Temperature Deg. F.	Expansion Inches	Rail Temperature Deg. F.	Expansion Inches
Below -10	5/16	Below 6	5/16
-10 to 14	1/4	6 to 25	1/4
15 to 34	3/16	26 to 45	3/16
35 to 59	1/8	46 to 65	1/8
60 to 85	1/16	66 to 85	1/16
Over 85	None	Over 85	None

78-Ft. Rail 68 Joints per Mile	
Rail Temperature Deg. F.	Expansion Inches
Below 35	5/16
35 to 47	1/4
48 to 60	3/16
61 to 73	1/8
74 to 85	1/16
Over 85	None

Anchoring of jointed rail may be done at any point that is convenient after the rail is spiked to the ties and before the track is placed in service. Remember that the basic purpose of rail anchors on jointed rail is to prevent rail creep under traffic.

The adjustment and anchoring procedure when constructing track with CWR is quite different. In addition to preventing rail creep, rail anchors must also prevent expansion or contraction of the rail due to thermal stresses. Rail anchors cannot perform this function unless the ties to which they are affixed are, in turn, adequately anchored. The ties will not develop their full potential for restraint until an appreciable amount of traffic has passed over the track. It would not be practical to wait until this condition is attained to adjust and anchor the rails.

Even so, several things need to be done before the track structure is capable of developing reasonably effective restraint against thermal stresses. Ballast must be applied in sufficient quantity to fill the tie cribs and provide the proper shoulders. The track must be surfaced and lined. Subjecting the track to some loading will increase the track stability. A few heavy axle loads will settle the track more than a greater number of light loads. Where available, ballast compaction equipment can add to track stability.

After the ties have been stabilized in the ballast, each length of CWR should be adjusted individually. If possible, this should be done when the rail temperature is within the specified range due to natural conditions. Otherwise, it will be necessary to use rail heating or cooling equipment to bring the rail within the desired range. In the adjusting process, each length of rail must be separated. If the tendency is for the rails to expand, the adjoining rail ends must be bypassed. The use of rail vibrating equipment can increase the efficiency of the adjusting process.

The rail is anchored with the full number of anchors which are specified, as quickly as possible after the rail's natural length for the desired temperature has been attained. The length of rail is then connected to the adjacent length of rail which has been previously adjusted. It should not be connected to the next adjacent rail in the direction toward which the work is moving until that length has also been adjusted.

The connection of the adjusted lengths of rail will involve cutting off some rail from the end of one of the strings, if the rails have expanded. Where the rails have contracted, a length of rail must be cut in. The connections may be made with conventional joint bars, with adhesive type joints, or with field welds.

PLACEMENT OF BALLAST

As previously indicated, there are two basic approaches to the placement of ballast. One method is to construct the track directly upon the sub-ballast. After assembly of ties, rails and fittings, ballast is unloaded directly from the ballast cars. The cars may be moved by means of a locomotive, locomotive crane or other similar equipment.

An advantage of this methods is the relative economy of unloading ballast in this manner. Offsetting this is the increased amount of tamping required. Depending on the amount of ballast to be placed under the ties, multiple cycles of raising, tamping and unloading of additional ballast may be required. Since the raises will be substantial, several insertions of the tamping head will be required at each tie.

The other method is to place the major portion of the ballast on the sub-ballast with trucks, before placement of any of the track materials. This ballast can be shaped with grading equipment and compacted. After the track is assembled on this base, only a relatively small raise (perhaps two inches) is needed. The amount of ballast to be unloaded from the ballast cars need only be enough to provide this amount of raise, plus that which is needed for the cribs and shoulders. The handling of ballast by trucks will probably be more costly. The amount of tamping will be less. Each job needs to be carefully considered in advance, in order to determine the economics of these alternatives.

Once the track has been brought to final grade, the shaping of ballast shoulders and dressing of crib ballast can be done effectively by a ballast regulator. These machines are as efficient on new construction work as they are on maintenance jobs.

It is necessary to be careful of the tie support provided where a track is constructed with concrete ties. Before a heavy load, such as a locomotive or ballast car, is placed on such a track, it is essential to have every tie bearing on the ballast or sub-ballast in the immediate vicinity of the rail seats. Concrete ties should not be subjected to such loads if they are center-bound or supported only at the extreme ends. Cracks in the ties might develop before the track is placed in service.

PANEL CONSTRUCTION (SKIP)

The advantages and disadvantages of the panel method of track construction have already been considered. It is a valid method of construction, and under certain conditions, it is the most desirable procedure.

This method also attains its greatest efficiency when there is parallel track from which to work. When this situation exists, the panels can be delivered by work train on flat cars or gondolas. An off-track crane is most effective for unloading the panels from the cars and placing them upon the roadbed. In this operation, the crane operates on the roadbed, and the panels are placed behind the crane. If an on-track crane is used, the crane must move forward on the last-placed panel in order to place the next panel. This requires the fastening of the rail ends before each move. This can have some effect on the speed of unloading.

If there is no parallel track, a supply of panels must constantly be brought to the end of the track for placement by the crane working at this location. This may be done by the crane which installs the panels, or they may be unloaded at track side by support equipment. In either case, it is likely that the panels will be set on the ground close to the side of the existing tracks, in order to avoid 180 degree swings by an on-track crane with these loads. Figures 4, 5, 6 and 7 show some of the special techniques that have been devised for handling panels.

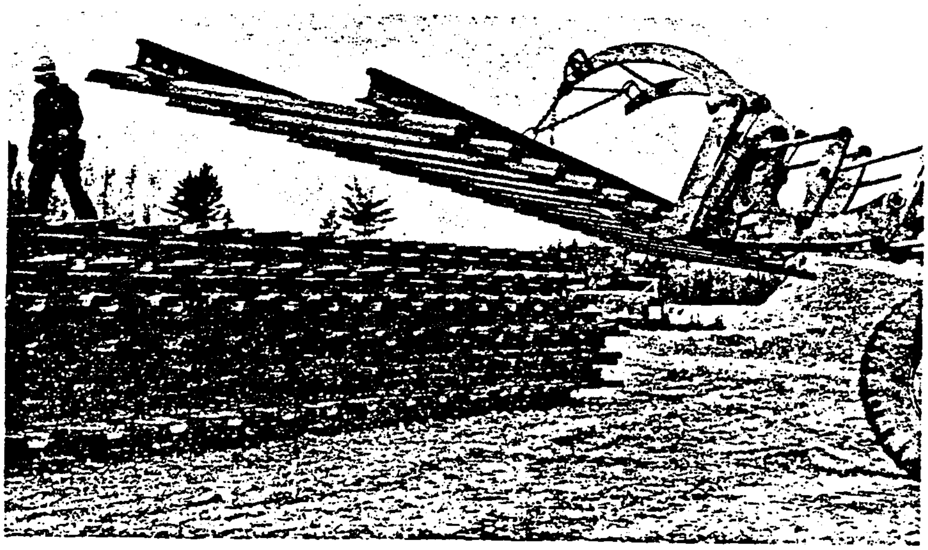


Fig. 4 *Handling track panels with a heavy-duty forklift. These panels are constructed with steel ties.* (Photo courtesy of Railway Track and Structures)

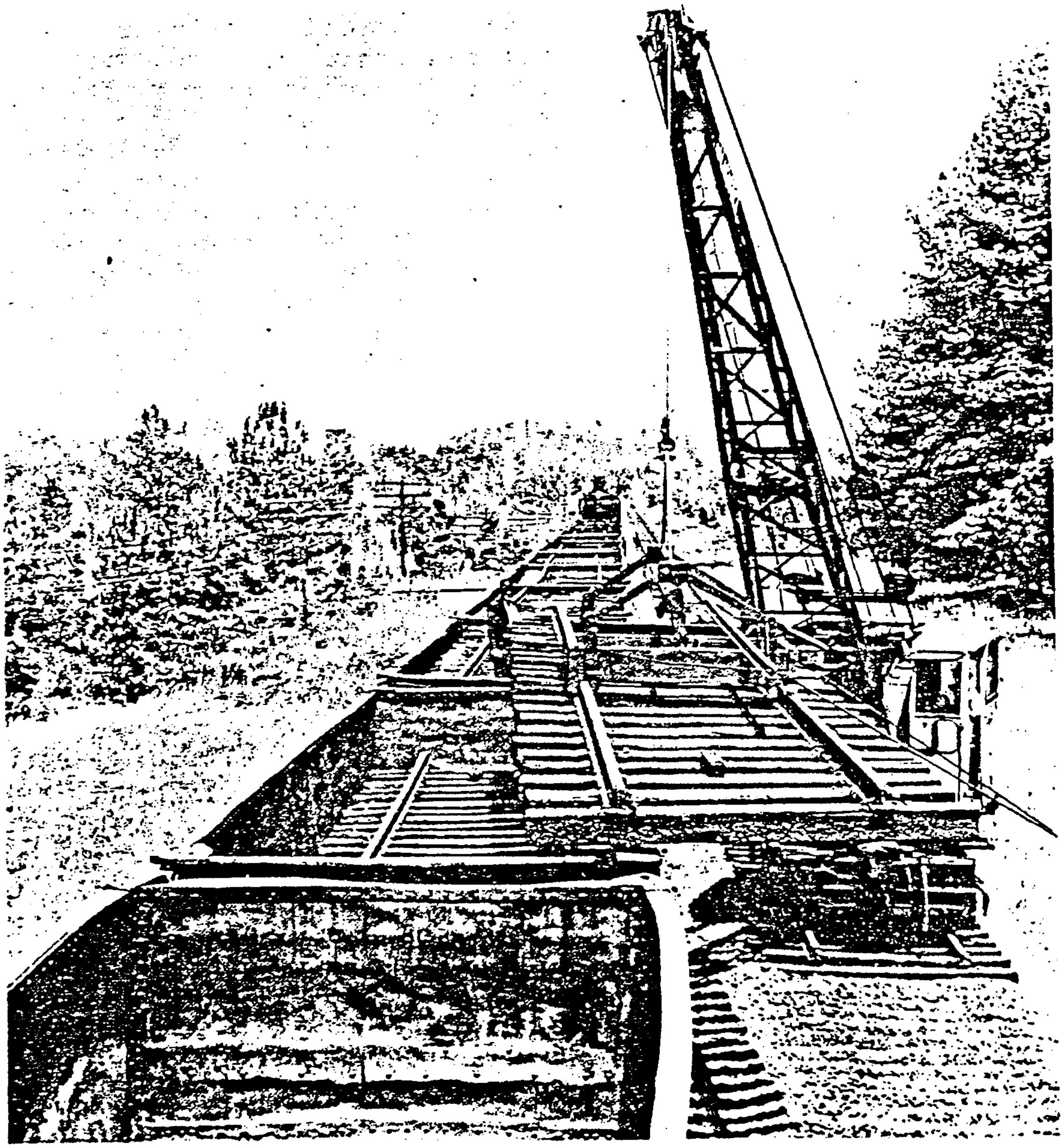


Fig. 5 *Unloading track panels with crane and panel track lifter.* (Photo courtesy of Burro Crane, Inc.)

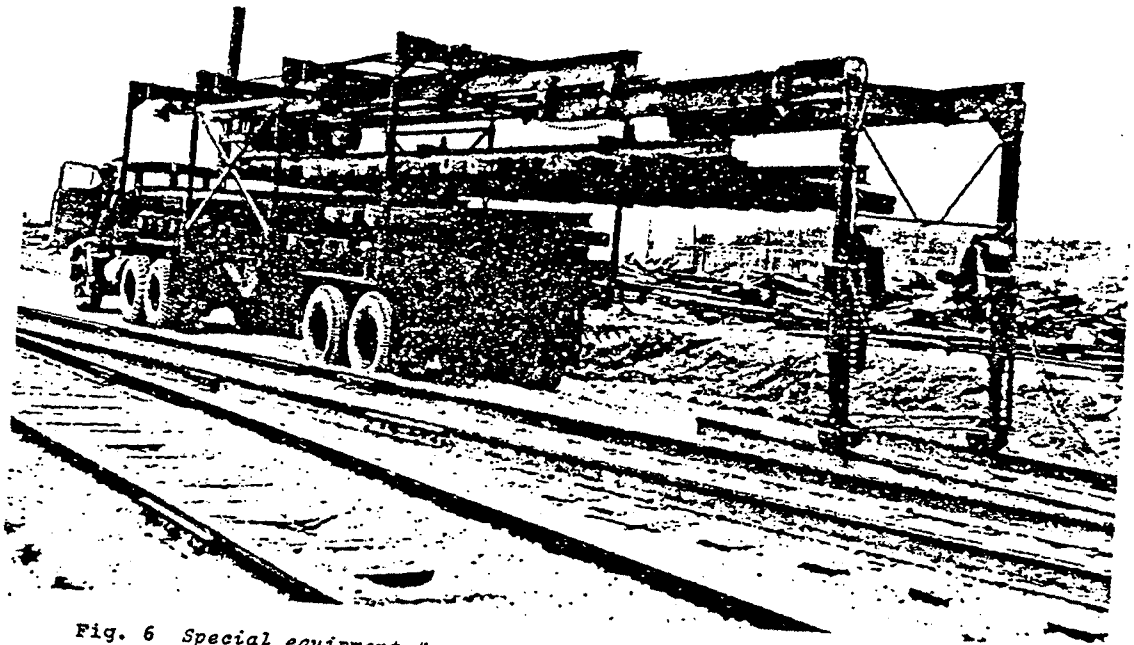


Fig. 6 *Special equipment for unloading panels from a flat-bed trailer.*

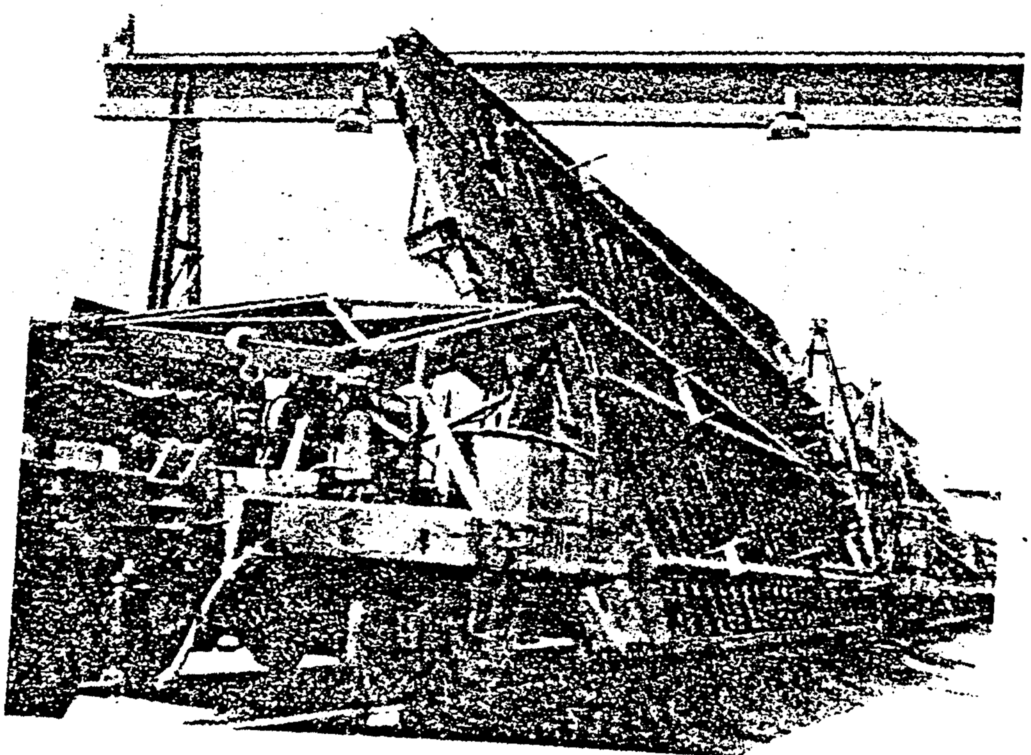


Fig. 7 *Special car for transporting panel turnouts.* (Photos courtesy of Railway Track and Structures)

Once the panels are in place, it is frequently desired to relocate the rails on one side of the track in order to obtain the desired joint stagger. This can be done by a cable pulled by a winch or other suitable equipment or another approved method. Care must be taken to preserve the proper rail end gaps for the rail temperature that exists at the time the rails are relocated.

If it is desired to install CWR, panel construction can still be a suitable method of track construction. Replacement of the jointed rail with the CWR can usually be done with the removal of one spike per tie plate. The rails used to construct the panels can be reused to make additional panels.

CONSTRUCTING SWITCHWORK

The replacement of worn-out portions of the track structure is generally considered as maintenance, rather than new construction. In the case of switchwork, the replacement of materials sometimes becomes so extensive that the project amounts to reconstruction. For this reason, switchwork construction procedures were considered together with maintenance procedures in Lesson 13, "Installation and Maintenance of Switchwork." It is not necessary to review them here.

SUMMARY

New track construction is the principal activity in which some Track Foremen are engaged. Many foremen are called on to construct new tracks at infrequent intervals. Even if this is likely to be the situation, you should prepare yourself to meet such a challenge when it is presented. Consider the equipment which is used in your normal maintenance operations, and consider which units are suitable for use on new construction. Should you know of any new track construction projects nearby, observation of the progress of the job and the methods used may prove beneficial. In such ways, you can better prepare yourself to take charge of a track construction project when the opportunity is at hand.

LESSON 20

EXERCISE QUESTIONS

1. What two types of references are needed to locate a track to be constructed?

2. List three ways in which ties must be adjusted when constructing track.

3. Name two advantages of constructing a track in-place.

4. What precaution should be taken when assembling track directly on the sub-ballast?

5. If ties are spaced 21 1/4 inches apart, center to center, how many ties will be needed to construct a track 390 feet in length?

6. How should tie plates be installed in relation to the rail?

7. Thirty-nine-foot jointed rails are being installed according to A.R.E.A. standards when the rail temperature is 75 degrees F. What amount of gap should be left between rail ends?

8. If it is necessary to readjust CWR which was previously installed when the rail temperature was below the specified range for installation of CWR, what must be done to the rail ends before adjusting the rail.

Answer the following statements as TRUE or FALSE.

9. An advantage of panel construction is the speed with which a track can be built.

10. Placing ties directly on the sub-ballast reduces the amount of tamping required in building a new track.

11. Grade stakes should be placed along the centerline of a track to be constructed.

12. Placing of rail anchors on a newly constructed track with bolted rail can only be done after the track is fully ballasted?

(Exercise Questions continued on next page)

13. Concrete ties must be supported in the area under the rail before placing heavy loads on such a track.

14. When constructing a long passing siding by use of the panel method, panels can be unloaded from a work train most efficiently with a crane mounted on a flat car in the work train.

15. When rails are relocated to establish proper stagger, shims of the same thickness used for the initial placement of the rail must be used for final placement, regardless of the temperature.

Submit your answers to these questions to The Railway Educational Bureau in the prescribed manner. Be sure to include your name, file number, address, company's name and lesson number in the upper right hand corner of your paper.

CP Rail

MAINTENANCE OF WAY TRAINING

Lesson no.: 14

Subject: IDENTIFICATION AND APPLICATION OF TRACK MATERIALS AND USE OF TOOLS

First issued: 79-03-29

Maintenance of way training

1. INTRODUCTION

This lesson will help you to name all the types of track tools and materials and to know if they are serviceable, or unserviceable. Track materials used and put on properly do their job well and need less maintenance.

The main points of this lesson are:

- Track materials.
- Application of track materials.
- Installation patterns and standards.
- Reuseable limits of part worn material.
- Description of hand tools and their use.

2. SPIKES

- Track spikes are supplied in 5-1/2" and 6" lengths.

	SPIKES PER BOX OR KEG 200 LB.	100 LB.	
TRACK SPIKES 20¢ EACH			
5 1/2"	267	133	
6"	248	123	
SHIMMING SPIKES 25¢ EACH			
6 1/2"	229	114	3 MARKS
7 1/2"	200	100	2 MARKS
8 1/2"	178	89	1 MARK

FIG. 1.

2. SPIKES (Cont'd)

Shimming spikes are supplied in 6-1/2", 7", 7-1/2", 8", and 8-1/2" lengths, and come in 100 lb or 200 lb boxes or kegs.

The 6-1/2", 7-1/2" and 8-1/2" spikes are marked on top of the head to show the length.

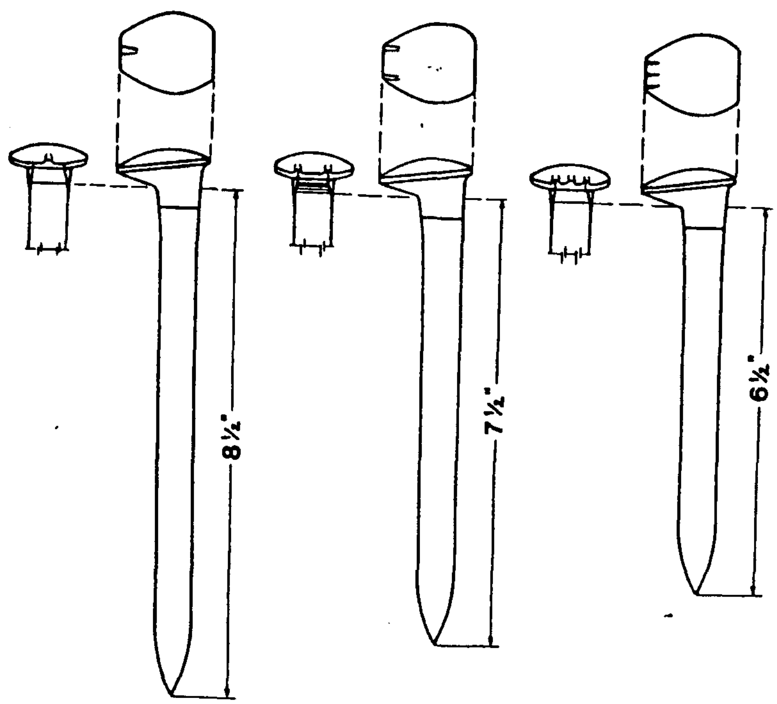


FIG. 2 - SHIMMING SPIKES.

2.1 Application of Spikes

A spike must be driven with the point (lip side) of the spike head pointing to the rail, it must be square in the hole with the shank touching the edge of the rail base. They must be driven straight down and not slanted, as the spike head is made to fit the sloping surface of the rail base. In other words, spikes must be started and driven vertically and square to provide a

2.1 Application of Spikes (Cont'd)

full bearing against the edge of the rail base. When driven in this way the spike keeps the rail from spreading better than if driven on an angle. If driven on an angle, the spike will work up.

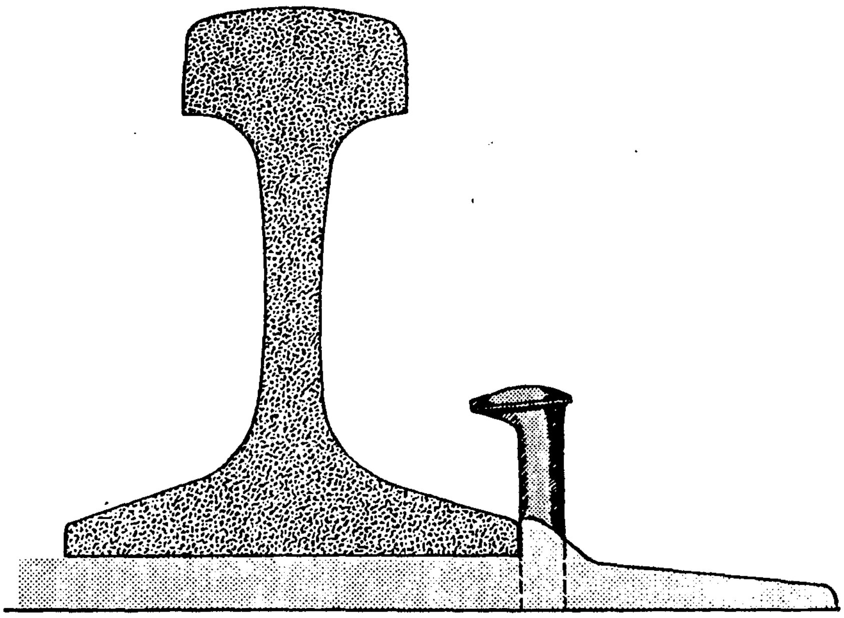


FIG. 3 - SPIKE STARTED CORRECTLY.

Spikes should be driven with 1/8" to 3/16" clearance between the underside of the head of the spike and the top of the rail base.

2.1 Application of Spikes (Cont'd)

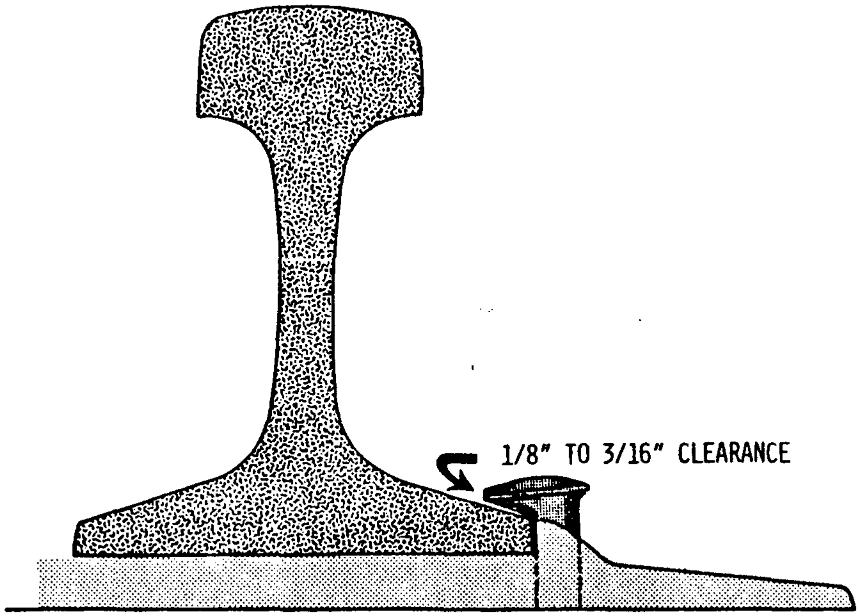


FIG. 4 - PROPERLY DRIVEN SPIKE.

Do not over-drive spikes, the last blow must be struck lightly.

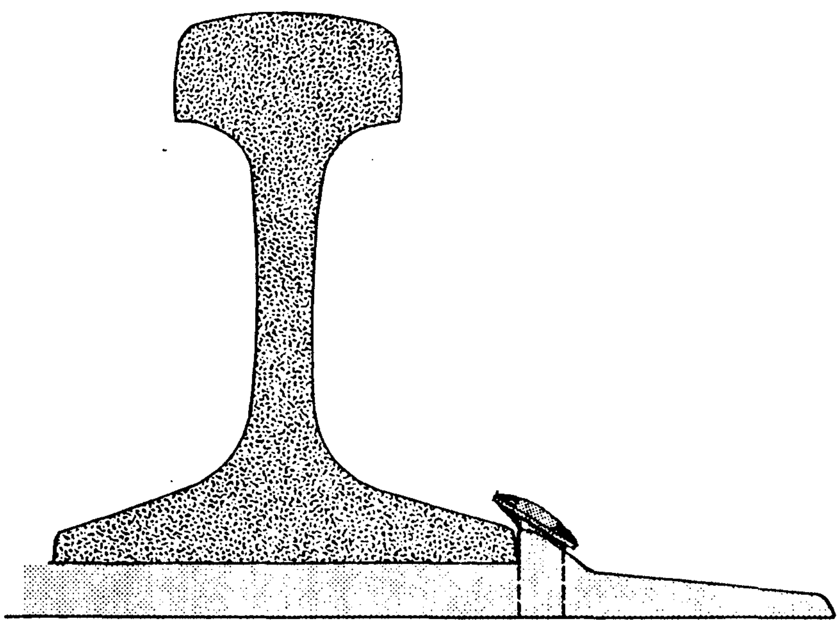


FIG. 5 - OVER-DRIVEN SPIKE.

2.1 Application of Spikes (Cont'd)

Do not drive spikes against the end of the joint bars or in the slots of slotted joint bars.

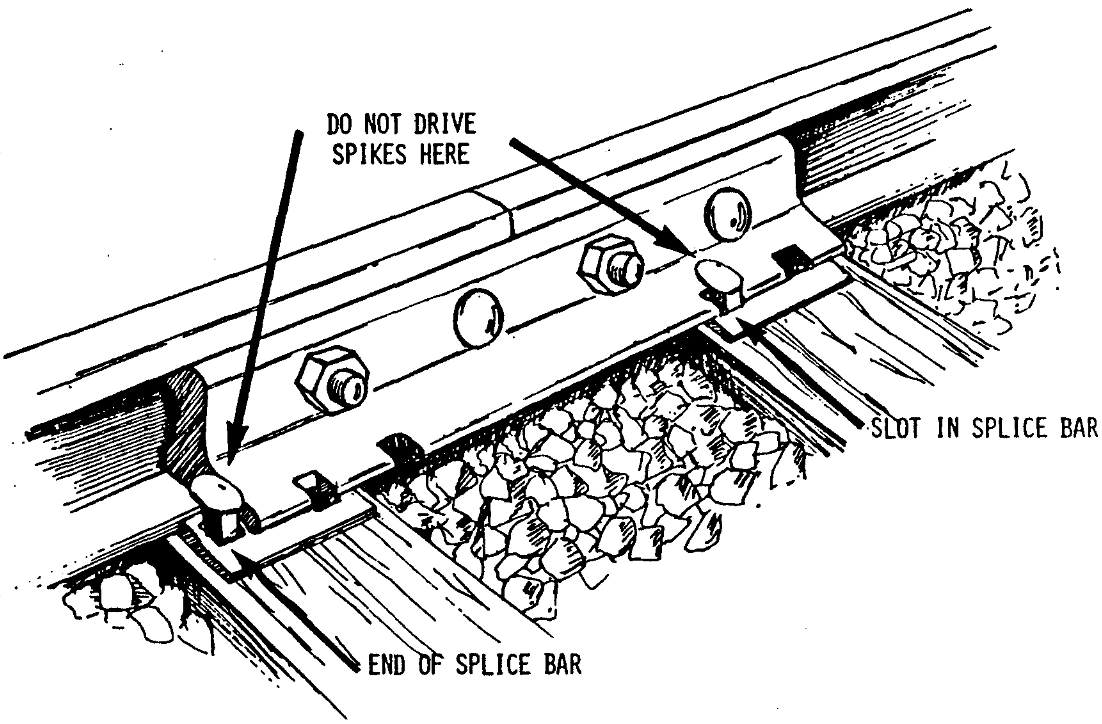


FIG. 6.

2.2 Spiking Procedure

When starting a spike, hold it so your fingers will not be between the spike and the rail. In other words, always set the spike with your palm up. In this way, if the spike is missed, the maul will hit the fleshy part of the palm rather than the bony part of the hand or the fingers.

2.2 Spiking Procedure (Cont'd)

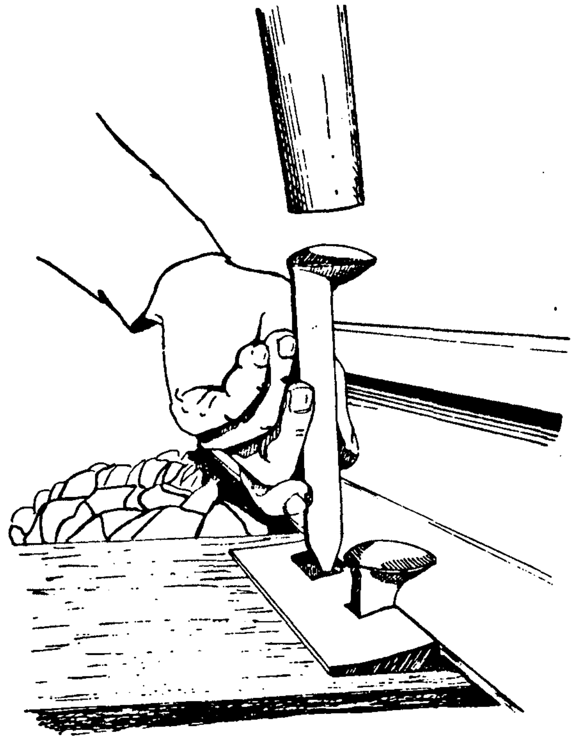


FIG. 7 - SPIKE HELD PROPERLY TO START IT.

The most common spiking accident is the glancing blow. The first blow should be light to start the spike into the tie, a heavy blow may bend the spike or cause it to fly up and hit someone. Stand on the same side of the rail as the spike, as spiking across the rail will cause the spike to slant, and also the spike maul could hit the rail.

Bend your body and keep your hands low as the hammer comes down, so that the handle of the spike maul will be horizontal when the maul hits the spike. Watch the head of the spike constantly and concentrate on hitting it squarely. Spike with a full swinging blow.

2.2 Spiking Procedure (Cont'd)

When spiking with a partner, stand beside each other and drive only the spikes on your side of the rail.

FIG. 8 - SPIKING.

2.3 Spiking Patterns

Double Shoulder Plates

On curves - one spike outside and two inside.

On curves with eccentric "C" plates - put additional spikes at the ends of the plate. These can be good second-hand spikes.

On tangents - one spike in and one spike out.

On tangents where
- rail is longer than 39'

2.3 Spiking Patterns (Cont'd)

or

- freight speeds are over 50 mph.
- one additional spike inside.

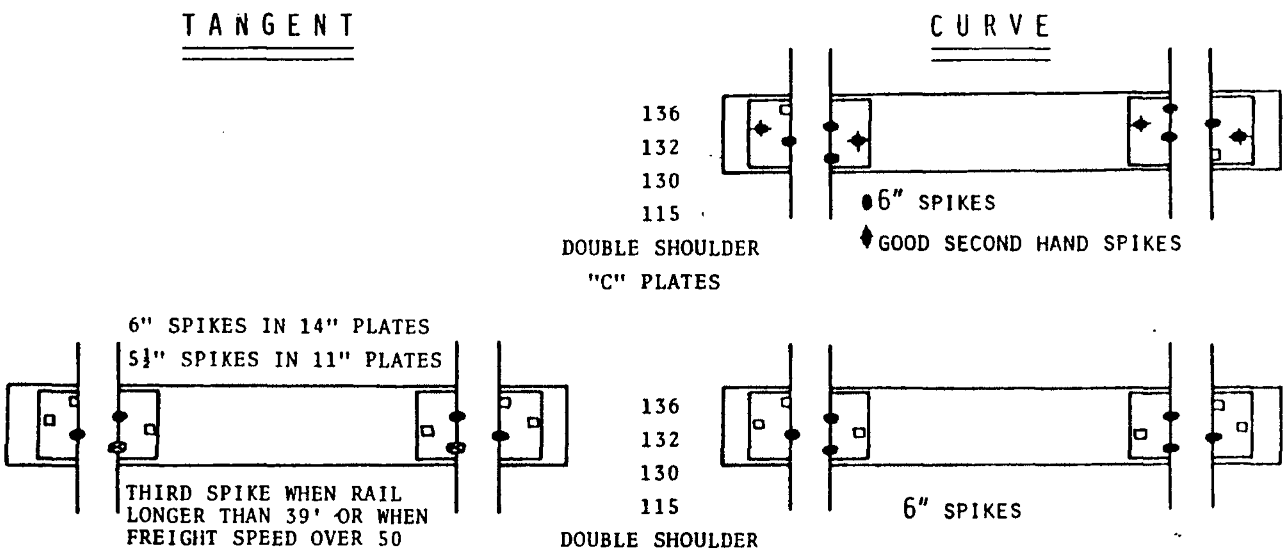


FIG. 9 - DOUBLE SHOULDER PLATES.

Single shoulder plates - 100 and 130 lb.

Curves - one spike out and two in.

Tangent - one spike in, one spike out.

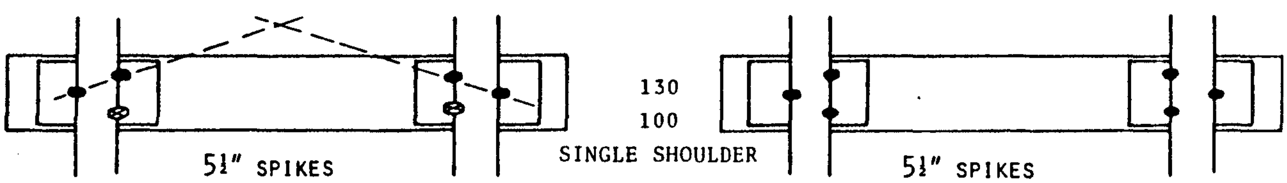
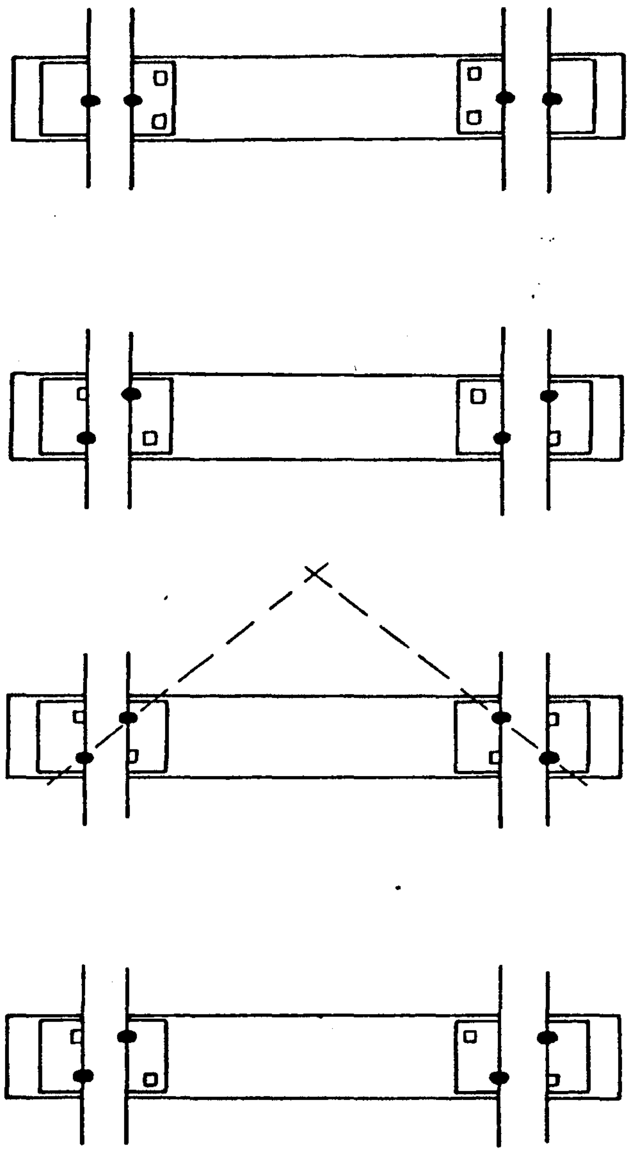


FIG. 10 - SINGLE SHOULDER PLATES.

2.3 Spiking Patterns (Cont'd)

Single shoulder plates - 85 lb.

- one spike in, one spike out.



85# WITH 85/100 PLATES

85# WITH 85/100 PLATES

85#

LIGHT RAIL WITH 85# COMBINATION PLATES

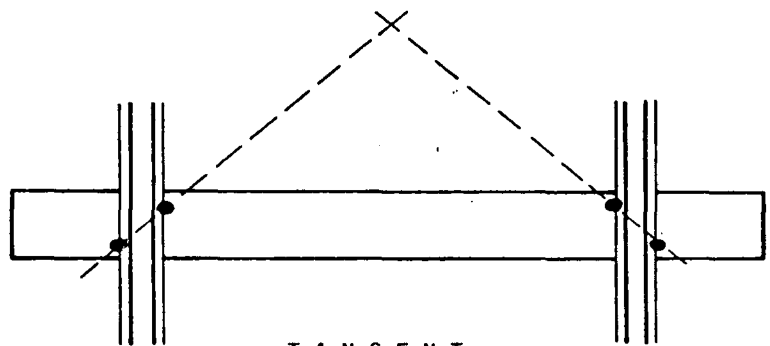
FIG. 11 - TANGENT.

2.3 Spiking Patterns (Cont'd)

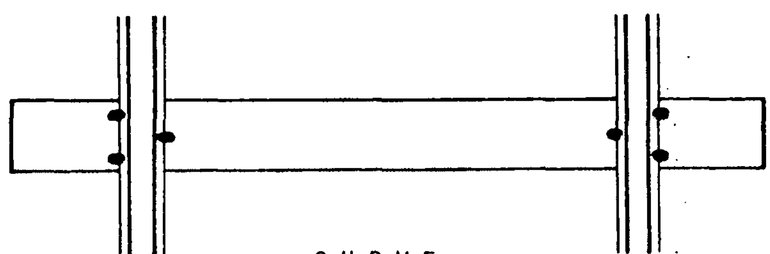
No tie plates

Tangent - four spikes per tie.

Curves - extra spike outside.



TANGENT



CURVE

FIG. 12 - NO PLATES.

2.4 Spiking Arrangement at Joint Bars

Spikes must be driven with the point of the spike head to the joint bar.

2.4 Spiking Arrangement at Joint Bars (Cont'd)

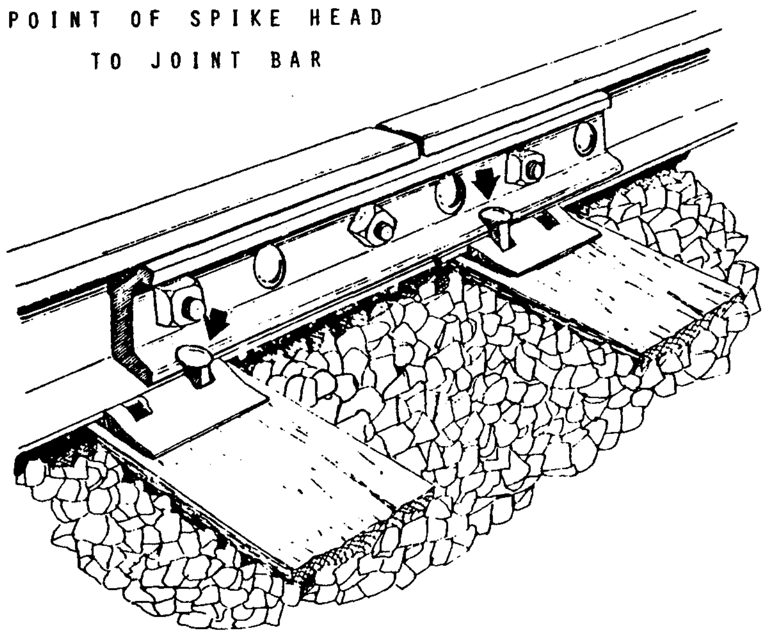


FIG. 13.

2.5 Reusable Limits of Second Hand Spikes

Spikes found to be neck-worn or cut under the head enough to make shearing off of the head under traffic possible, must be replaced. Also badly bent or corroded spikes should be replaced.

3. TIE PLATES

The main purpose of the tie plates is to provide a flat and uniform bearing surface between the rail and the tie and to prevent the rail from cutting into the tie. They also help keep the track to gauge. Some tie plates have a ribbed or wavy bottom to assist this. Some tie plates have a single shoulder and some have a double shoulder.

3. <u>TIE PLATES (Cont'd)</u>

Tie plates are also sloped slightly towards the center of the track. The slope makes it easier to maintain gauge, it reduces wear on the rail head and it puts the load more evenly across the base of the rail. The slope on most plates is 1 in 20, which means that a rail with a 6" base would be about 1/3" higher on the field side than on the gauge side. Other slopes have been used in the past, Switch plates have no slope.

Single shoulder tie plates are supplied in weights from 56 lb. to 130 lb.

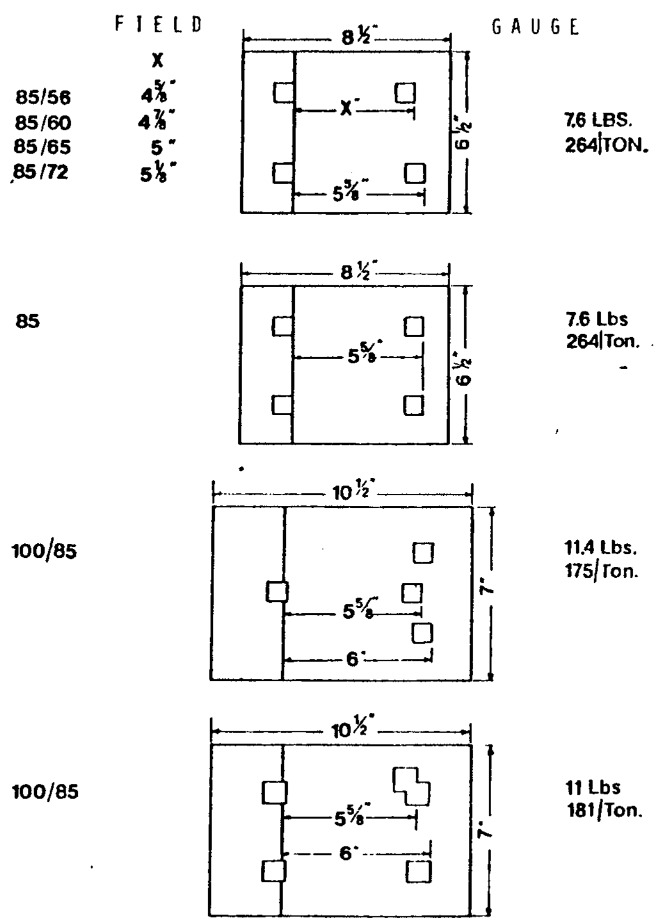


FIG. 14 - SINGLE SHOULDER TIE PLATES.

3. TIE PLATES (Cont'd)

85-56 lb, 85-60 lb, 85-65 lb, 85-72 lb, and 85 lb plates are all the same size (6-1/2" x 8-1/2"), and weight (7.6 lbs). The slope is 1 in 20.

The 85-100 lb combination single shoulder tie plate is 7" x 10-1/2" and has a slope of 1 in 20.

130 lb single shoulder plates are 7" x 12" and weight 12 lbs each.

3.1 Double Shoulder Tie Plates

Double shoulder tie plates are supplied for rail weights of 115, 130, 132 and 136 lbs. The slope is 1 in 20. 115 lb plates are also available, that have a slope of 1 in 40.

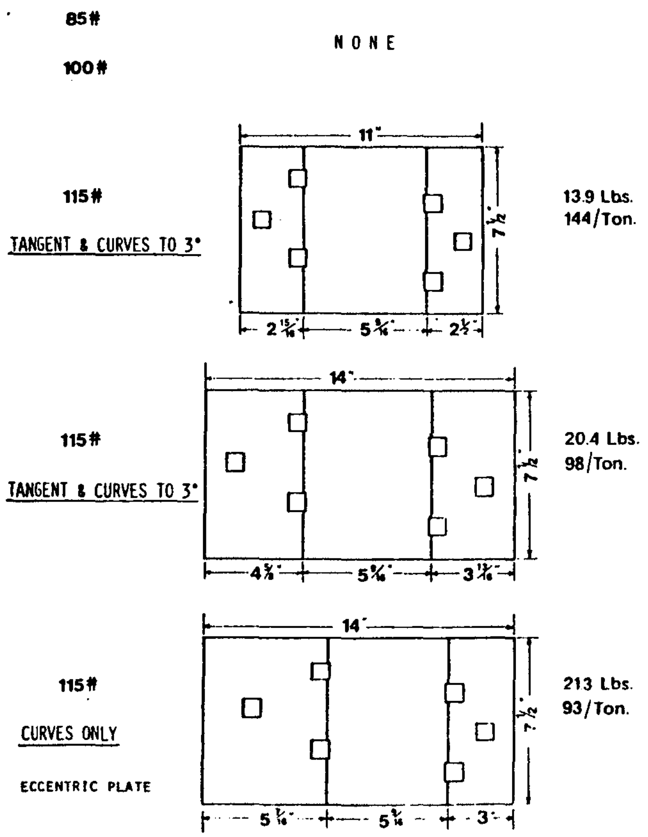


FIG. 15 - DOUBLE SHOULDER TIE PLATES.

3. TIE PLATES (Cont'd)

3.2 Joint Tie Plates

There are two sizes of single shoulder joint tie plates, 100 and 130 lbs. They are used to allow spiking at a joint that has joint bars with a wide toe.

3.3 Special Tie Plates

Abrasion Plates

These are special single shoulder plates used under armored insulated joints or insulated rail joints. They are not used on switch ties. They can be used on joints from 85# to 130#.

3.4 Installation Procedure of Tie Plates

Tie Plates Must be Installed as Follows:

- The plate must be centered on the tie.
- The rail must be seated in the tie plate.
- No portion of the shoulder of the tie plate should be under the base of the rail.
- The slope of the plate must be inward. Do not install backwards.
- Tie plates having different slopes on the rail seat must not be mixed together in the same stretch of track.

3.5 High Eccentricity Double Shoulder Tie Plates

For rails from 115 to 136 lbs and are for use on curves. These plates shall only be used on curves when approved. This will usually be where the plates are cutting into the field side of the tie. These high eccentric tie plates shall not be used in tangent track. Due to the difference in plate seat thickness, a 6" long spikes must be used, except that 5-1/2" or 6" anchor spikes may be used with 115 lb plates. These larger tie plates spread the vertical load over a larger area of the tie and reduce

3. TIE PLATES (Cont'd)

the cutting of the tie and general weakening around the bearing area. They also provide additional holes (two at each end of the plate) for extra spikes to help hold the track to gauge.

3.6 Reusable Limits of Tie Plates

Tie plates which are; broken, bent, worn thin, badly corroded, or have enlarged spike holes, must be removed from track and replaced. Where tie plates are in poor condition over a long distance the track is weaker than it appears to be and if it is not possible to replace them immediately a slow order or speed restriction must be arranged.

4. RAIL ANCHORS

Rail anchors control the movement of the rail. They do this by a tight bearing on the rail and against the tie. Movement may be caused by changing temperatures, steep grades, heavy loads mainly in one direction, and by the braking action of trains.

These are 7 types of rail anchors.

- Erickson
- Fair
- Improved fair
- Fair XL-1
- Super Fair
- Woodings
- Compression

Rail anchors are available to fit all sizes of rail, 56 lb to 136 lbs, but must be ordered to fit the specific rail section to be held, if they don't fit they will break or slip.

4.1 Erickson Anchor

The Erickson anchor is a two piece anchor with a steel yoke and iron shoe. The shoe slides onto the base of rail and the yoke loops around the shoe and the base of rail to hold it in place. This type of anchor is obsolete, but many are still in service on 85 lb and 100 lb rail.

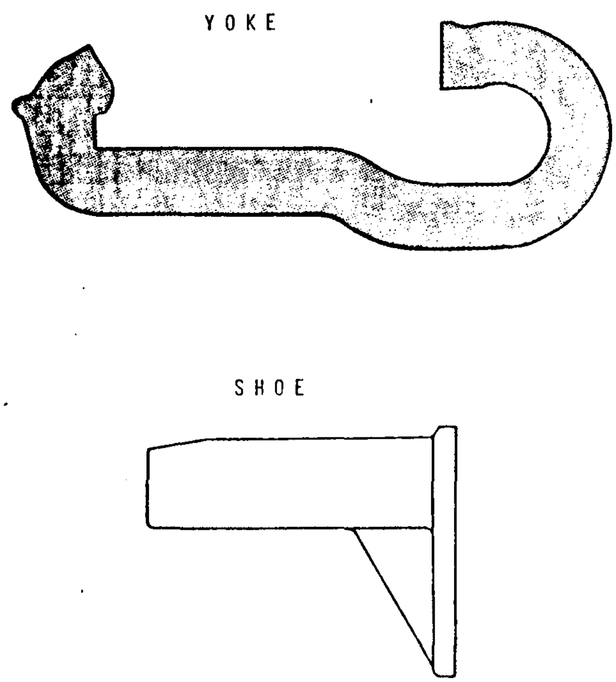


FIG. 16 - ERICKSON RAIL ANCHOR.

4.2 Fair Anchors

The Fair anchor is a one piece anchor with a square cross section and a wide tie bearing area designed to snap onto the base of the rail. This anchor is now obsolete and is being replaced by the Improved Fair anchor. The Improved Fair anchor has a "T" shaped cross section. It has greater stiffness and gives a better bearing against the tie where tie plates are in use. It has a

4. RAIL ANCHORS (Cont'd)

higher resistance against slipping than any other anchor. The Super Fair anchor is also "T" shaped but is stronger and has a larger bearing area than the Improved Fair.

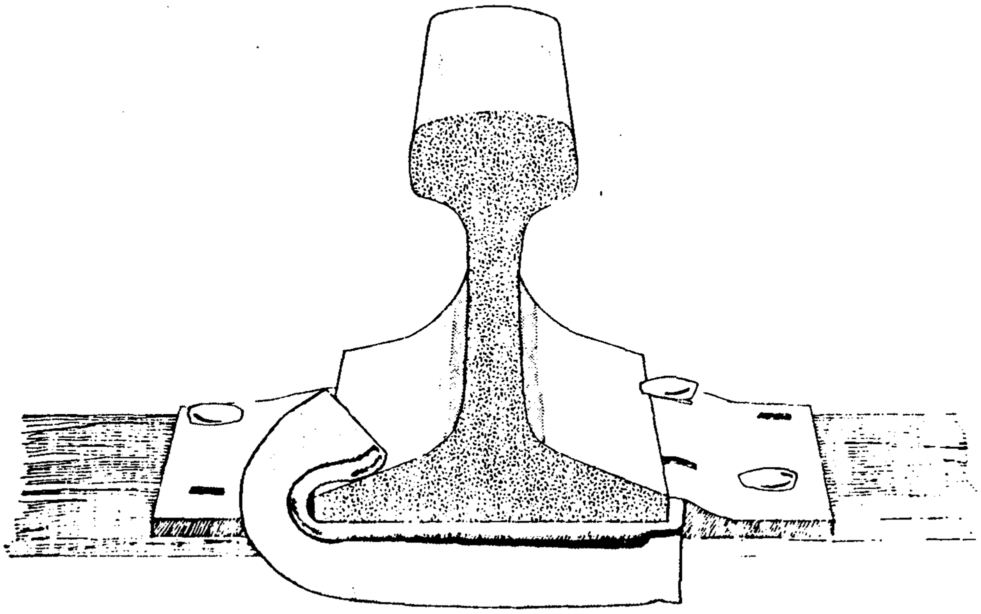


FIG. 17 - IMPROVED FAIR RAIL ANCHOR.

4.3 Woodings Anchors

This is a one piece anchor with two equal grip jaws, one on each side of the rail base. It has a wide and deep tie bearing area.

4. RAIL ANCHORS

4.3 Woodings Anchors (Cont'd)

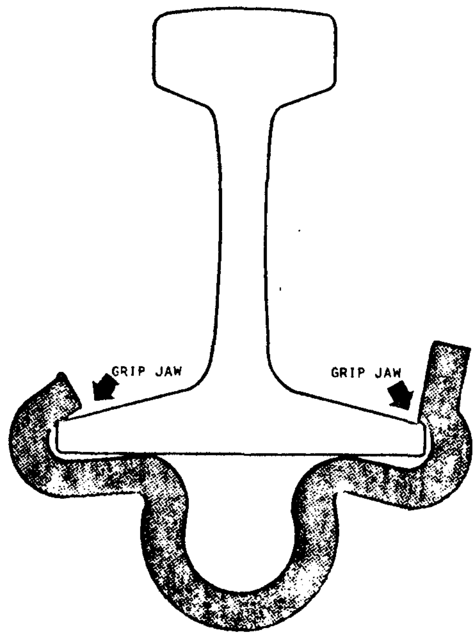


FIG. 18 - WOODINGS RAIL ANCHORS.

4.4 Compression Anchors

A compression anchor is a clip type anchor which is held in tension by a bolt passing through the anchor to the tie plate. This type fits all rail sections.

4.5 Rail Anchor Installation Patterns and Standards

The arrangement or pattern of rail anchors throughout a length of rail, a section of track and/or a subdivision should be in accordance with current instructions.

4. RAIL ANCHORS (Cont'd)

Pattern No. 1

For mainline track, carrying traffic in both directions, 16 anchors per 39 ft. rail length, or 4300 anchors per mile are required.

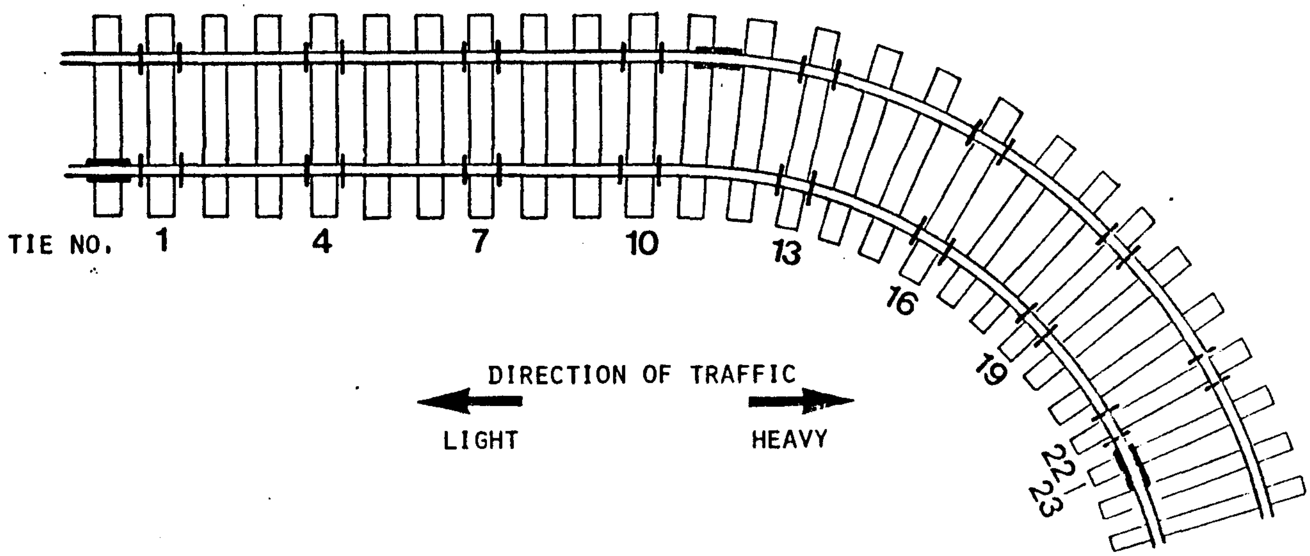


FIG. 19 - RAIL ANCHOR SPACING FOR 39'
RAIL-PATTERN NO. 1

4. RAIL ANCHORS (Cont'd)

Pattern No. 2

For mainline track, carrying heavier traffic in one directions than in the other, 8 anchors are applied per rail in the direction of the greatest traffic or rail movement and four anchors are applied in the opposite direction. Twelve anchors per 39 ft. rail length, or 3360 per mile are required.

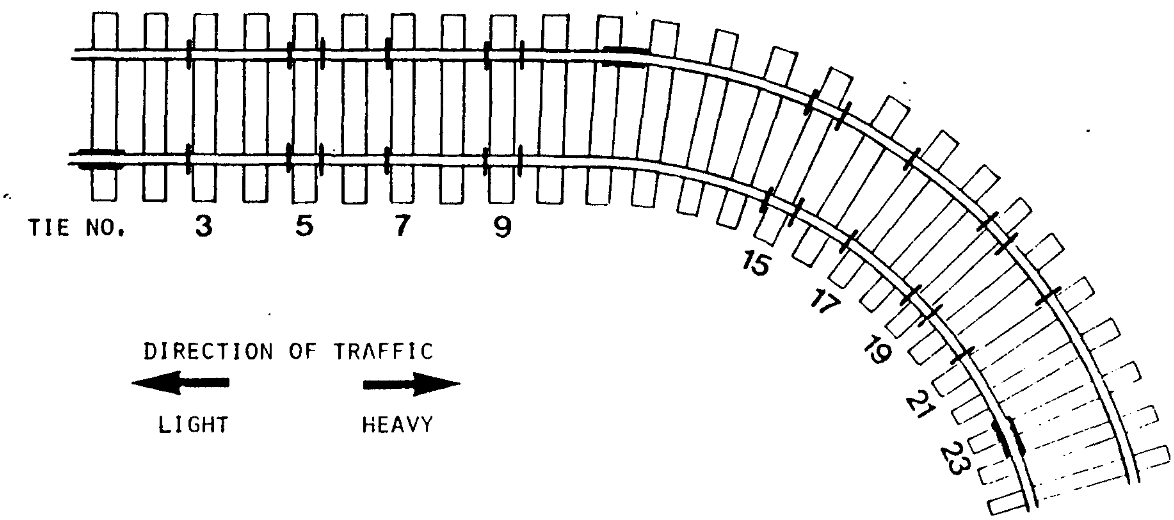


FIG. 20 - RAIL ANCHOR SPACING FOR 39' RAIL-PATTERN NO. 2.

4. RAIL ANCHORS

Pattern No. 3

For two track mainline, carrying traffic in one direction on each track, 10 anchors per 39 ft. rail length, 8 in the direction of normal traffic and two in the other, or 2800 per mile are required.

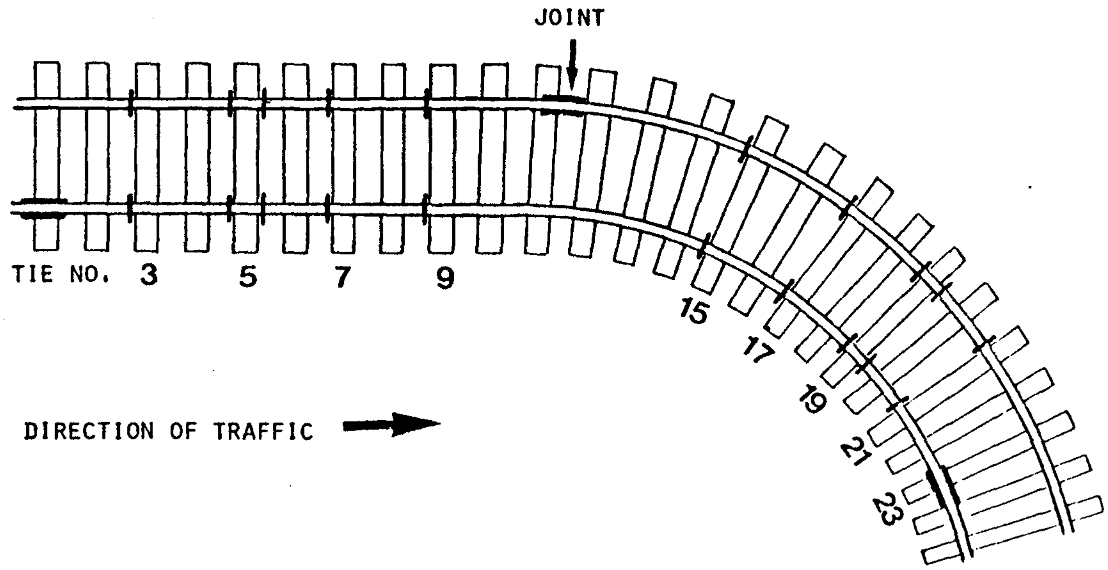


FIG. 21 - RAIL ANCHOR SPACING FOR 39'
RAIL-PATTERN NO. 3.

4. RAIL ANCHORS

Pattern No. 4

For main track or branchline carrying traffic heavier in one direction than in the other, install six anchors in the direction of the greatest traffic and two in the opposite direction. A total of eight anchors per 39 ft. rail length or 2200 per mile are required.

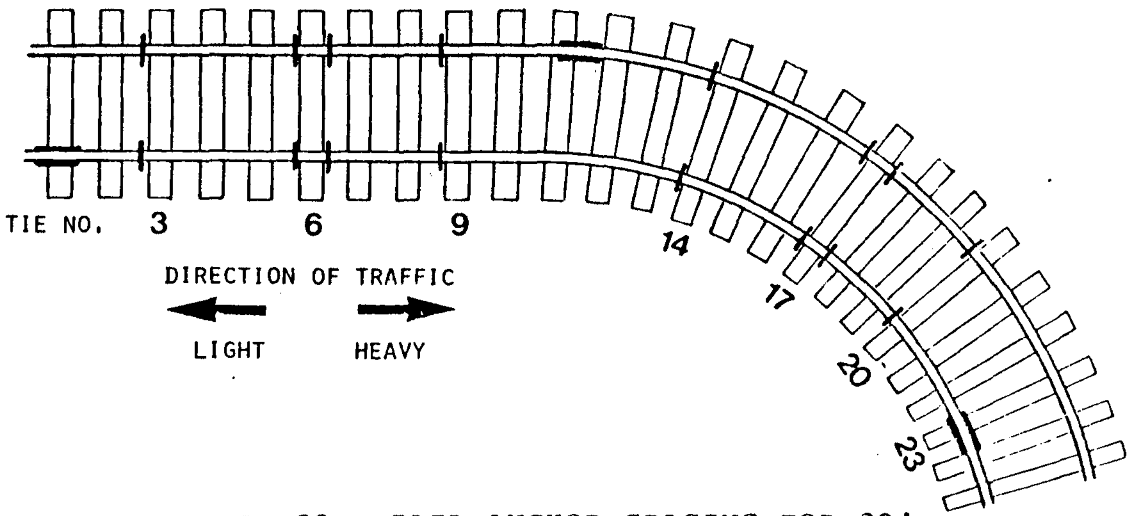


FIG. 22 - RAIL ANCHOR SPACING FOR 39' RAIL-PATTERN NO. 4.

Pattern No. 5

For main line track carrying the majority of tonnage in one direction install 16 anchors per 39 ft. rail length or 11 in one direction and five in the other, 4300 per mile are required.

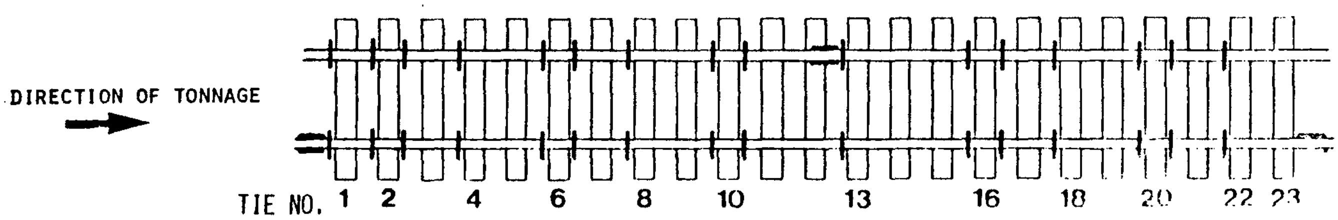


FIG. 23 - RAIL ANCHOR SPACING FOR 39' RAIL-PATTERN NO. 5.

4. RAIL ANCHORS (Cont'd)

4.6 Long Rails

Rails 60 to 78 feet long are to have every third tie boxed.

4.7 Anchor Pattern and Standards in Welded Rail

Rail anchors are to be applied in CWR territory as follows:

- The end sections of 195 feet on each string are boxed every tie and the centre section is boxed every 2nd tie.

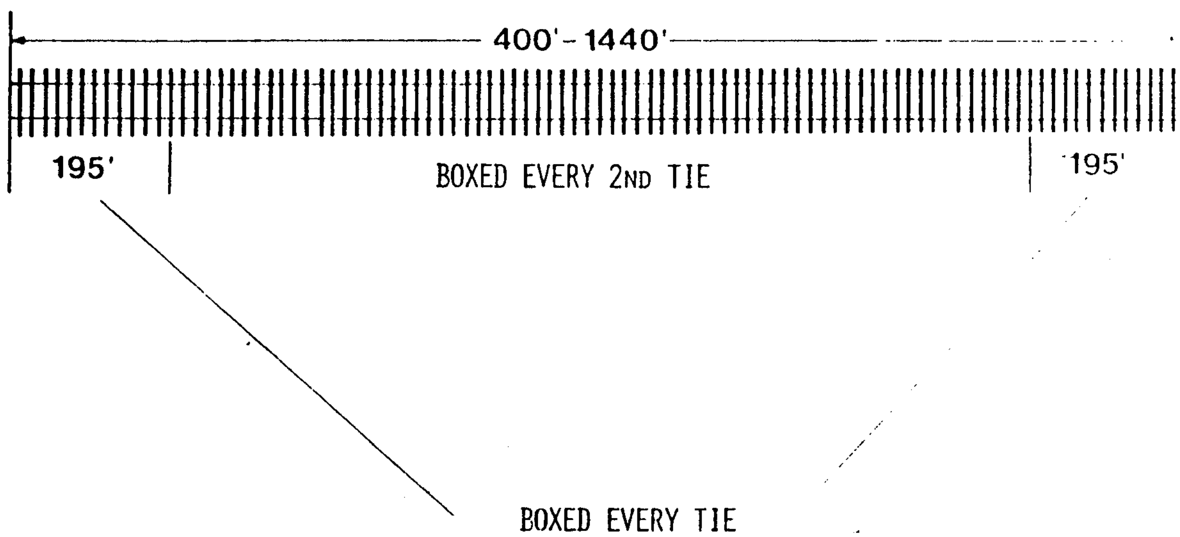


FIG. 24 - C.W.R. ANCHOR PATTERN.

- 91' to 399' welded lengths must be boxed every tie.
- Buffer rails are boxed every 2nd tie.
- Turnouts and other special track work adjoining CWR must be boxed every 2nd tie.
- Where continuous welded strings are connected to 78' rails, the 78' lengths will be boxed every 3rd tie.
- Where CWR adjoins bolted rail the first six bolted rails shall be anchored in both directions at every 3rd tie except that additional anchors, to prevent movement of track, are to be installed as required.

4. RAIL ANCHORS

4.7 C.W.R. Anchor Pattern and Standards (Cont'd)

- Buffer rails on each side of an insulated joint must be box anchored every 2nd tie.
- If a CWR string is cut to put in an insulated joint or to repair a broken rail or a pull-apart, it is now two strings and the two new ends must be box-anchored for 195 feet. Any rail put in a string must be anchored as a buffer rail.

4.8 Rail Anchor Application Procedures

Erickson Type Anchors

The shoe is placed snug to the tie and the yoke is driven on with a spike maul. Drive the yoke carefully by tapping it on a little at a time. The last tap is given on the small end of the yoke to lock it in place.

Application of Fair Anchors

- First place the anchor on the rail solidly against the side of the tie. Then drive the anchor onto the base of the rail with horizontal blows until the locking notch engages on the base of the rail.

4. RAIL ANCHORS

4.8 Rail Anchor Application Procedures

Application of Fair Anchors (Cont'd)

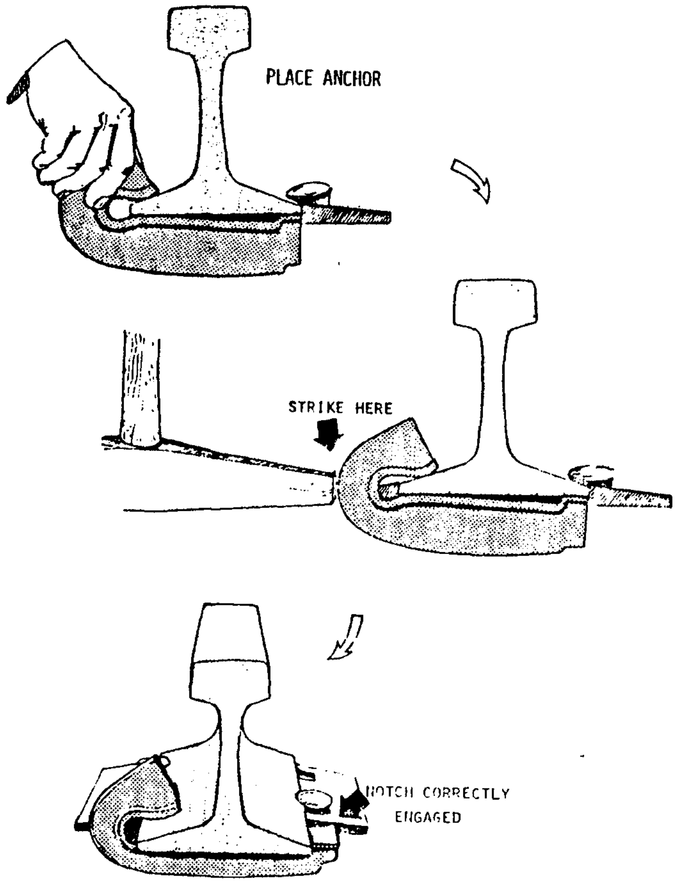


FIG. 25 - APPLYING FAIR ANCHOR.

Application of Woodings Anchors

A special anchor applicator tool is used to apply the woodings anchor. The procedure is as follows:

Step 1 - Put the anchor on the rail.

Step 2 - Engage the anchor with the applicator tool.

Step 3 - Snap the anchor home with a short pull on the tool.

4. RAIL ANCHORS

4.8 Rail Anchor Application Procedures (Cont'd)

To remove the anchor, apply the tool to the other end of the anchor and pull down.

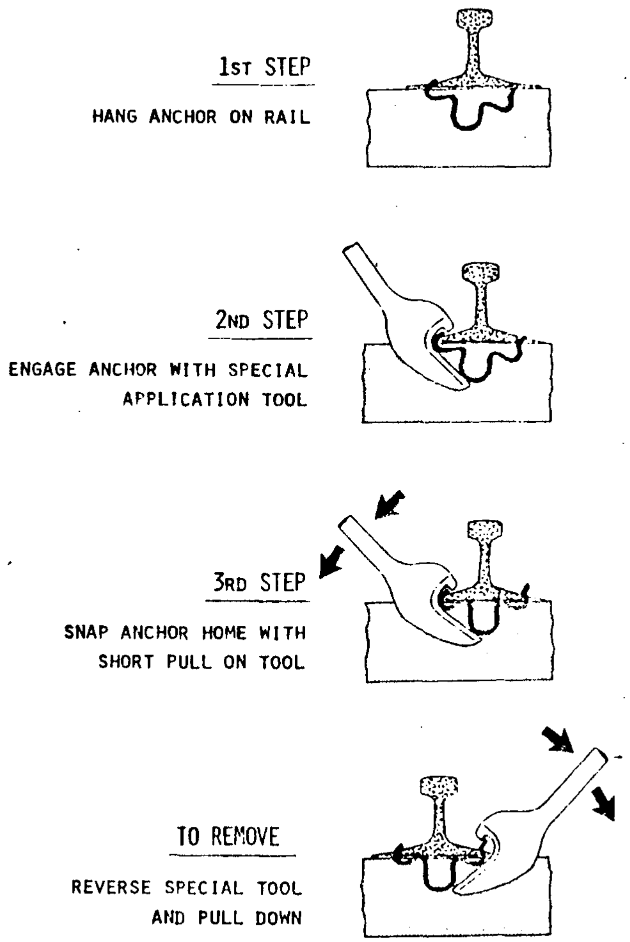


FIG. 26 - APPLYING WOODINGS ANCHOR.

Application of Compression Anchors

Compression anchors are installed with a wrench. The nut on the bolt which passes through the anchor, must be turned to a certain tension which depends on the type of anchor.

4. RAIL ANCHORS (Cont'd)

4.9 Some Words of Caution

- Rail anchors are made for a specific rail section and must be applied to the proper rail section.
- Do not drive anchors along the rail to adjust them (remove and re-apply snug to tie).
- Do not mix various types of anchors.
- Replace anchors immediately after they have been removed for any reason such as shimming, changing rail or gauging.
- Do not remove anchors in hot weather, except in an emergency, as shifted anchors are a sign that the rail is running. Removal may cause the rail to buckle.

4.10 Reusable Limits

Anchors which are loose, or slipping on the rail should be replaced.

5. TRACK BOLTS AND NUTS

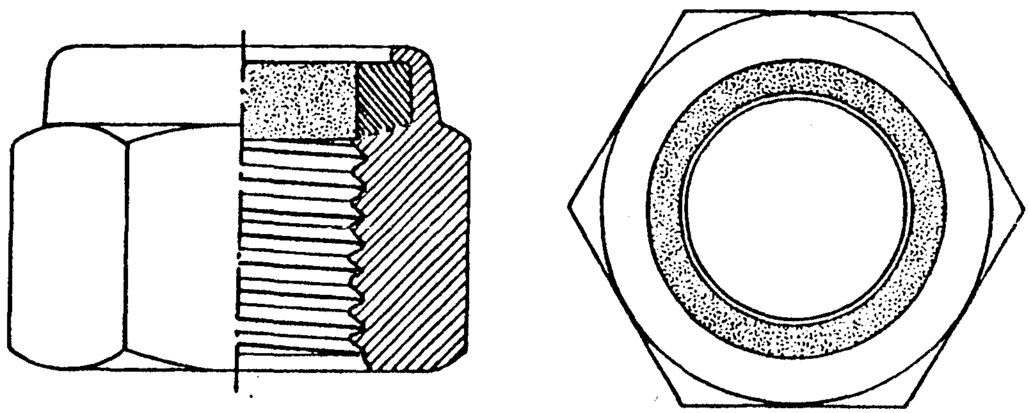


FIG. 27 - ESNA ELASTIC STOP NUT.

5. TRACK BOLTS AND NUTS (Cont'd)

Track bolts and nuts used on rail joints come in different sizes depending on the size of the rails being joined. The following table shows the size of bolt to be used with the different rail weights.

RAIL WEIGHT	DIAMETER	LENGTH
85 lb.	7/8"	5"
100 lb.	1"	5-1/4"
115 lb.	1"	5-3/4"
130, 132, 136 lb.	1-1/8"	5-3/4"

Standard recessed nuts and Esna nuts are used with all track bolts. The bolts must be dipped in SAE 30 or 20, oil before they are applied.

5.1 Reusable Limits

Bolts which have worn threads, a worn shank, or are bent, must be removed and replaced.

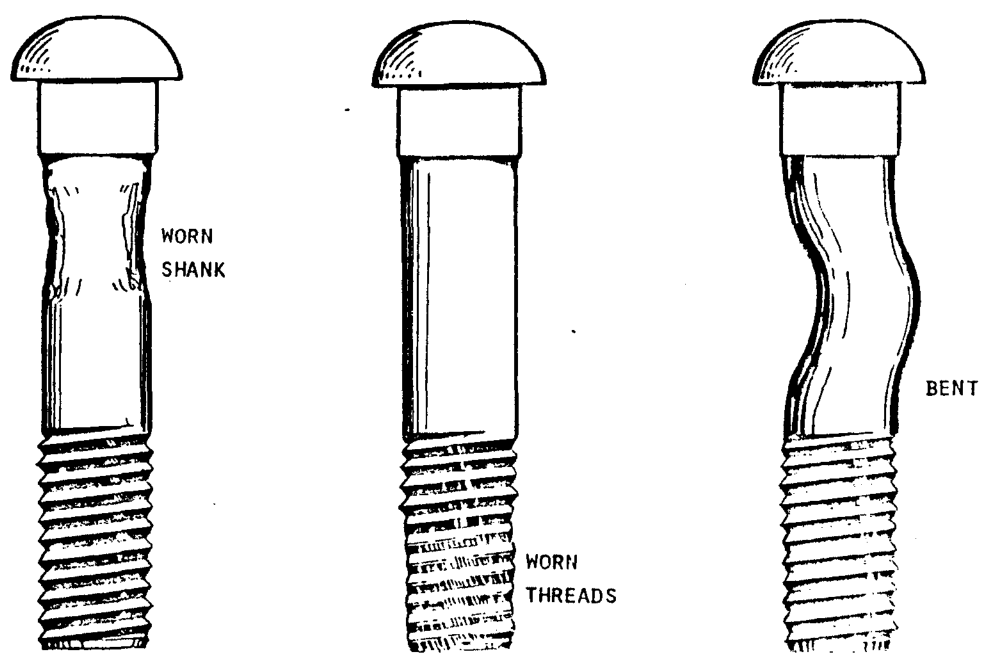
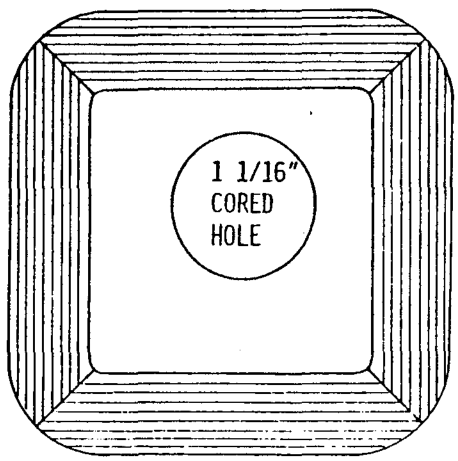


FIG. 28 - DEFECTIVE BOLT.

6. RAIL CLIPS AND ANCHOR BOLTS

Rail clips and anchor bolts are used on scale decks and engine houses to hold the rails to the concrete. The anchor bolts are either set permanently in the concrete or on the scale decks where they are installed through holes drilled in the scale deck. The rail clips have a four way adjustable edge to maintain proper line and gauge.



RAIL CLIP

ASSEMBLY RAIL CLIP
AND ANCHOR BOLT

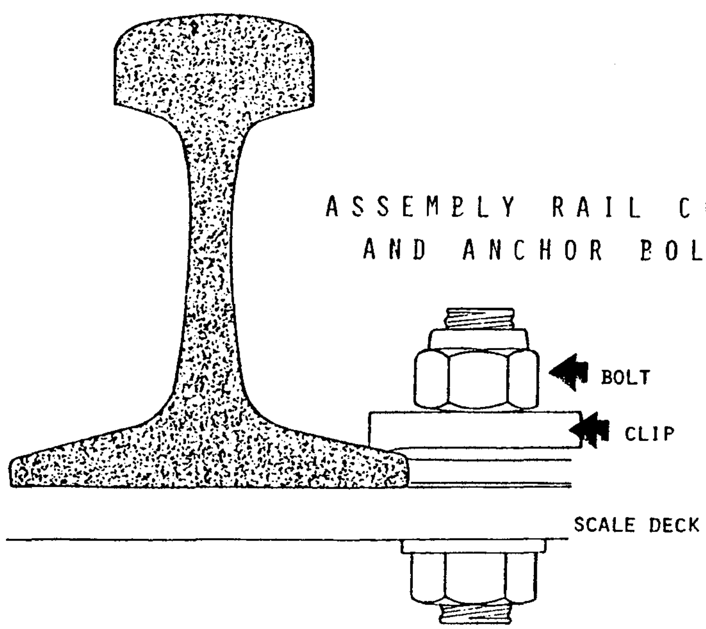


FIG. 29.

6. RAIL CLIPS AND ANCHOR BOLTS (Cont'd)

6.1 Application Procedure for Rail Clips

Ensure that the correct edge is used against the base of the rail to maintain gauge and line. Avoid forcing too large an edge against the base of the rail. The torquing requirements of a one inch anchor bolt is only 380 ft. lbs. as compared to 500 ft. lbs. for a one inch track bolt.

6.2 Reusable Limits of Rail Clips and Anchors Bolts

When the edge of the rail clips are worn, the bolts are bent or the elastic stop is worn on the esna nuts they should be replaced.

6.3 Pandrol Clips for Concrete Ties

The pandrol clip serves as both a spike and as a compression rail anchor. The rail is secured by driving two pandrol clips into the housings on the ties. Bearing is obtained by a flattened portion on the clip at the point of contact.

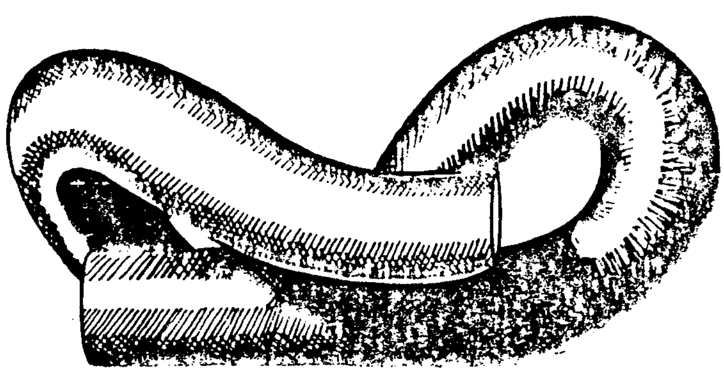


FIG. 30 - PANDROL CLIP.

6. RAIL CLIPS AND ANCHOR BOLTS (Cont'd)

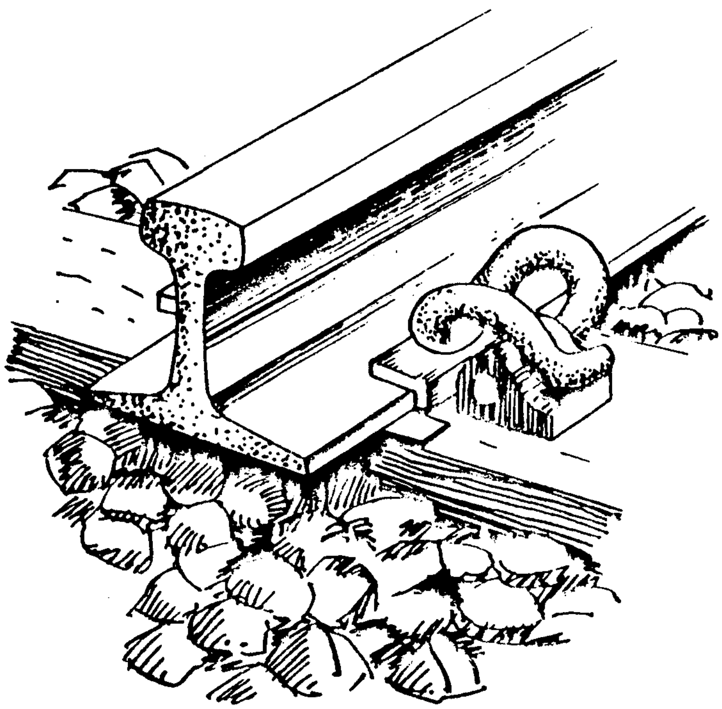


FIG. 30a- PANDROL CLIP.

Pandrol clips don't need adjusting, but they can be damaged by being driven too hard into the socket.

On concrete ties a plastic pad is put on the tie under the rail, and a plastic insert is put on the base corner of the rail and under the clip to insulate the rails.

7. TIE PLUGS

The plugs are square wooden dowels or pegs, and 5" long.
There are three types of plugs:

- Treated
- Untreated
- Hardwood gauge plugs

Treated Tie Plugs are used during rail laying operations or when plugging second hand ties for re-use.
Untreated Plugs are used for gauging only.
Hardwood Plugs are used only by rail laying gangs in every 3rd or 4th tie to maintain gauge during a rail laying operation.

7.1 Installation Procedure of Tie Plugs

Drive the full length of the tie plugs into all spike holes.

8. TIE PADS

Tie pads are used under tie plates to lengthen tie life and to reduce vibration. They are used on concrete crossings, diamond crossings, open deck bridges and tunnels.
There are two approved types of tie pads.

- Fabco - SA47-1/3", 3/8" and 1/2" thick (Goodyear).
- Alert - TB-58 - 1/4", 3/8", 1/2" thick (Uniroyal).

8.1 Installation Standards for Tie Pads

When installing tie pads, the size of the pad is to correspond to the size of the tie plate under which it is to be used. Pads must be slightly smaller than the plate to prevent it from being crushed and to reduce the chance of its burning.
The thickness of the pad to be used shall be as shown in the following table:

8. TIE PADS

8.1 Installation Standards for Tie Pads (Cont'd)

Primary Main Track	USE
Over 15 - M.G.T. traffic per annum.	3/8" thick
Other main secondary and branch lines.	1/4" thick
Diamond crossings where tie pads are specified.	1/2" thick
Concrete and rubber plank crossings.	3/8" thick

9. GAUGE RODS

There are three types of gauge rods:

- One piece (non-insulated)
- Two piece (insulated)
- Adjustable (nut on one end)
- Adjustable (insulated and non insulated)

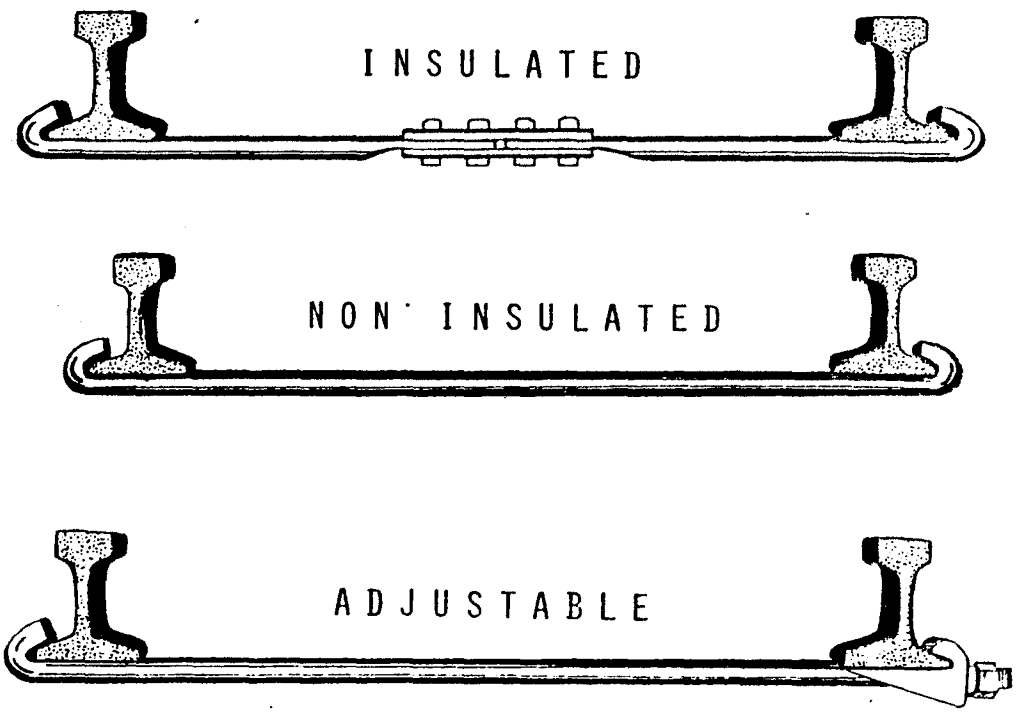


FIG. 31 - THREE TYPES OF GAUGE RODS.

9. GAUGE RODS (Cont'd)

- Gauge rods are used to hold the rails to gauge. Non-insulated gauge rods are used in non insulated track such as:
  - Industrial trackage on sharp curves.
  - Turnouts with severe curvature.
  - Wye tracks.
- Insulated rods are used in signal territory as follows:
  - Turnouts.
  - Wye tracks.
  - Severe curves.

9.1 Installation Procedure of Non-adjustable Gauge Rods

(a) During New Construction

After the line rail has been spiked, place one end of the gauge rod in place by hooking it on the outside of the base of the line rail. Then hook the other end on the opposite rail. Using a lining bar push the rail out to the proper gauge and spike it in place.

(b) In Existing Track

Pull the spikes from the gauge rail (inside and outside), place one end of the gauge rod in place on the line rail (which is fully spiked). Bar the gauge rail in enough so that the gauge rod can be hooked on the outside base of the rail and then bar the gauge rail out to the proper gauge and re-spike.

9. GAUGE RODS (Cont'd)

9.2 To Install Adjustable Gauge Rods in Existing Track

Pull only those spikes needed to correct the gauge before applying rods. Dig out enough ballast in the cribs to permit the rod to be pushed under both rails, then hook the non-adjustable end of the rod over the outside of the rail base. Place the adjustable clamp end of the assembly over the rod and against the rail base on the other side of the track. Apply and tighten the nuts against the clamp end until it is solid.

9.3 Reusable Limits of Gauge Rods

Gauge rods which are stretched, weakened or cracked must be replaced.

10. HAND TOOLS AND THEIR USE

The following tools and their use is covered in Lesson 78:

Adze	Spike Maul
Ballast Fork	Tamping Bar
Claw Bar Tie	Tie Plug Punch
Level Board	Tie Tongs
Lining Bar	Track Chisel
Pick	Track Gauge
Rail Tongs	Track Jack
Scythe	Track Shovel
Sledge Hammer	Track Wrench

10. HAND TOOLS AND THEIR USE (Cont'd)

10.1 Pickaroon

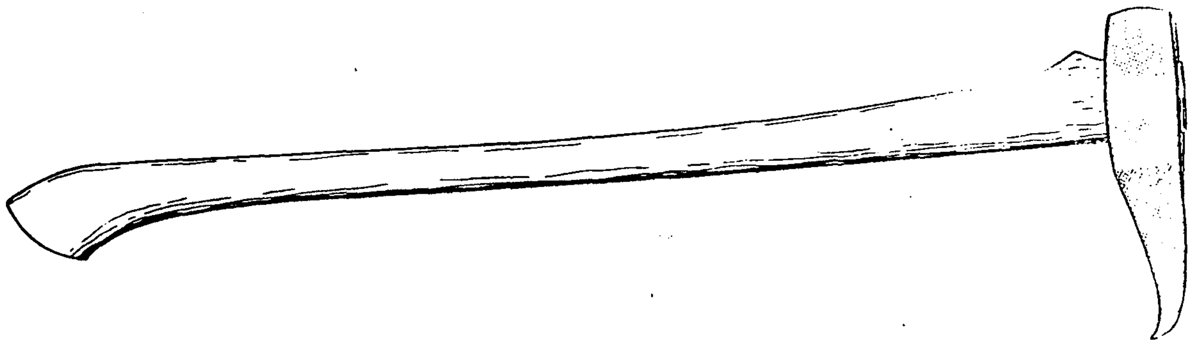


FIG. 32 - PICKAROON.

This tool is used for handling track ties during an unloading operation. The angle and the sharpness of the point makes it possible to pull the track ties from a car with a minimum of wood penetration or damage to the tie. With a pickaroon the workman works from one side of the tie. As the tie is pulled past him the pickaroon releases easily. The pickaroon can be controlled with one hand while the other hand is free to grasp the door frame if necessary. It is a safer tool for this work than tie tongs and will not damage the tie when used properly.

10. HAND TOOLS AND THEIR USE (Cont'd)

10.2 Tie Unloading Hook

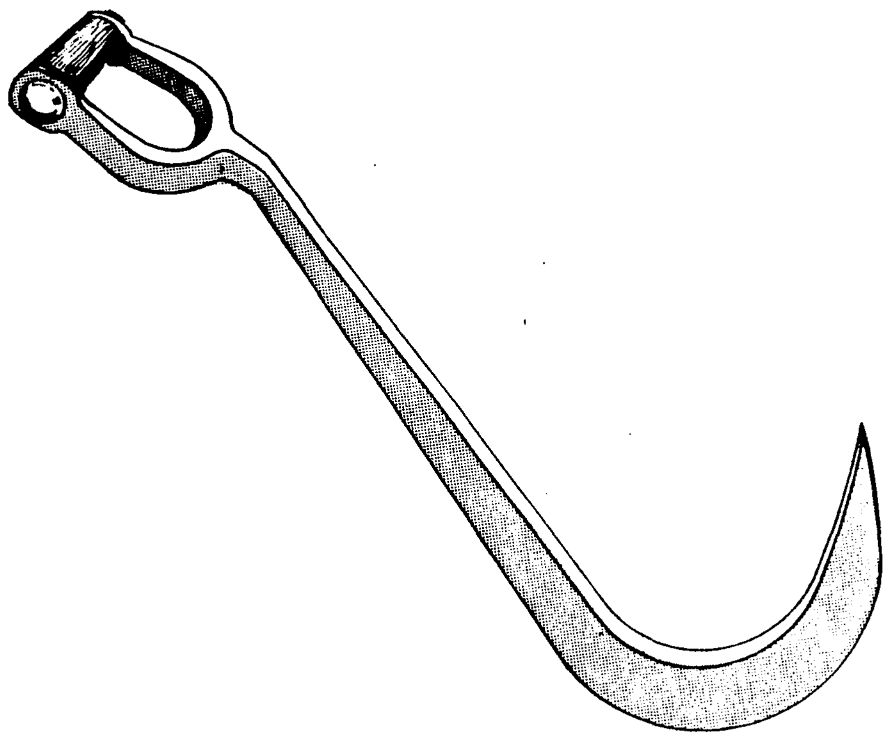


FIG. 33 - TIE UNLOADING HOOK.

The unloading hook is used to unload ties from cars. The ties are hooked at one end and pulled out of cars with one hand, similar to the way a pickaroon is used.

10. HAND TOOLS AND THEIR USE (Cont'd)

10.3 Torque Wrench (4X Multiplier)

The torque wrench is used to torque bolts to the required foot lbs.

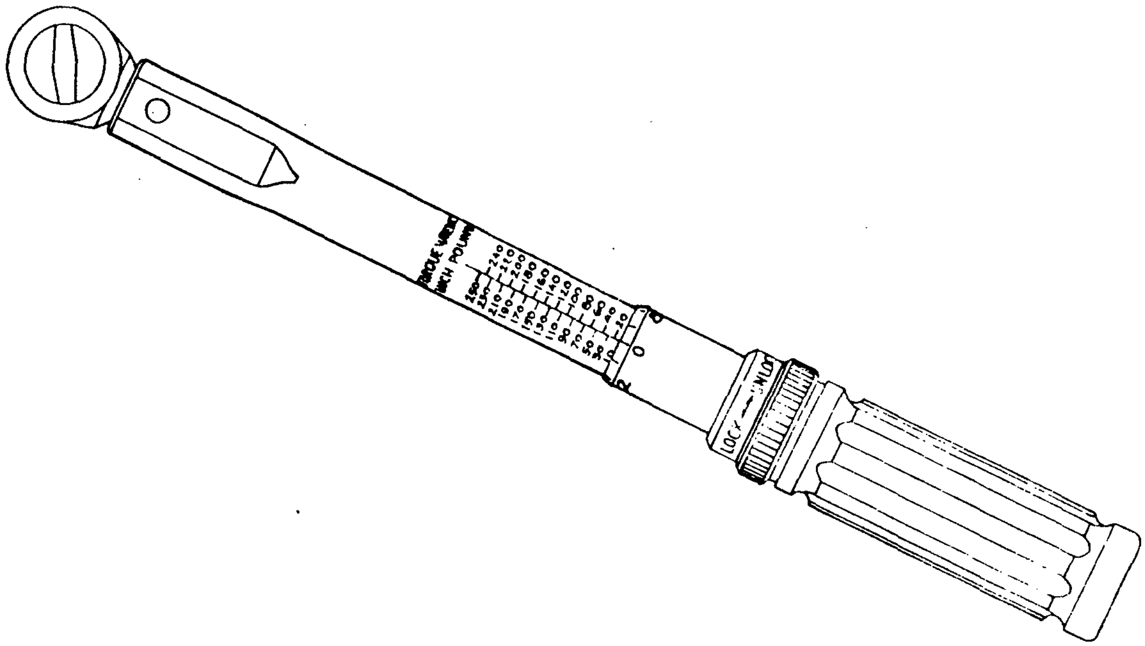


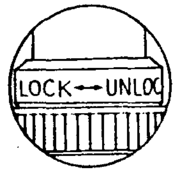
FIG. 34 - TORQUE WRENCH

There are several types of torque wrenches, but basically they are all operated in the same way.

Adjusting the Torque Setting

The following procedure is used to adjust the wrench to the proper torque:

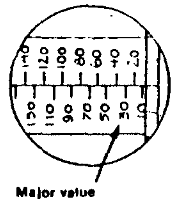
Step 1 - Unlock the wrench by turning the lock ring clockwise.



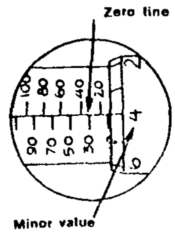
10. HAND TOOLS AND THEIR USE

10.3 Torque Wrench (4X Multiplier) (Cont'd)

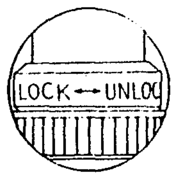
Step 2 - Then rotate the grip until the major torque value appears above the minor calibration scale.



Step 3 - Next rotate the grip until the Minor Torque Value reading lines up with the "zero" line.



Step 4 - Lock the torque setting by turning the lock ring counter clockwise.



Using the Torque Wrench

The correct amount of torque is applied when the wrench makes a clicking sound while the handle moves freely for a few degrees. The combined sound and movement tells you when the correct amount of torque has been applied.

Torque wrenches are often used with a "Torque Multiplier" to reduce the pull needed to get full torque. The torque multiplier is a geared wrench attachment that fits between the torque wrench and the nut. Most of these are "x4" multipliers meaning that it puts out four times as much torque as it gets from the wrench. Thus if the bolt is to be tightened to 600 foot pounds, the torque wrench should be set for 150 foot pounds.

10. HAND TOOLS AND THEIR USE

10.4 Spike Puller

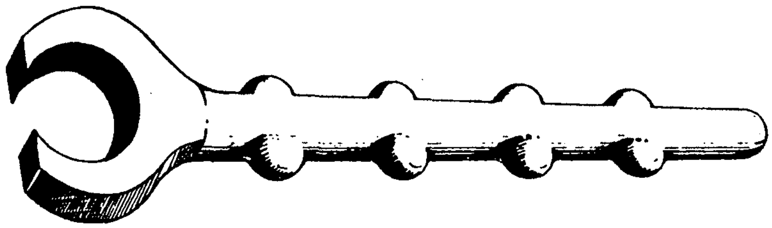


FIG. 35 - SPIKE PULLER.

The spike puller is used with a claw bar to remove spikes at places where there is not enough room for a claw bar alone to be used. This includes spikes at; guard rails, ends of switch points, toe and heel of frogs and crossings. The jaws of the puller are attached to the spike head and the claw bar fork goes between the knobs of the shaft of the spike puller with the heel of the claw bar bearing against the rail head as shown below.

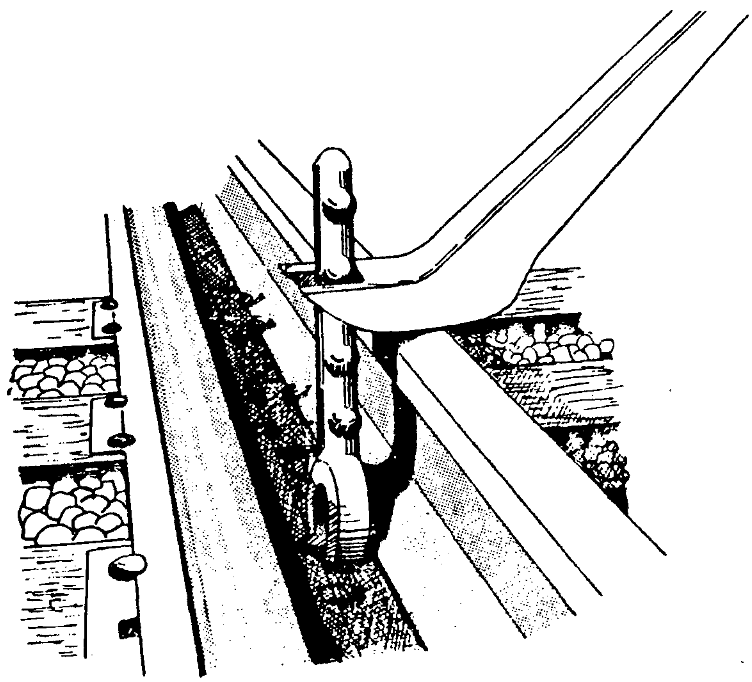


FIG. 36 - SPIKE PULLER USED WITH CLAW BAR.

10. HAND TOOLS AND THEIR USE (Cont'd)

10.5 Rail Anchor Applicator

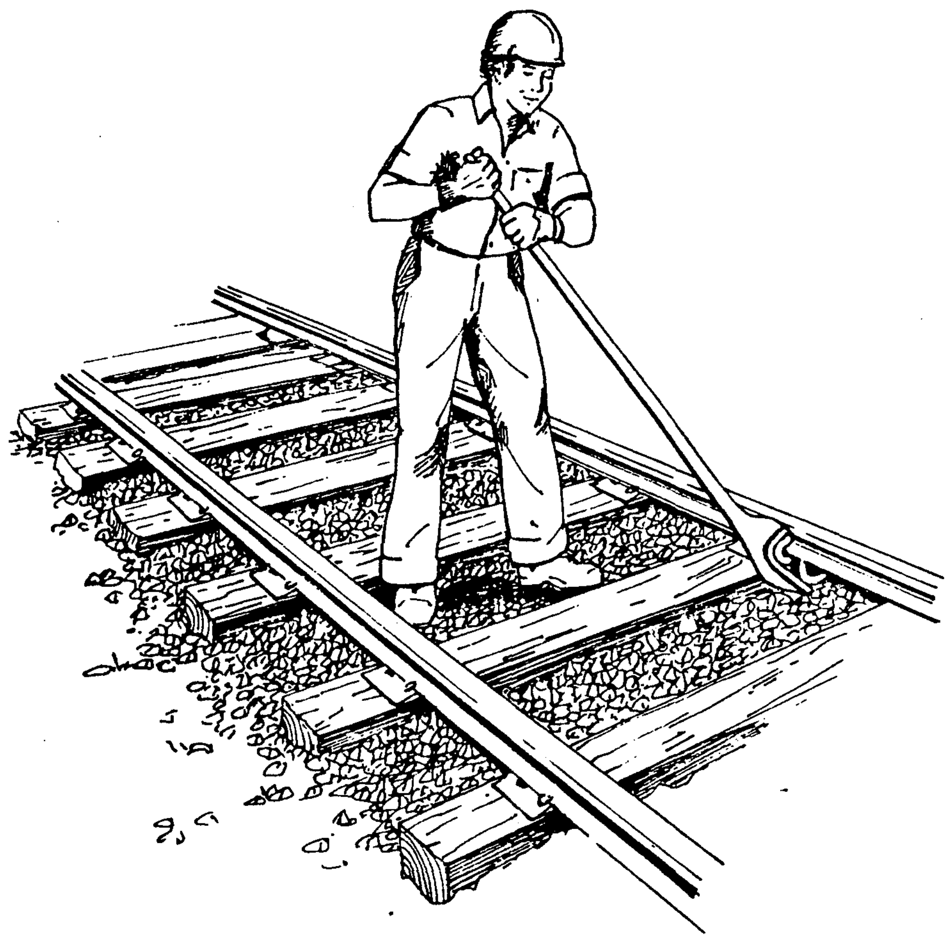


FIG. 37 - RAIL ANCHOR APPLICATION.

The rail anchor applicator is used only to apply the "Woodings" type rail anchors. To apply the anchor, first hang the anchor on the rail, then engage the anchor with the applicator tool and pull with a short snap to set the anchor.

10. HAND TOOLS AND THEIR USE (Cont'd)

10.6 Trowel

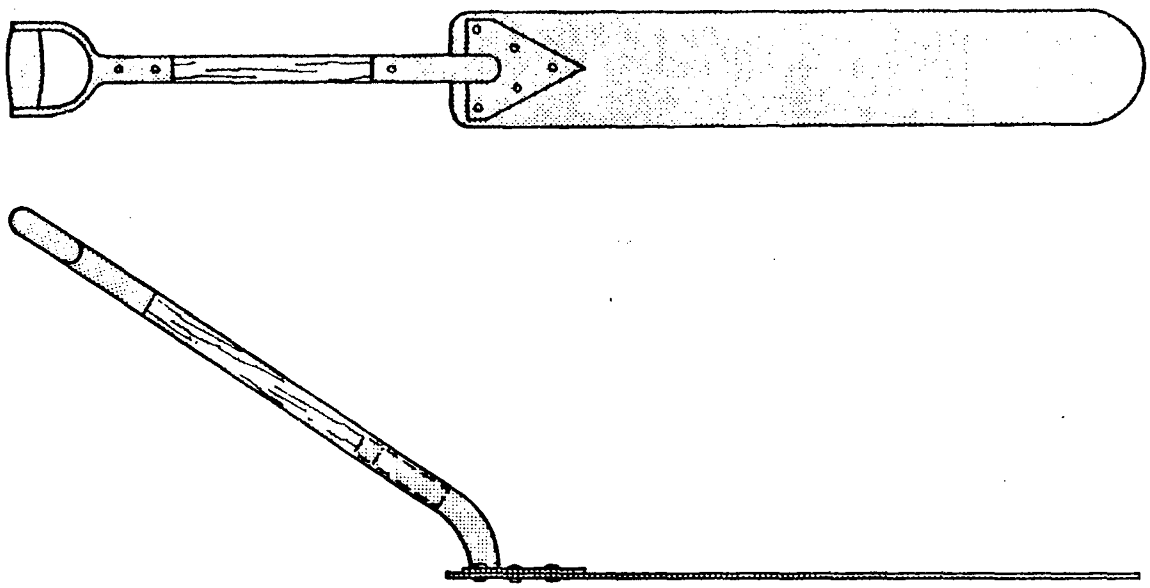


FIG. 38 - TROWEL.

The trowel is used to hand surface track, when hand surfacing the tie ends are dug out first and the track raised with a track jack enough to clear the trowel when loaded with ballast. Then the right amount of ballast is placed on the blade of the trowel and it is inserted, for its full length, under the tie. Then withdraw the trowel with a quick movement so that the material will be left behind. Do not throw the material in or it will be under the centre of the ties and cause centre bound track. Troweling methods are discussed in more detail in Lesson 33 Surfacing and Trimming.

CP Rail

MAINTENANCE OF WAY TRAINING

Lesson no. 28

Subject MECHANIZED TIE RENEWAL PROGRAM

First issued 79/02/06

Maintenance of way training

INTRODUCTION

You will be able to supervise a tie gang, or if the tie gang is on your territory you will be able to ensure that the work is done properly, with the least amount of clean up work. You will also know how to select, mark, distribute and dispose of ties. Whether you are supervising the gang or working with it, you will be doing the job safely and with the least amount of work.

Summary of Main Points

- Selection of ties for renewal
- How to remove and install ties
- Duties of the foreman and supervisor
- Disposal of old ties

1. SELECTION OF TIES FOR RENEWAL

1.1 Selecting, Counting and Marking Ties

Selecting the ties to be replaced, and counting and marking them is one of the most important things that a Track Maintenance Foreman must do. The budget for the renewals and the scheduling of the tie gangs is based on the Foreman's tie count.

If the tie count is badly done, two things can happen. If too many ties are changed it is very costly, and could cause an unnecessary cut in the budget for other things that might be badly needed. If too few ties are changed you will have weak track needing more work to keep it in good condition, and there will be more possibility of derailments. Derailments caused by bad ties are apt to be at high speed, cause a lot of damage, and endanger lives.

1.1.2 Defective Ties

A defective tie is a tie which is:

a) Split or weakened so that it will not hold the spikes.
b) Severely crushed.
c) Spike killed.
d) Decayed.
e) Broken.
f) Adzed over two inches.

The question is always - How Much?
How crushed is "severely crushed"? The Foreman has to use his judgement, especially for crushed, spike killed and decayed.

1.1.2 Defective Ties (Cont'd)

The Foreman's tie count is made in the spring or early summer for ties to be replaced next year, so he has to judge whether a tie that is poor but O.K. this year will be considered defective next year. A Foreman that isn't sure, or a new Foreman, should ask his Roadmaster to go with him for a mile or two on his section to show what is wanted.

In fact, the Roadmaster must make spot checks on each section to see that the Foremen are making the proper selections.

1.1.3 Tie Standards

After a tie gang goes over a stretch of track there should be very few or no defective ties left. But in between passes of the tie gang, the main track ties must be maintained to AT LEAST these standards.

Primary and Secondary Main Lines

a) Not more than 4 defective ties per 39 foot rail length.
b) Not more than one defective tie in the joint area.
c) Two adjacent ties must not be defective.

Branch Lines

a) Not more than 5 defective ties per 33 foot rail length (6 in 39 feet).
b) Not more than one defective tie in the joint area (same).
c) Not more than two adjacent defective ties.

1.1.4 Tie Count and Marking

As the foreman selects the ties for replacement NEXT year he must make two counts.

1) How many defective ties will there be next year?
2) How many of these are needed to maintain to the minimum standards?
3) From both of these, deduct the ties he will install THIS year.

Defective ties should be marked on the tie end at the time of counting. The tie count should be recorded and sent to the Roadmaster for each mile of main track. The Roadmaster should spot-check each Foreman's tie count, and then he passes his requests to the Division Engineer. Then it goes to the Regional Engineer and the Chief Engineer. A decision is made about September for how many ties will be changed on each territory, and for the scheduling of the tie gangs.

1.1.5 Renewals Between Tie Gangs

If the tie gangs do not come to a section the next year, the Foreman will be given enough ties to maintain the standards, and these ties will have to be installed by hand. The section gang will replace at least one defective tie, where there are two bad ties at a joint, and at least one where there are two or three adjacent bad ties, depending on the line. They may have to replace some other ties to stay above the maximum bad ties per rail length.

The number of ties unloaded may not be the number of ties requested, in which case the Foreman must decide which ties should be changed.

1.1.6 <u>Marking for Tie Gangs</u>

If the tie gang is coming next year the Foreman should, in the fall, or as soon as possible the next spring, mark the ties again for the tie gang. The mark should be about a foot inside the rail so the machine operators can see it. Use a paint colour that can be clearly seen, white, yellow - orange or light red.

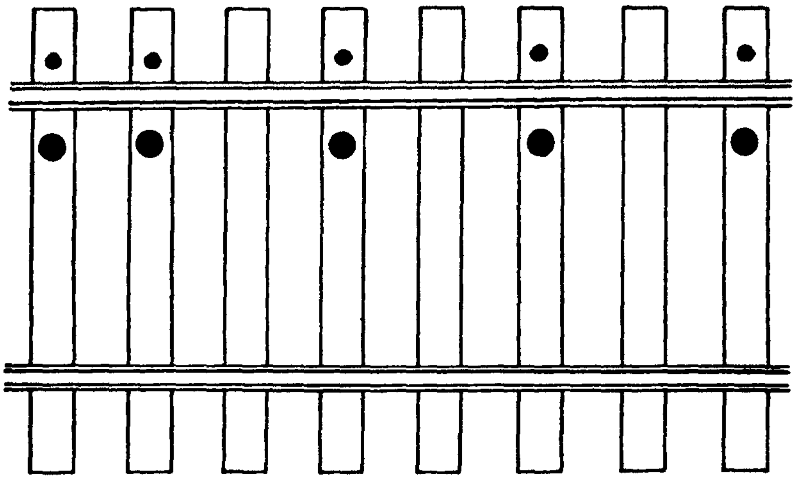


FIG. 1 - TIES MARKED FOR RENEWAL.

The Roadmaster will tell the Foreman how many ties he will get, so the Foreman may have to mark more or less ties for the machines than he had already marked for his tie count.

Before the tie gangs the tie renewals used to be concentrated on a different part of the section each year. This should not be done any longer, and tie renewals should be marked and done over the whole section according to the need.

1.1.7 <u>Recording for Unloading</u>

Although the tie request sent in to the Roadmaster is for each mile, the Foreman should keep a more detailed record to be used when unloading ties.

1.1.8 The Track Maintenance Foreman selects and marks the ties to be replaced, not the tie gang foreman.

Even if the ties received are less than the ties requested the Track Maintenance Foreman is still responsible for his track condition. If there are too many bad ties he should ask the Roadmaster for help. In extreme cases the Track Maintenance Foreman might have to put on a slow order.

1.1.9 <u>Other Tracks</u>

The Foreman must use judgement about the tie conditions for other than main tracks. The following are some suggestions:

- Signalled sidings and signalled yard tracks - same as for main tracks.
- Other sidings - depends on the speed and traffic.
- Yard and industrial tracks - depends on the speed, traffic and curvature.
- Interchange tracks used by another railway - should be better than for the same traffic in a yard.
- Shop tracks - better than a yard track as the shop staff often run engines too fast, and the oil around shop tracks tends to soften the ties.

1.1.10 <u>Platforms, Rock Cuts, Tunnels and Crossings</u>

Watch the ties in these areas carefully because mechanized tie gangs usually don't change the ties where it will slow them up too much. You will probably have to do these areas by hand. Don't neglect them.

1.2 Preparation for the Mechanized Tie Gang

Tie plates, rail anchors, and spikes may be found defective, or may be buried when the ties are being removed. Additional plates, anchors and spikes should be distributed along the way so that all broken or worn out material can be replaced. This additional material can be unloaded at every 1/2 mile as follows:

Tie Plates	- Approximately 25 pieces
Rail Anchors	- Approximately 1 bag
Spikes	- Approximately 2 kegs

2. HOW TO REMOVE AND INSTALL TIES

Provide the protection needed on the subdivision, and advise both the foreman and operators the limits of the protection and when it expires. Using the time available, and the number of ties to be replaced determine how much track can be completed, then advise the men pulling spikes, and removing rail anchors where you wish them to stop: Example - mile 100.0 to 101.5 approximately.

If changing ties in C.W.R. territory always check present rail temperature and compare it with the preferred laying temperature. If the rail temperature is more than 10°F higher than the laying temperature, do not change out ties.

The minimum spiking for the passage of trains without having to apply slow order protection is as follows:

Mainlines - not more than one tie in a row and no more than 6 ties in one rail length are to be left unspiked.

Branchlines - with speed less than 35 M.P.H. - not more than 2 ties in a row and 8 ties in a rail length are to be left unspiked. The above minimum spiking assumes that the spiked ties are good ties and that the unspiked ties are tamped.

2. HOW TO REMOVE AND INSTALL TIES (Cont'd)

When closing up always make sure that:

1) All ties removed are replaced with a new tie.
2) All ties are spiked, anchors applied and ballast is restored.

2.1 Gang Organization

Here is a typical gang organization where:

- There is a separate machine to remove tie ends and centres.
- The Kershaw tie injector is used where the ties are placed ready for it, across the rails, by a tie crane.
- Two men with claw bars pull the spikes.
- One man removes rail anchors.
- One man operates the tie axe, shear or saw, cutting the ties in three pieces and placing the centre piece on adjacent ties.

  Some machines also push the tie butts from under the rails.

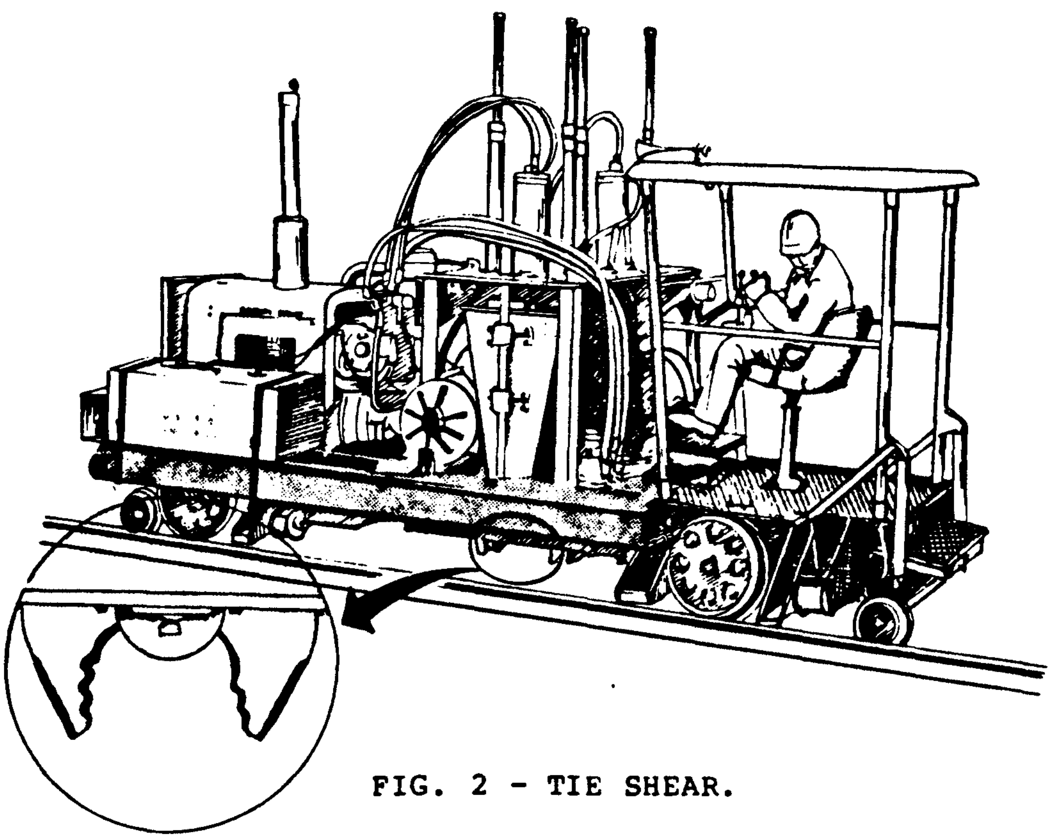


FIG. 2 - TIE SHEAR.

2.1 Gang Organization (Cont'd)

- One man operates the butt pusher, scarifier, or cribber, removing butt ends, and cribbing holes for new ties.

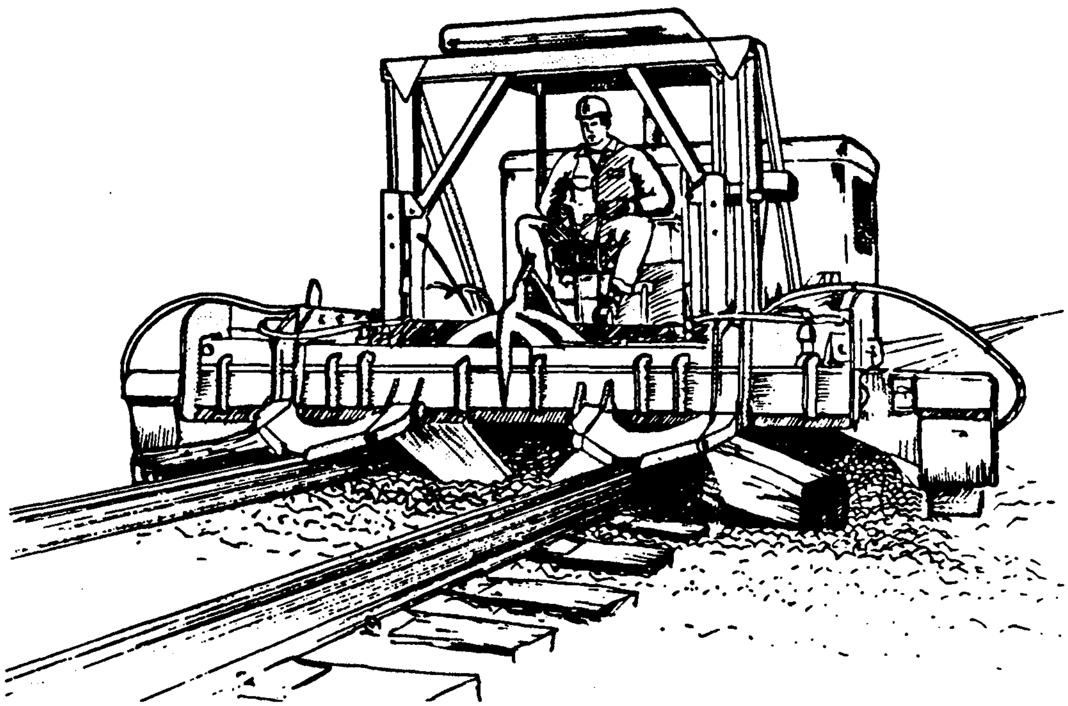


FIG. 3 - TIE BUTT PUSHER-SCARIFIER.

- Two men pick up tie pieces and pile them in the centre or beside the track in piles to be picked up by the tie crane.

2.1 Gang Organization (Cont'd)

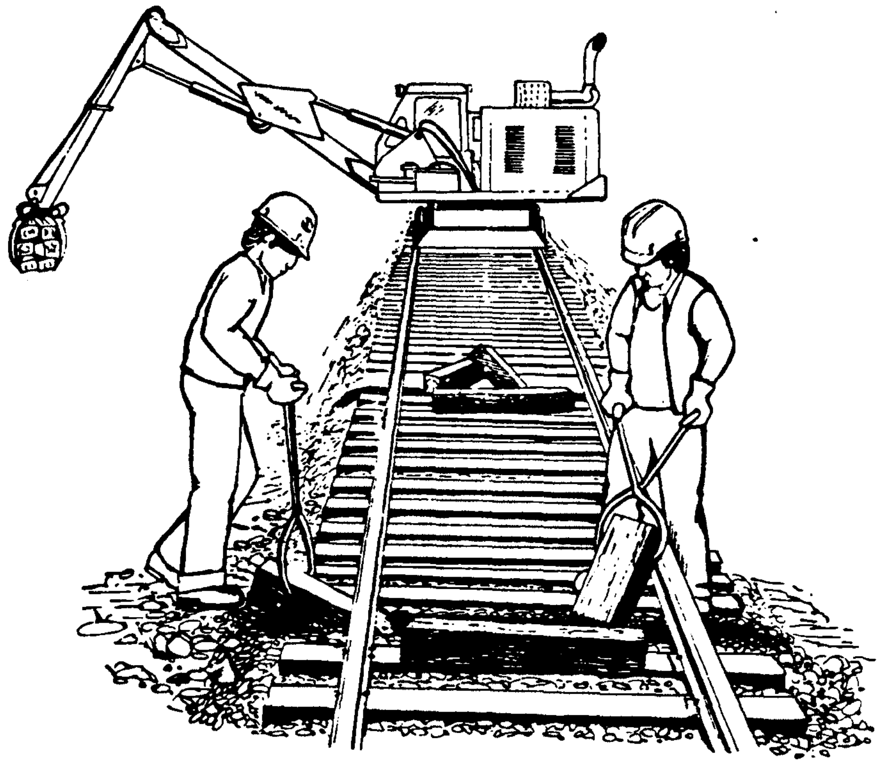


FIG. 4 - REMOVING TIE BUTTS.

- One man operates the tie crane, piling the tie butts on the right of way preferably on side opposite to the pole line. Do not pile the ties in tight rock or clay cuts or against steep slopes. Burning ties in a tight cut could set fire to a train if it stops in the cut. If ties piled against a steep slope catch fire, it will move quickly up the slope and spread.

2.1 Gang Organization (Cont'd)

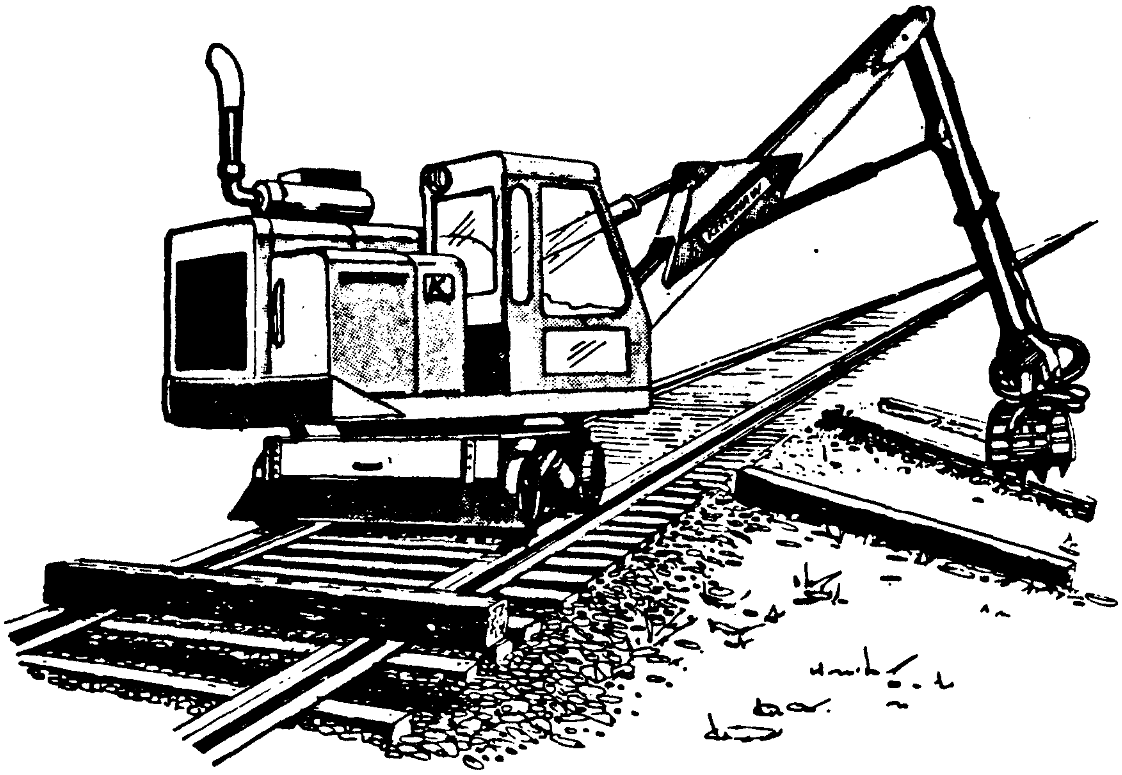


FIG. 5 - TIE CRANE.

- One man operates the tie crane, picking up new ties and placing them at right angles on the rail for the tie injector or beside the track for the tie inserter. The ties are to be placed with the year stamping on the line side and right side up.

2.1 Gang Organization (Cont'd)

One man operates the injector. This machine picks up the tie and puts it under the rail.

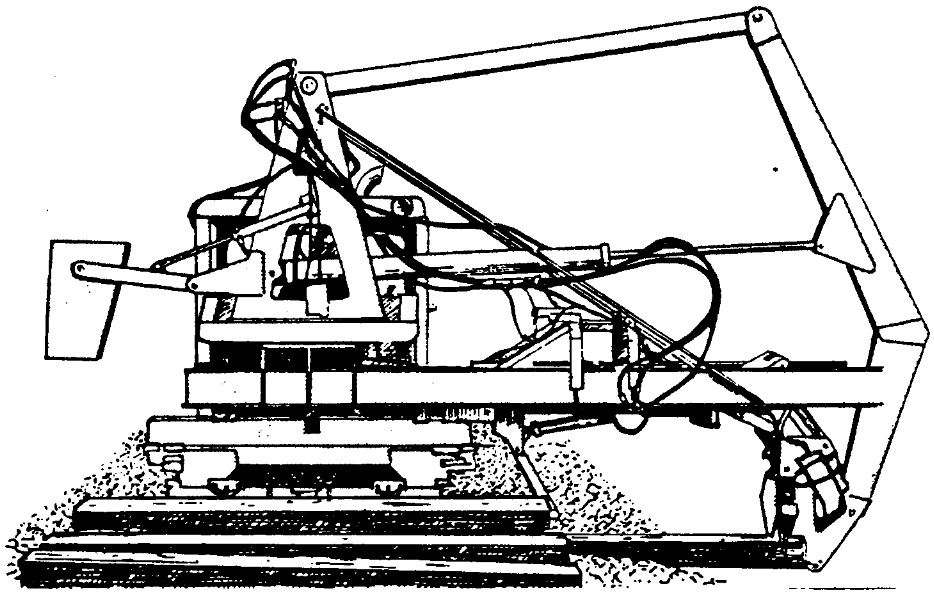


FIG. 6 - KERSHAW TIE INJECTOR.

Two men, behind the injector straighten and line the ties at right angles to the rails.

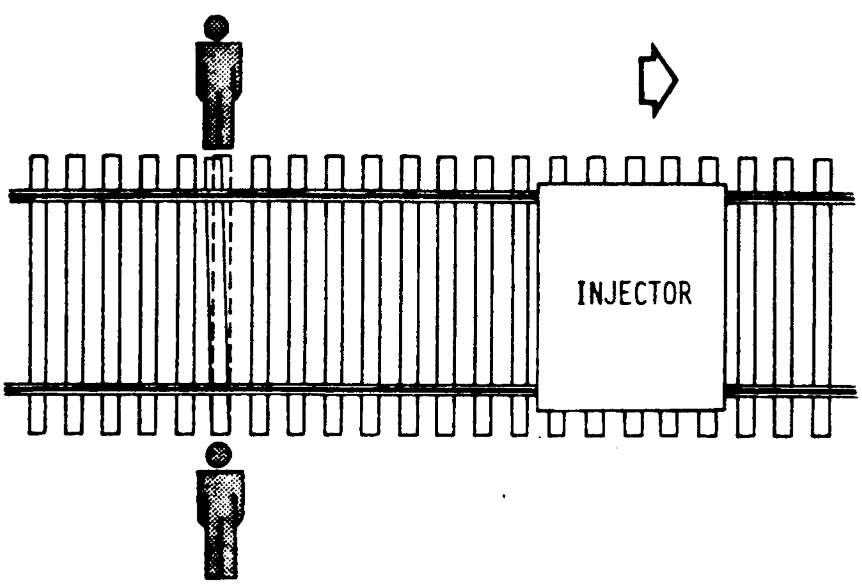
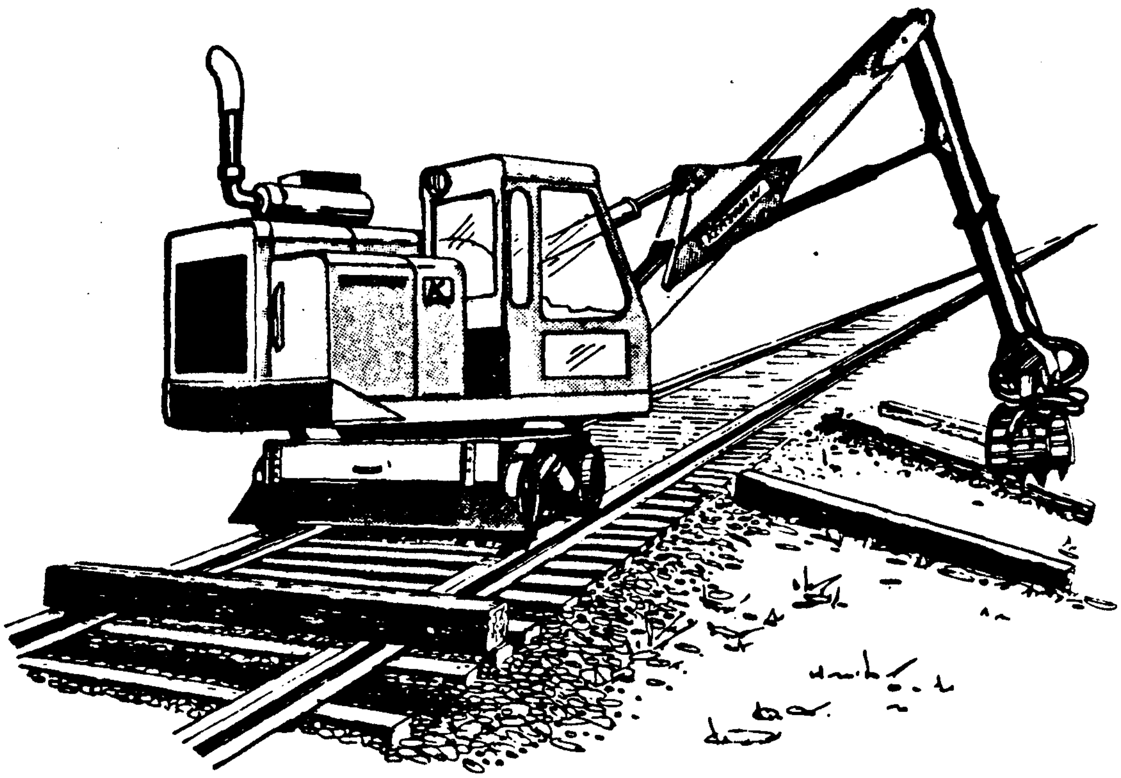


FIG. 7.

2.1 Gang Organization (Cont'd)



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2.1 Gang Organization (Cont'd)

One man operates the injector. This machine picks up the tie and puts it under the rail.

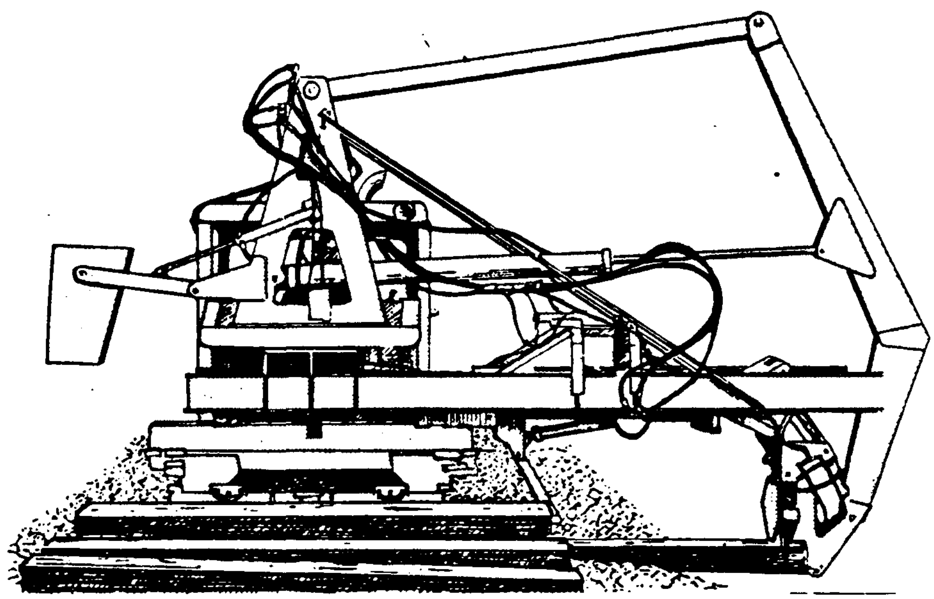


FIG. 6 - KERSHAW TIE INJECTOR.

Two men, behind the injector straighten and line the ties at right angles to the rails.

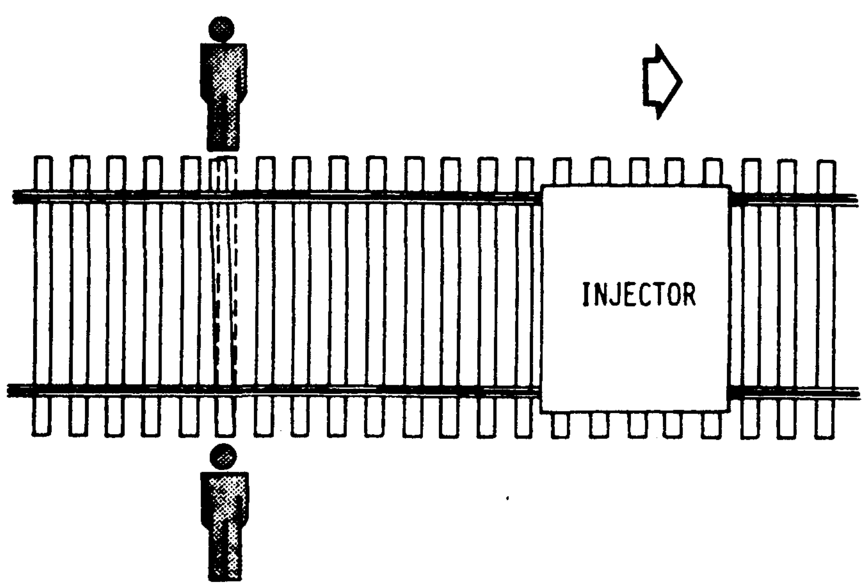


FIG. 7.

2.1 Gang Organization (Cont'd)

- Two men operate the tie plate placer, inserting tie plates under the rail on new tie.

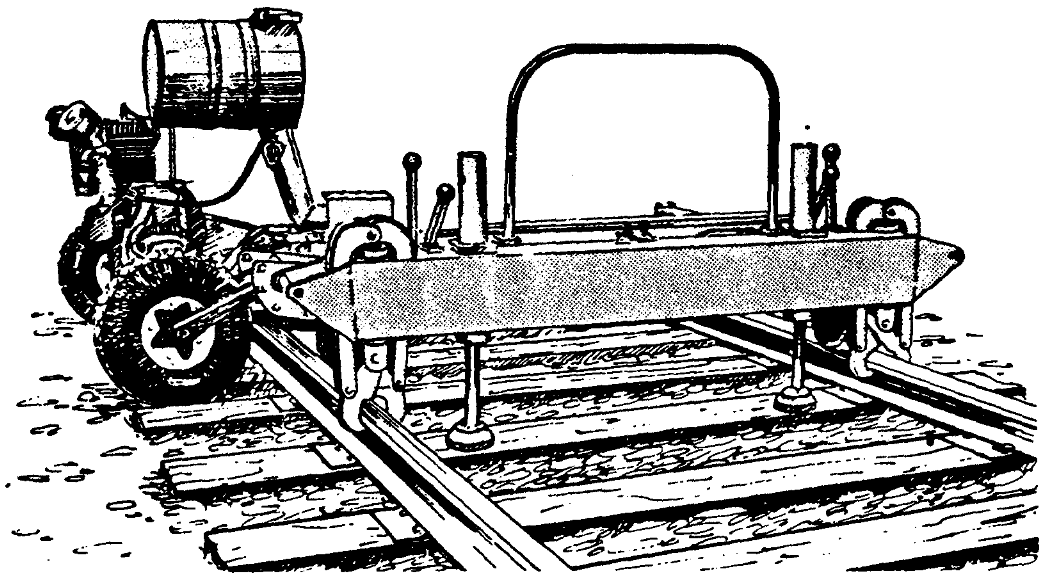


FIG. 8 - TIE PLATE JACK.

- Tie plates must be placed on the new tie before it is fully tamped unless the gang is authorized to use a tie plate jack to insert the plate after the tie is tamped.
- This authorization may be necessary where ballast conditions are such that there is considerable settlement of a new tie, even after tamping.
- One man operates the tamper, tamping ties tight to the rail.

2.1 <u>Gang Organization</u> (Cont'd)

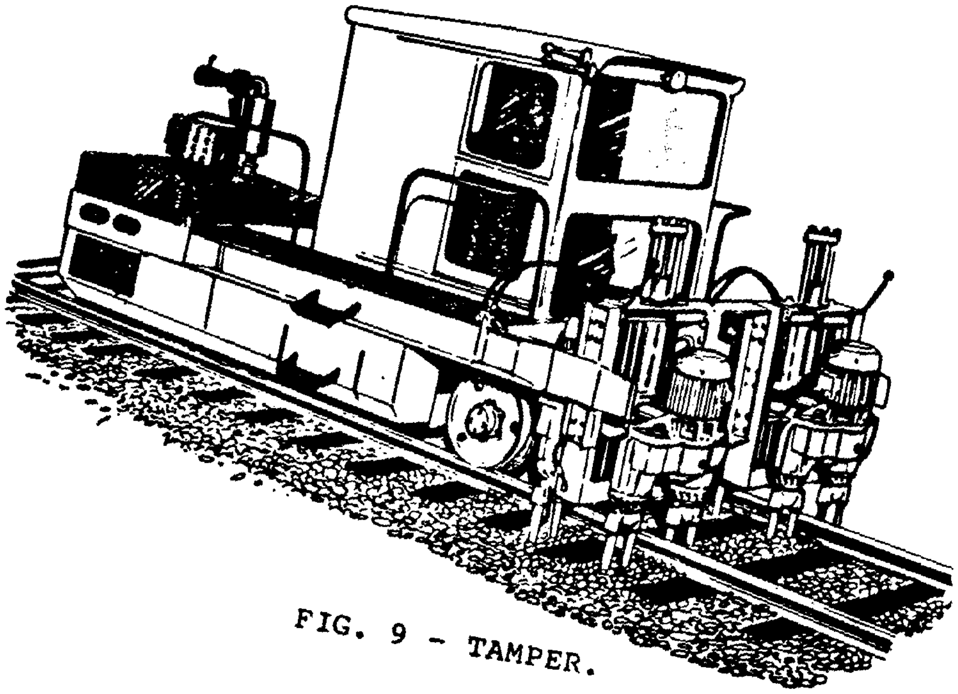


FIG. 9 - TAMPER.

- One man with a push car distributes spikes and tie plates.

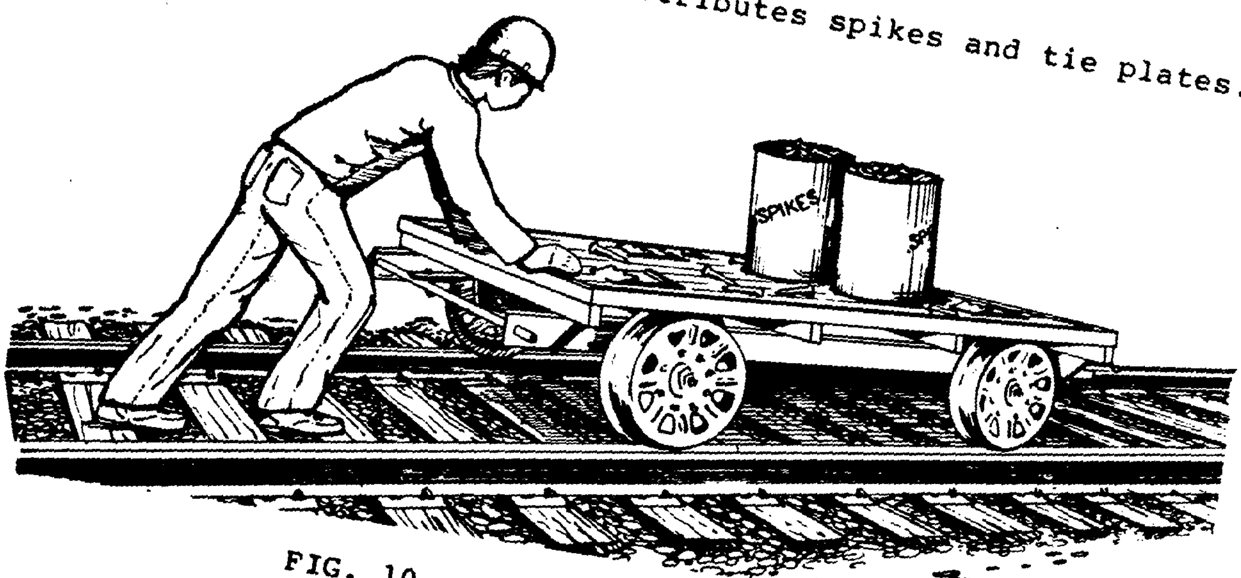


FIG. 10 - DISTRIBUTING MATERIALS.

Four men, two on each rail, start the spikes for the spike hammers and spike the joint ties. Outside spikes first.

2.1 Gang Organization (Cont'd)

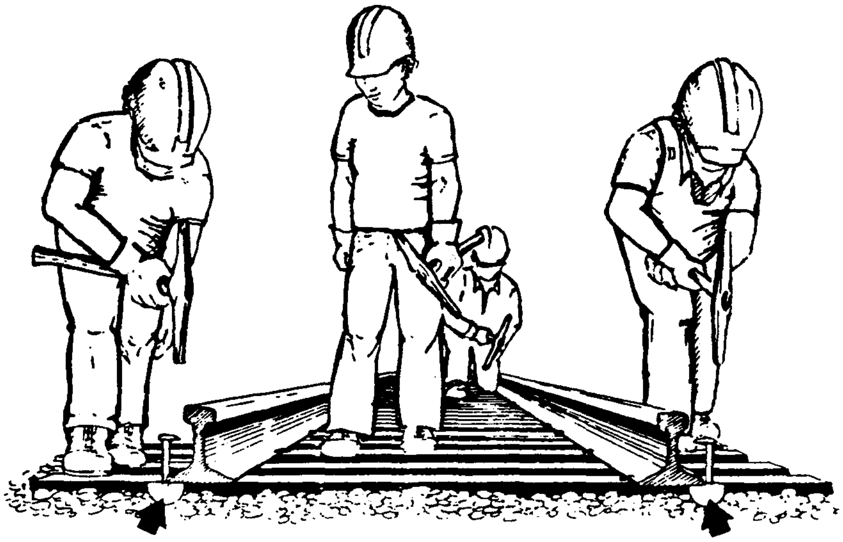


FIG. 11 - STARTING SPIKES.

- Two men operate the spike hammer driving spikes into new ties. Outside spikes first.

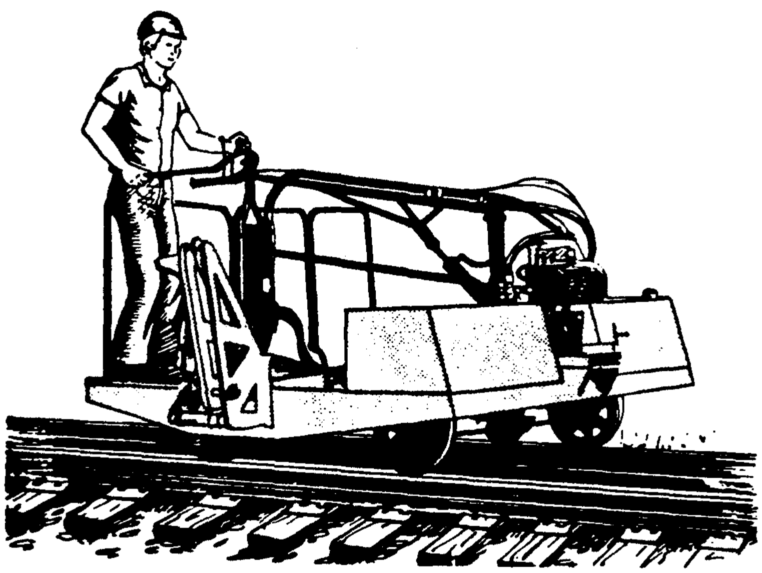


FIG. 12 - SPIKE HAMMER.

2.1 Gang Organization (Cont'd)

- Gang car and trailer carries extra rail anchors so that worn ones can be replaced.

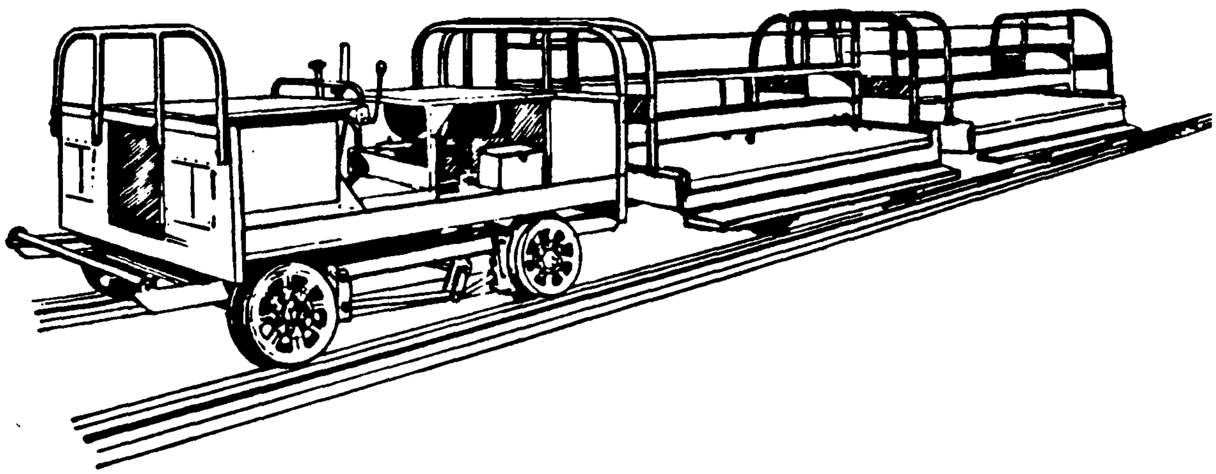


FIG. 13 - GANG CAR AND TRAILERS.

- Two men apply rail anchors, changing worn out anchors, and make sure all other anchors are properly boxed.
- In some areas, you could have:
- One man operating a rail slotter, slotting joints where required. Slotting is not to be done in hot weather, when the joints are closed, it will take twice as long to slot the joints and the joint will not be as well slotted.

2.1 Gang Organization (Cont'd)

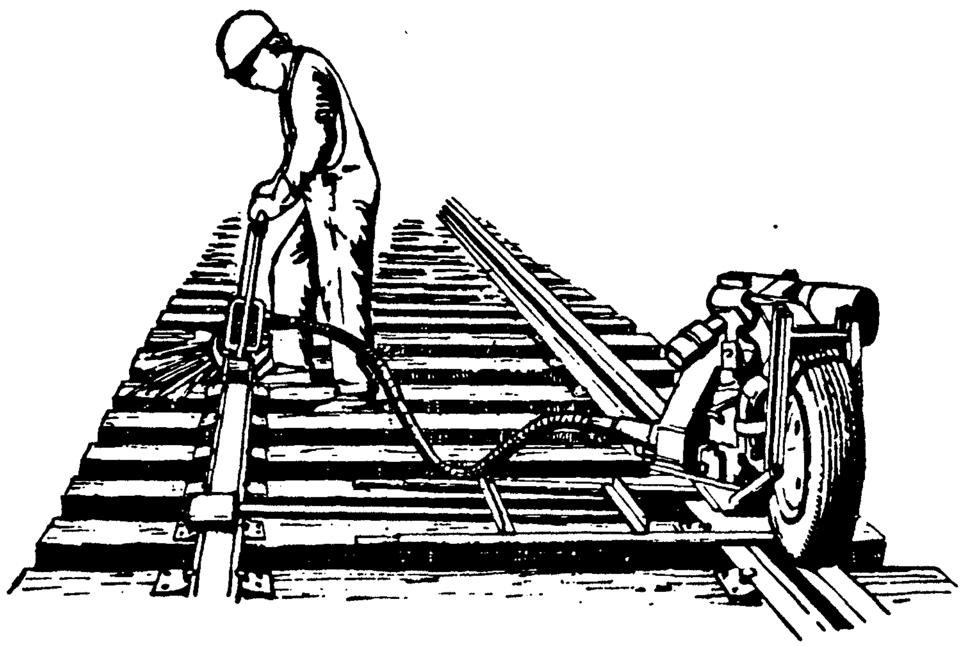


FIG. 14 - RAIL SLOTTER.

- One man operating Racor Bolter tightening all bolts.

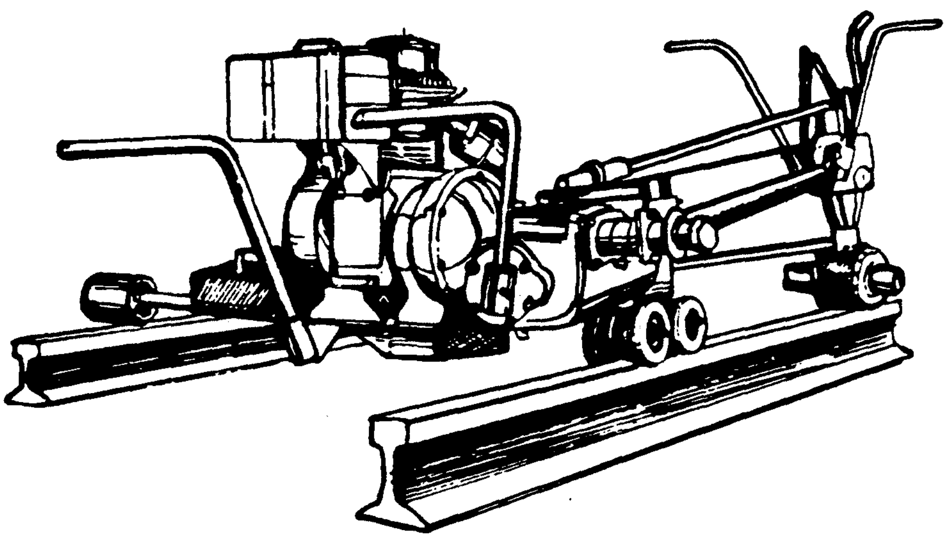


FIG. 15 - POWER BOLTER.

2.1 Gang Organization (Cont'd)

- Ballast regulator, regulating ballast, with two men, one operating, one assisting.

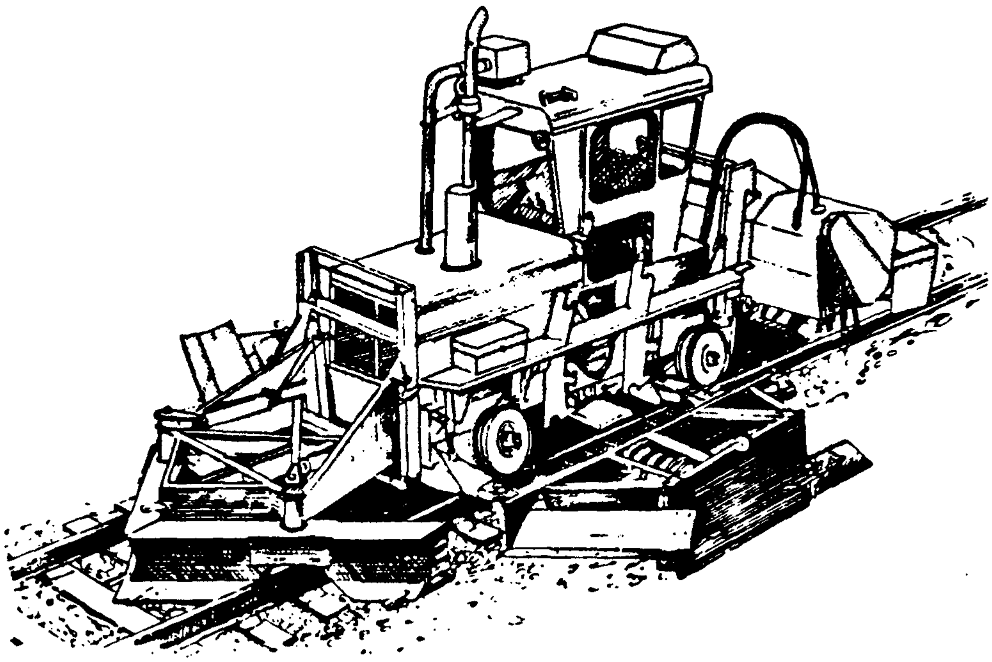


FIG. 16 - BALLAST REGULATOR.

- Two to four men flagging.
- Remove protection when finished.

Here are some variations to the tie gang:

- The tie saw also pushes out the tie ends and places the centre part of the old tie on the next tie. This does not change the number of men needed.

2.1 Gang Organization (Cont'd)

- If the old Nordberg inserter is used, the ties should be placed at right angles to the track, about two feet from the rail and one tie ahead of where the tie is to be inserted. This work can be done manually ahead of the tie gang by section men if a crane is not available.
- The scarifying is done by the tie inserter, as it pulls the tie in from the side of the track with a cable pull. This needs two men to work with the machine but no tie crane to place the new ties.
- Sometimes the tie crane piling scrap ties comes behind the gang. If so the tie pieces must be piled outside the track.

3. DUTIES OF THE FOREMAN AND SUPERVISOR

While the gang is working you should see that:

- All men are at their working position.
- All tools are in good condition.
- Ties are placed at a right angle to the rails.
- All second hand spikes being used are in good condition (spot check).
- Ties are placed with the year stamping on the line side and facing upward.
- Men tapping spikes, and spiking joints, are spaced properly and that spikes are driving properly.
- Tie plates are in good condition and centered on the ties.
- Ties are tamped tight to the rail.
- Rail anchors are applied correctly.
- Ballast regulating is also done properly.
- All ties are spiked properly.
- Outside spikes are set and driven first.

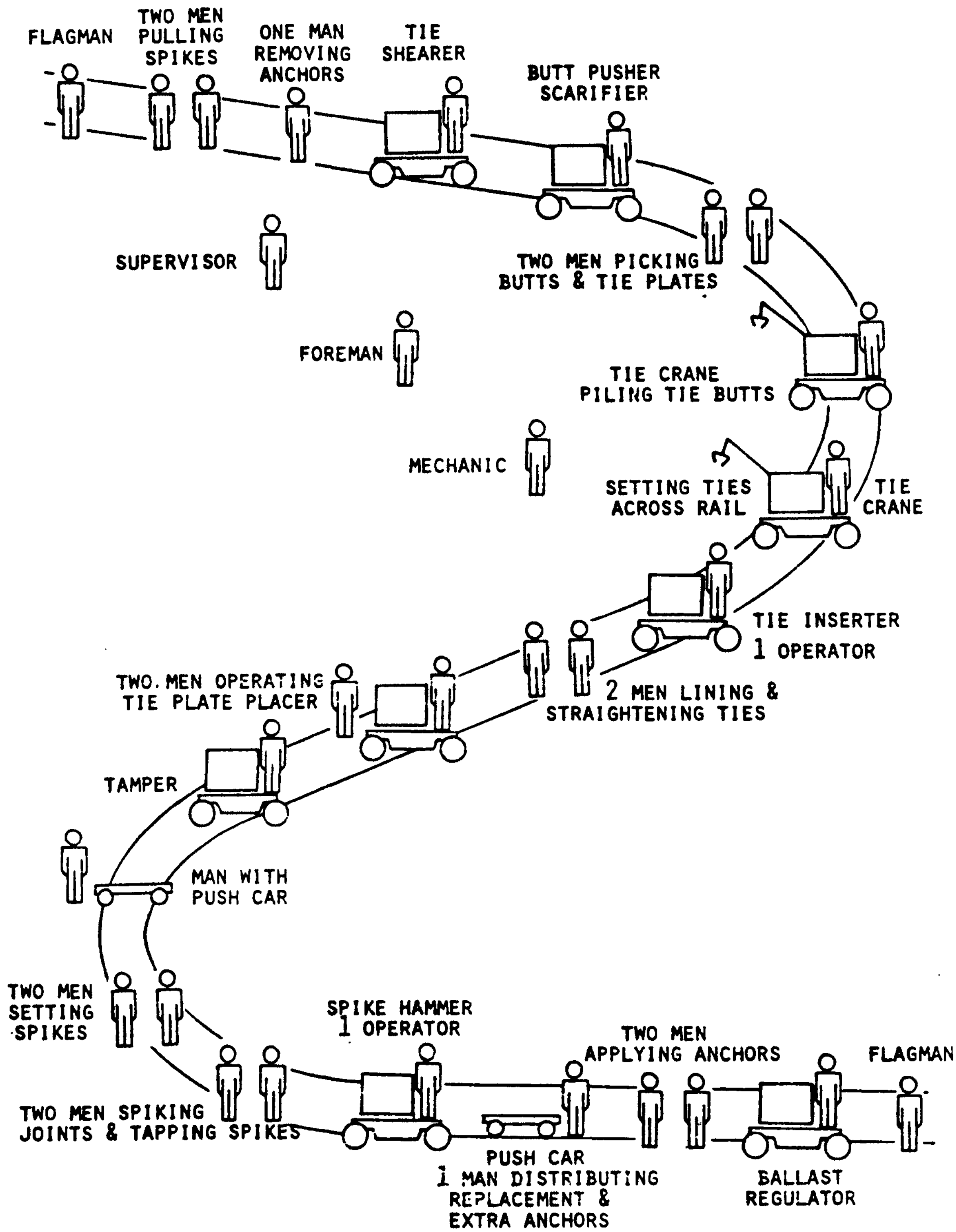

FLAGMAN
TWO MEN PULLING SPIKES
ONE MAN REMOVING ANCHORS
TIE SHEARER
BUTT PUSHER SCARIFIER
SUPERVISOR
TWO MEN PICKING BUTTS & TIE PLATES
FOREMAN
TIE CRANE PILING TIE BUTTS
MECHANIC
SETTING TIES ACROSS RAIL
TIE CRANE
TIE INSERTER 1 OPERATOR
2 MEN LINING & STRAIGHTENING TIES
TWO. MEN OPERATING TIE PLATE PLACER
TAMPER
MAN WITH PUSH CAR
TWO MEN SETTING SPIKES
SPIKE HAMMER 1 OPERATOR
TWO MEN APPLYING ANCHORS
FLAGMAN
TWO MEN SPIKING JOINTS & TAPPING SPIKES
PUSH CAR 1 MAN DISTRIBUTING REPLACEMENT & EXTRA ANCHORS
BALLAST REGULATOR

FIG. 17.

3. DUTIES OF THE FOREMAN AND SUPERVISOR (Cont'd)

- When working in C.W.R. make sure that when pulling spikes out of a tie to be removed, the next three adjacent ties are fully spiked and anchored. If two ties in sucession need to be replaced, they should be replaced one at a time, spiking and anchoring one before the other is removed.
- Any improper fastening of ties, anchoring and spiking is to be corrected immediately.
- When working outside C.W.R. territory and more than two ties in succession are removed you satisfy yourself that the gauge of the track is correct.

4. HOW TO DISPOSE OF OLD TIES AND TIE BUTTS

Old ties may be burned if local by-laws will permit. They can be used as fence post when they are not cut by machanized tie gang. Can be used for building retaining walls. Can be given away or sold if permission is obtained. Can be hauled away to a gravel pit and buried if unable to burn. Can be used as fuel in a lunch room shelter.

In populated areas they should be picked up the same day so they won't be put on the track by vandals and so that local people will not complain about them being an eyesore.

CP Rail

MAINTENANCE OF WAY TRAINING

Lesson no.: 34

Subject: SURFACING AND TRIMMING

First issued: 79/05/16

Maintenance of way training

2. BASIC SURFACING TECHNIQUES

2.1 General

The purpose of surfacing is to make the running surface of both rails as smooth as possible and on tangent track to bring both rails to the same level. On curves the proper curve elevation should be applied. You should have a copy of the curve list which shows the curve elevation for each curve.
To get good surface, various methods are available, such as trowelling, spot surfacing, etc.

On tangent track the following steps apply:

1. Sight the general condition of both rails.
2. Try the level board throughout the area to find the high rail.
   (Rail with highest spots).

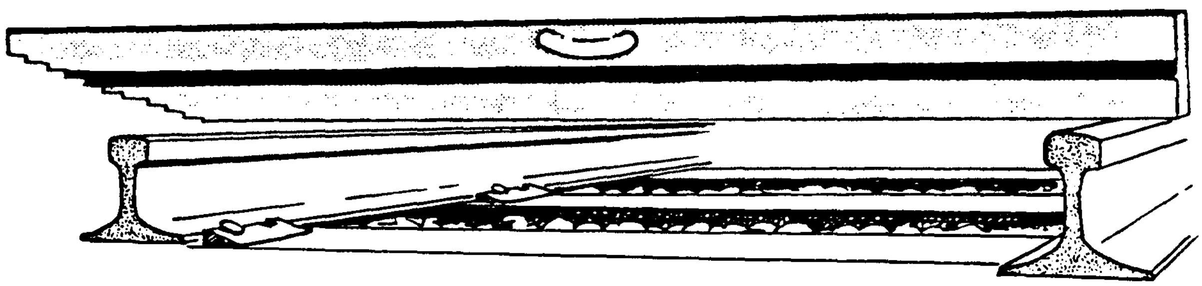


FIG. 1 - HIGH RAIL MUST BE SURFACED FIRST.

3. Surface the high rail first by lifting it to the proper surface by eye.
4. Lift the other rail to the proper surface by using the level board.
5. Check and correct alignment.
6. Trim the ballast.

In curves find out if the elevation is good, whether more is needed or whether it is necessary to lower the elevation.

2. BASIC SURFACING TECHNIQUES (cont'd)

If more elevation is needed or if the elevation is good:

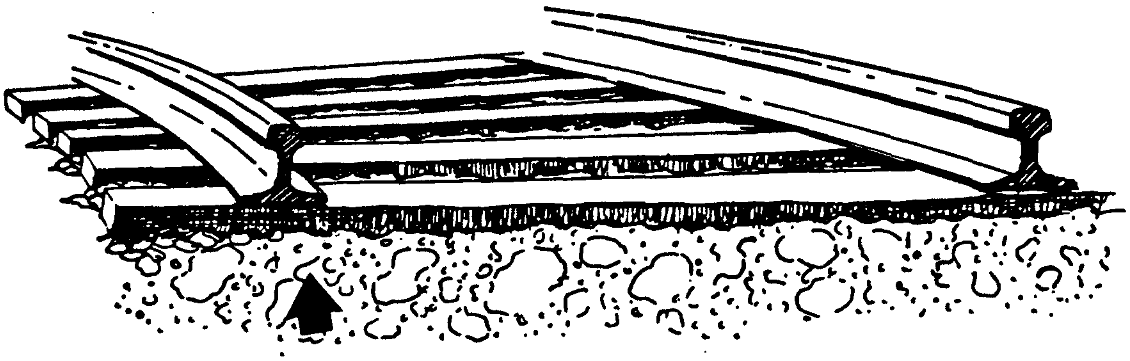


FIG. 2 - TROWEL LOW RAIL FIRST.

1) Surface the low rail first, by eye.
2) Bring the high rail to surface with a level board.

When the curve elevation on a curve is more than is needed:

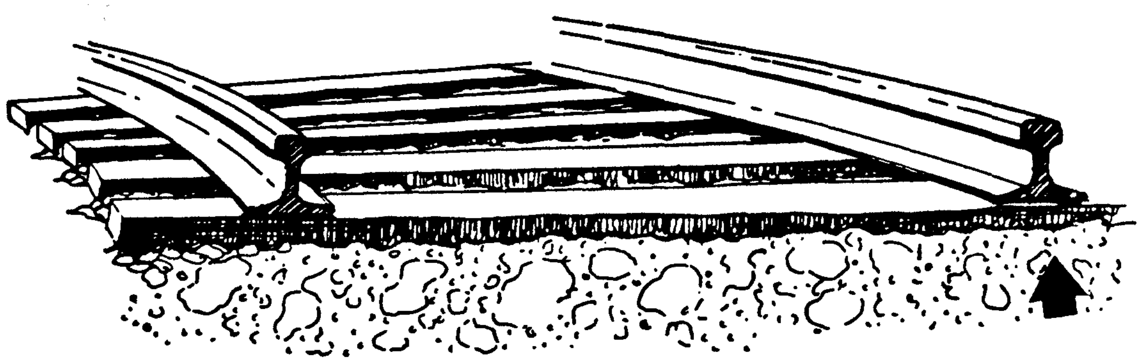


FIG. 3 - TROWEL HIGH RAIL FIRST.

1) Surface the high rail by eye.
2) Bring the low rail to the correct surface with a level board.

2. BASIC SURFACING TECHNIQUES (Cont'd)

Note: No matter what method is used to surface the track, a level board must be used to do it properly.

3. SPOT SURFACING PROCEDURES

This can be low spots on one rail or on both rails. These spots may vary in length from a few ties to several rail lengths. Joints or spots on one rail can be tamped, shovel packed or trowelled, depending on the decision of the Foreman. Do not trowel both rails at the same time because:

1. The track is not solid in the ballast.
2. The track could be driven out of line causing a serious condition.

   (Trowelling will be discussed in detail later on in the lesson).

3.1 Raising the Joints Only

Sight the general surface condition and use the level board to check the cross level. Then sight from at least one rail length behind the joint along the bottom of the head of the rail, on the gauge side. Next put the jack under the joint and raise the joint, "Crowning" it slightly (a bit above level - 1/4" to 3/8" maximum). This is done because the joints will settle slightly when the jack is removed. Tamp or shovel pack ballast under the tie and drop the jack, then trim the track. To keep the joint from settling either too high or too low the foreman should know how his men pack and tell them to pack tight or loose depending on the ballast condition.

NOTE: A bent or battered joint cannot be corrected by surfacing. A bent rail must be changed and a battered rail welded or ground.

3.2 Spot Lifting (One rail or Both Rails)

This is usually called "fixing a rough spot" and is done as follows:

- First sight the overall condition to find the beginning and end of the low spot.
- Use the level board through the area to find the high rail. (Be sure to use the board beyond both ends of the low spot).
- Sight the high rail and bring it to a level surface.
- Start lifting at one end of the low spot and go through the low spot, over lifting enough to allow for settlement.
- The amount to allow for settlement is a judgment of the foreman. It depends on traffic, ballast, packing, and roadbed conditions.
- If in doubt, do not allow for settling, just lift the rail level and re-check when time permits, because it is easier to lift a low spot than to lower a high spot.
- Next check with the level board and if necessary, raise the other rail to level.
- Complete the job by trimming the track.

(NOTE: Check the line at every spot surfaced and fix it if necessary).

4. LIFTING A TURNOUT

Surfacing in a turnout could be just in the switch point area or it could be throughout the whole turnout.

4.1 The Switch Point Area

First sight the straight side of the turnout. Sometimes, it is easier to make the first lift at the "heel". Next bring the turnout side to level with a level board. Because the switch point is higher than the stock rail, place a tie plug or shim under each end of the level board so it will be higher than the point. Pack both rails at the same time.

4.2 Lifting Entire Turnout

In the lead and frog areas there should be at least 6 jacks, 1 jack on straight side, 1 jack on the closure rail and 1 jack on the turnout rail.

The other jacks are put in the same positions 1/2 rail length ahead, to take up part of the load.

Provide flagging protection before placing the jacks. Sight the straight side and bring the other rails to level with a level board.

It is important that the jacks are pumped at the same time and when lifting at heavy spots, use two men on each jack.

Pack both rails at the same time. (Do not pack the turnout rail as tight because it will not settle as much because there is less traffic over it).

Drop the jacks and check the cross level. Check that the switch points fit correctly. If you have opened the switch, check that the points are in the normal position. Remove the flags.

Finally trim the turnout area.

5. TROWELLING

Trowelling is a good method to use when the shoulders are not too heavy.

5.1 Advantages of Trowelling

- There is little disturbance of the existing roadbed.
- The track can be surfaced quickly.
- The top ballast is not disturbed.
- The tie ends are dug out and this improves drainage.
- Trains can operate at normal speeds.
- A small track force can keep the track in good surface.

5.2 Tools Required

- Track jacks and bars.
- Trowel.
- Pointer.
- Pick.
- Shovels.
- Ballast Fork (in crushed rock territory).
- Level board.
- Marking crayons.
- Track wrench.
- Spike maul.
- Track thermometer.

5.3 Material

Most often existing ballast either crushed rock or slag is used (provided it is not too coarse).

5.4 Trowelling Procedure

Sighting and Marking

Sighting and marking is done by the foreman and one man. The man will continue with the level board throughout day and he will also help the foreman to mark out the low spots.
First, check the level board for accuracy then use the level board to find the high rail. In this way the cross-level is always known and work to be done on the other rail can be planned. Also spots badly out of level can be found and fixed faster.

When marking the low spots the foreman should check the expansion at the joints. If the joints are tight and the temperature is high do not trowel. Watch for frozen joints and if necessary fix them by loosening the bolts and tapping the joint with a maul. When the joint comes together, the bolts are tightened.

5.4 Trowelling Procedure (cont'd)

Sighting

Sight the high rail to find the beginning and the end of the low spot. If the spot is fairly long, have the man with the level board help to mark out the spot. The judgment of the sighter (usually the foreman) is needed to find the depth and length of the hole.

Caution

At a joint, don't mark the low spot too far into the quarter section of a rail, even if it shows, because the quarter will stay high when the joint goes down.

After finding the depth of the hole, mark the lift needed on one end of the tie. Remember to add on the amount that the tie is "hanging", (The distance between the plate and the base of the rail). For example, if you judge the depth as 2/8" and the tie is hanging 2/8", then mark 4/8" on the tie.

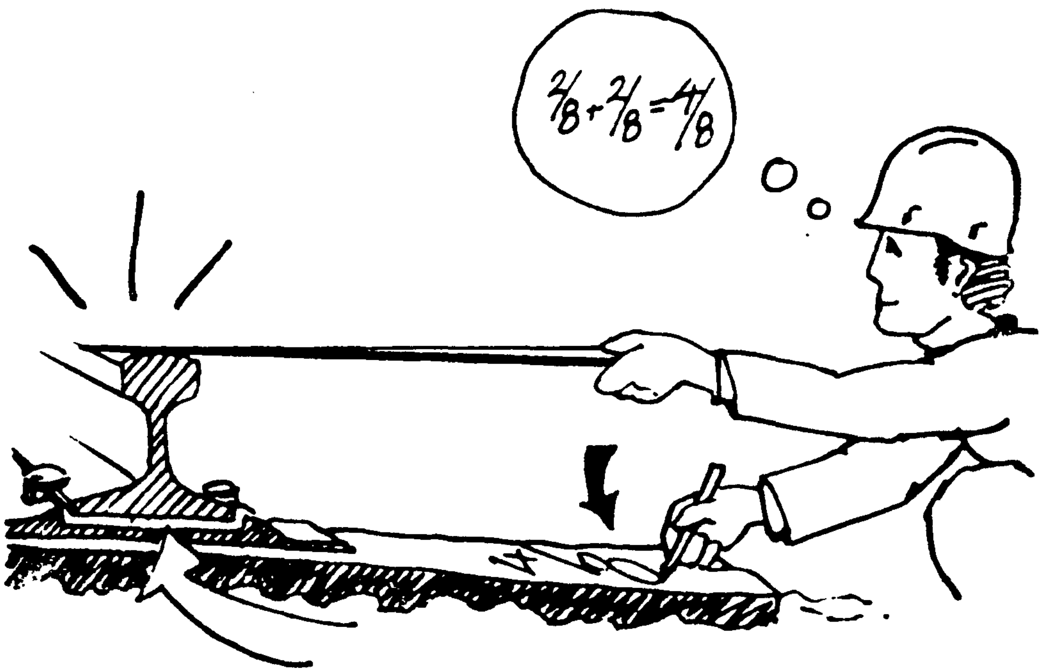


FIG. 4 - HANGING TIE.

5.4 Trowelling Procedure (cont'd)

When sighting, the foreman should sight the spot from one rail length behind as well as looking several rail lengths ahead to see what's coming up.

Trowelling

The spot to be trowelled can range from 1/8" to a maximum of 3/4". When trowelling you first dig out the shoulder ballast flush and level with the bottom of the tie. Where the ballast is heavy or compacted, pick it loose, then dig it out. Dig back at least 34 inches to make space to put a 34 inch trowel under the tie.

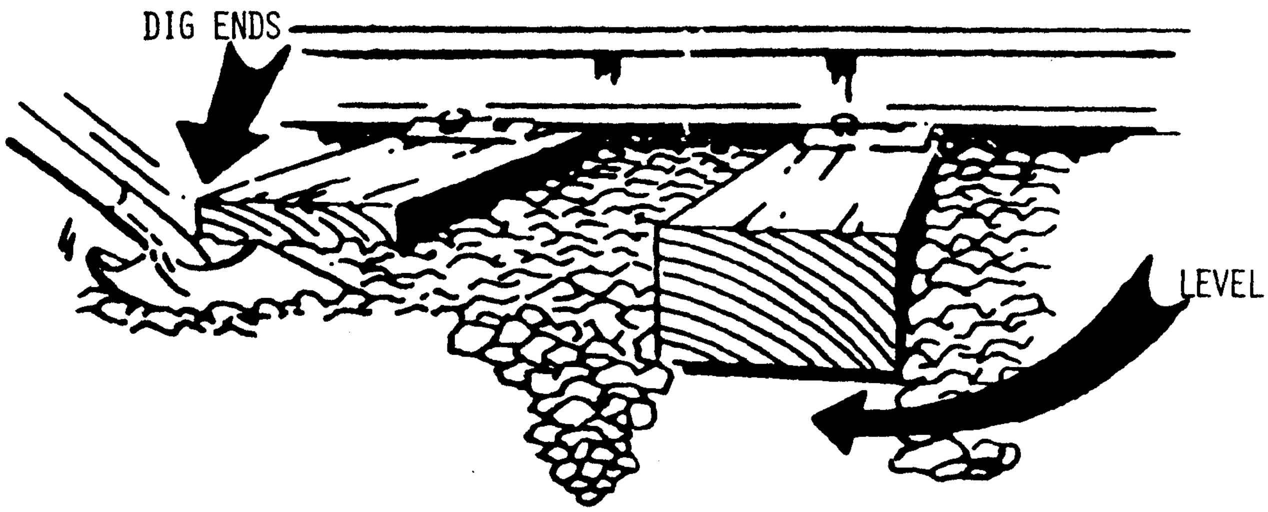


FIG. 5 - TROWELLING.

If lifting a joint, place the jack on the field side of the rail in the deepest part of the low spot. If the spot is long, set the jack at the 3rd tie before the first tie marked and then continue setting the jack 6 ties apart until finished.

5.4 Trowelling Procedure (cont'd)

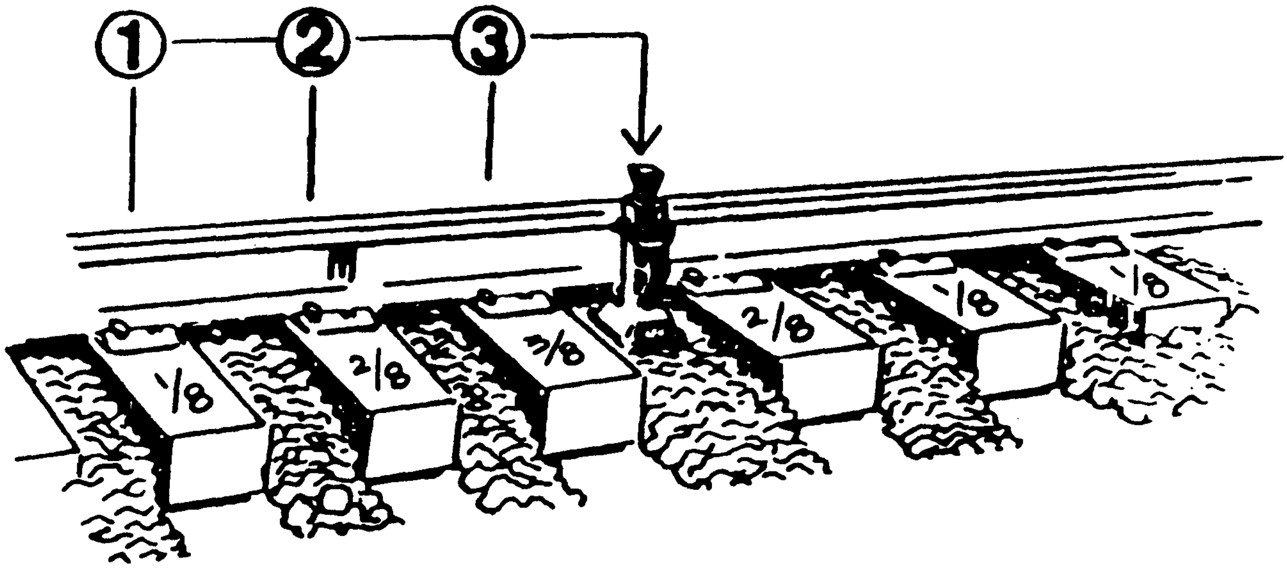


FIG. 6 - SET TRACK JACK THIRD TIE FROM FIRST MARKED TIE.

Then raise the track high enough to put a loaded trowel underneath the tie. Do not jack too high or the ballast will run underneath the tie from the sides. Be especially careful of this when working in slag.

When the track is raised, slide an empty trowel slowly under the tie to check for obstructions. If an obstruction is found, force it out of the way. Next spread the ballast needed evenly over the trowel. Then push the loaded trowel carefully under the tie, shake it slightly sideways and then withdraw it quickly straight back to remove the ballast from the trowel. If more than a 1/4" raise is needed, put only enough ballast on the trowel for a 1/4" raise, place it under the tie, then repeat until the tie is raised the correct amount.

ɔ.4 Trowelling Procedure (cont'd)

Use slightly more material when working in pit-run gravel and slightly less when working in slag ballast.

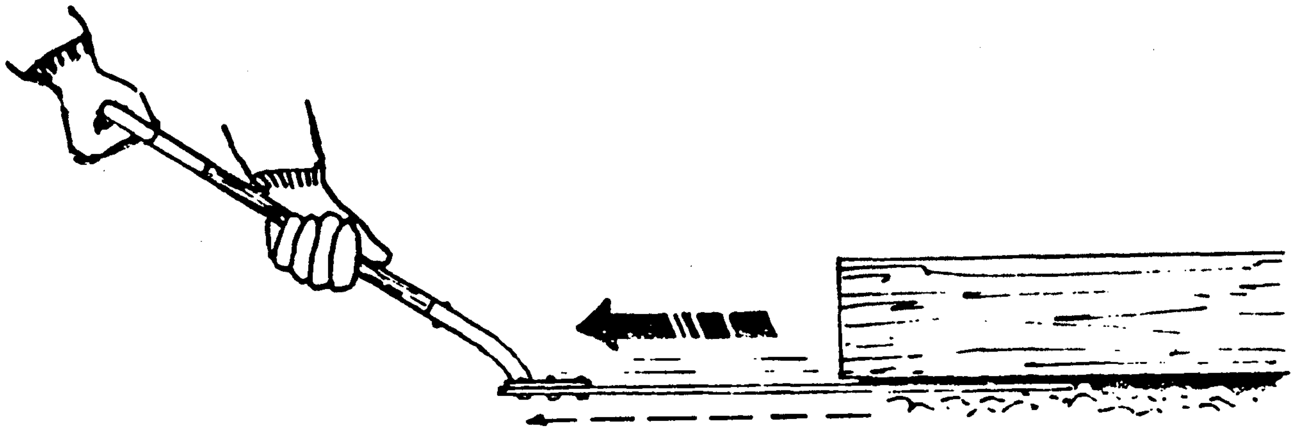


FIG. 7 - WITHDRAW QUICKLY - STRAIGHT BACK.

Trimming

When trimming, the proper shoulder is restored and the jack holes are filled in. Do not leave the track untrimmed over night.

Other Points

1) Never trowel both rails at same time.
2) Trowel the other rail level, using a level board after the first rail has settled. The time needed to settle will depend on the traffic.
3) If the low rail runs consistently slightly off level, say 1/4" for a number of pole lengths, do not disturb and trowel out of face, because a train will not feel it.
4) The real danger is when the track is irregularly out of level, where one rail is level-low-level-low.

5.4 Trowelling Procedure (cont'd)

Gang Organization

With a small gang (average of 3 men) it will be necessary to make 2 passes.

The following is the organization of a trowelling gang:

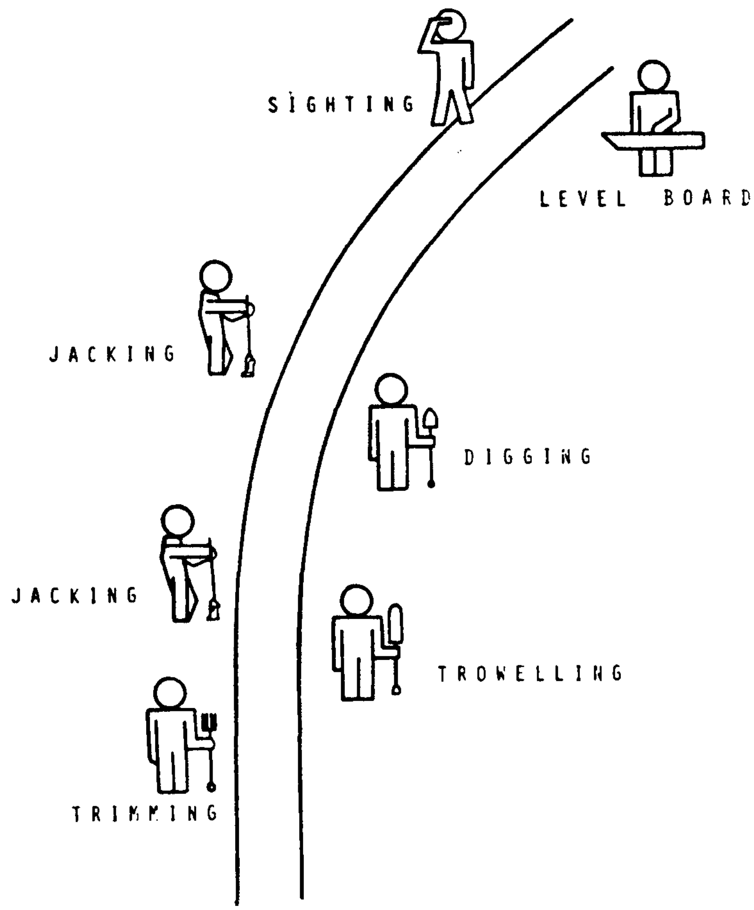


FIG. 8.

Additional men can be used either digging out the ends, trowelling or trimming. Also the foreman should rotate his men regularly so one man isn't always doing the same job.

6. OUT OF FACE OR LIFTING BY SPOT BOARD

Today most out-of-face lifting is done mechanically but you may be called on to lift out-of-face by hand.

6.1 When An Out-Of-Face Lift is Required

An out-of-face lift is needed when the surface or cross-level is poor over a long portion of the track and where there are sink holes.

Before making an out-of-face lift a Foreman should talk it over with the Roadmaster. Caution should be taken because lifting disturbs the roadbed.

6.2 Tools Required

- Spot board.
- Step blocks or a supply of shims.
- Level board.
- Pocket level or another level board.
- Track jacks (minimum of 4).
- Jack bars.
- Sledge hammer.
- 1 sighting block - 7½ inches.
- Tamping bars or shovels.
  (packing may be done mechanically)

6.3 Materials

The correct amount of ballast for that lift should have been unloaded before the work begins. Make sure there is enough for the lift before starting, or you might find the track up in the air.

6.4 Description of a Spot Board

A spot board is a board 10 ft. long and 1¼" thick. It is painted with a wide black stripe. The top of the black stripe is exactly 7½ inches from the bottom of the board.

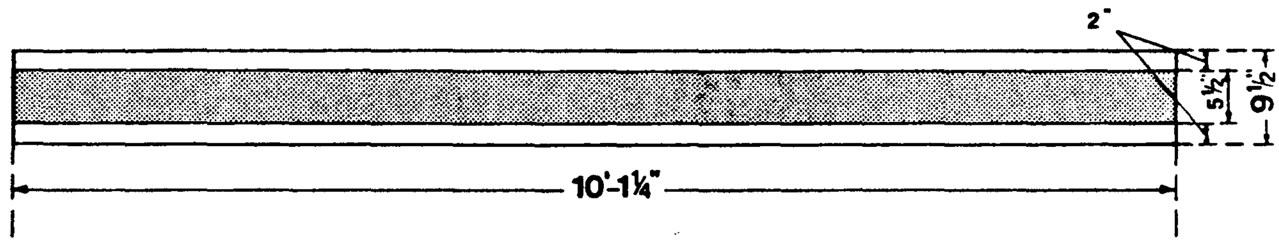


FIG. 9 - SPOT BOARD.

6.5 Description of A Sighting Block

A sighting block is a wooden block which must be exactly 7½ inches high.

6.6 Description of a Level Board

A level board is 7 inches high. When used with the spot board and a sighting block it gives an automatic ½ inch overlift to allow for settlement.

6.7 Out-Of-Face Lifting Procedure

The starting point is usually marked by the Foreman and the Roadmaster before the work starts. At the starting point, select the sighting rail which is usually the line rail (but it can be either rail, except that on a curve it must be the low rail.)

Set the spot board out 4 to 6 rail lengths from the starting point. If the amount of lift is already known place shims equal to that amount plus the amount of settlement over 1/2" under the spot board. (Remember the 1/2" automatic overlift). For example, a 3" lift plus 1" settlement place shims that amount to 3-1/2" under the line rail side of the spot board.

..7 Out-Of-Face Lifting Procedure (cont'd)

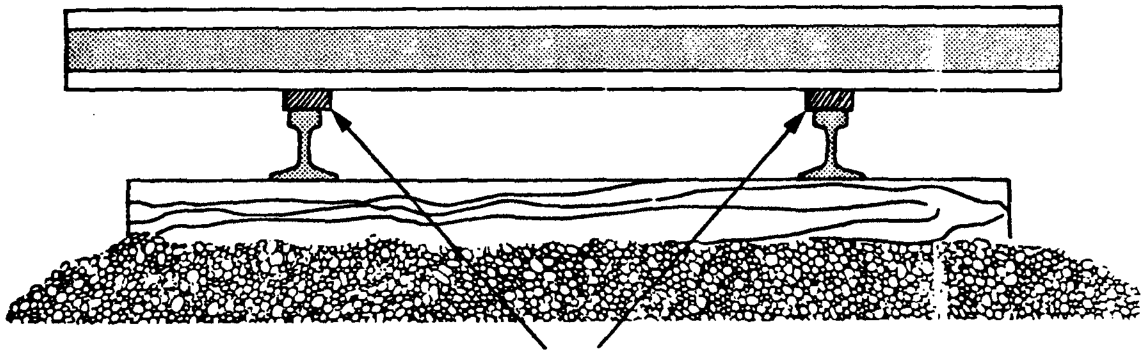


FIG. 10 - SHIMS.

Then shim under the board on the other rail until the spot board is level using a pocket level or a level board to level it. (This can also be done by putting the spot board up on notch blocks to the required height). On windy days it may be necessary to brace the spot board with a claw-bar behind it.

If the amount of the lift is not already know, set the spot board out 4 - 6 rails. If the lift is short the spot board can be on the rails on good track. Next place the level board in the deepest part of the lift and then go back 1 rail behind the starting point and place a sighting block squarely on top of the rail. Sight from the sighting block to the spot board and place shims under the level board until the sight line from the sighting block to the top of the level board, to the top of the black line on the spot board is true.

6.7 Out-Of-Face Lifting Procedure (cont'd)

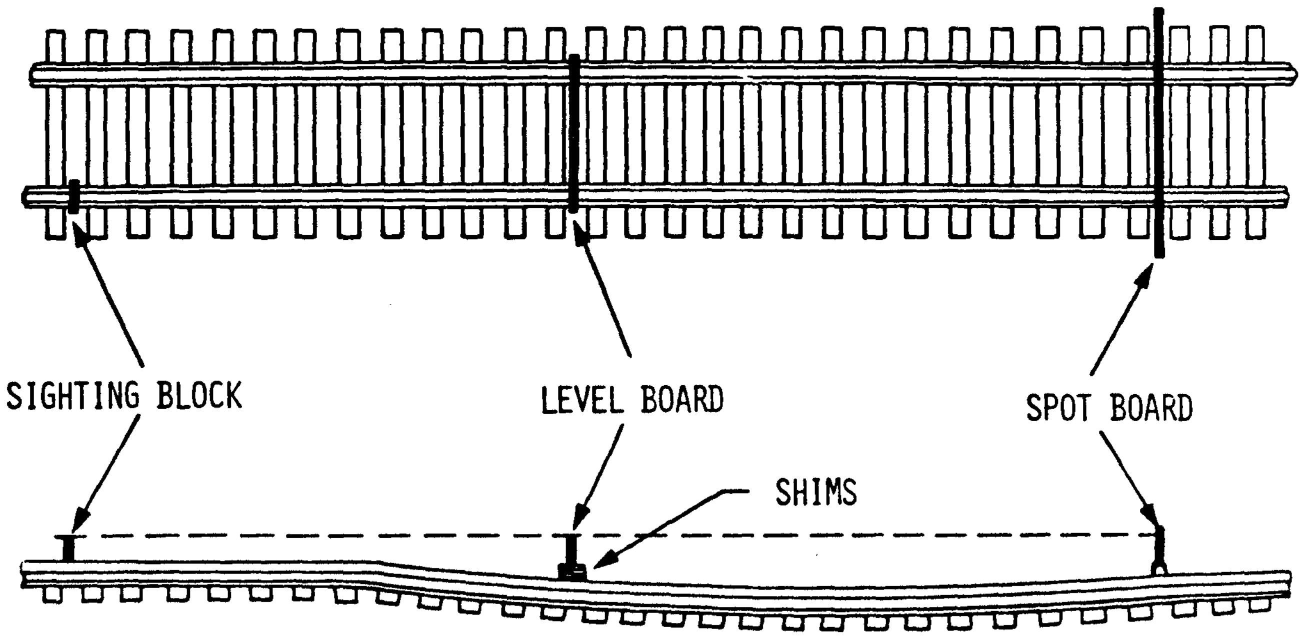


FIG. 11.

The amount the level board has been raised will be the amount of lift. But the amount of lift may have to be adjusted depending on the amount of ballast available.

6.8 Out-Of-Face Lifting

Place the jack 2 ties ahead of first joint to be lifted and place the level board on the rail over the tie behind the jack. Sight over the sighting block to the top of the black stripe on the spot board. Signal for the lifting to begin and jack until the top of the level board comes in line with the top of the black stripe on the spot board then stop the jacking.

6.8 Out-Of-Face Lifting (cont'd)

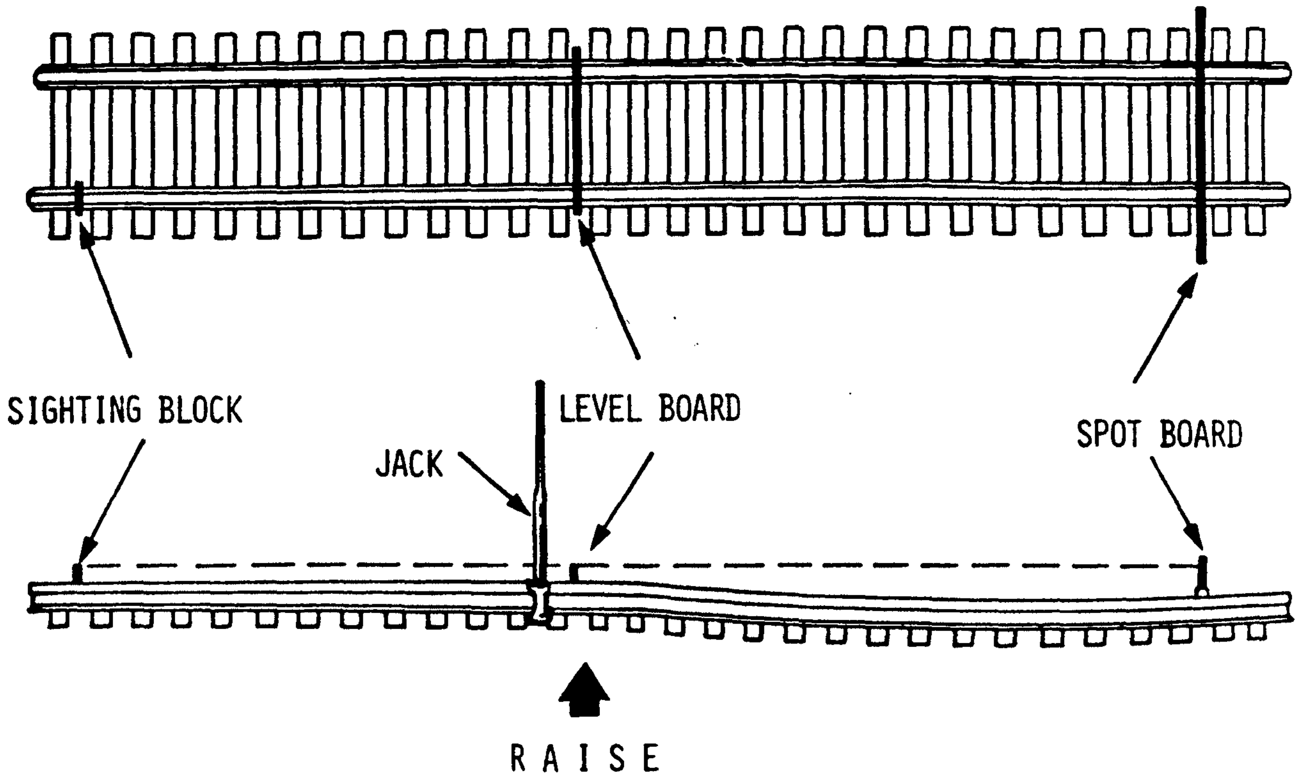


FIG. 12.

Raise the other rail using the level board to bring it level with the first rail. Pack 2 ties on each side of the raised spot then drop the jacks and check by resighting. If the track has not been raised high enough, lift again. If it has been raised slightly too high, tap the end of the ties down with a sledge hammer until correct. Accuracy is important.

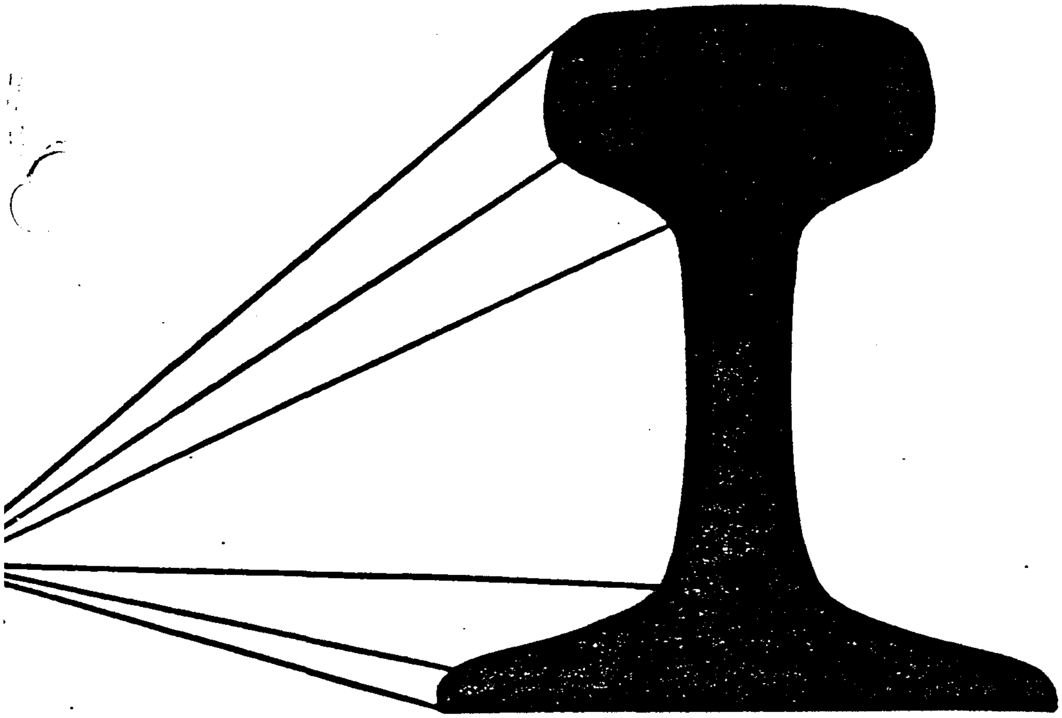
Go ahead to the centre of the rail and repeat the lift, then go to the next joint and repeat and so on. Move up with the sighting block whenever convenient.

6.8 Out-Of-Face Lifting (cont'd)

To make lifting easier, use a jack on each rail ahead of the jacks at the lifting spot to ease the pressure (as described on lifting turnouts).

The men packing behind should not get any closer to the lifting than 1/2 rail length because the rail may hump a bit behind the jacks because of the track hanging in front of the jacks, and you wouldn't be able to get it down again if you pack too close to the jacks.

When you get within a rail length from the spot board, set the spot board out 4 - 6 rails again and repeat the whole process. Run out at the end of the day or at the end of the lift by removing the shims from underneath the spot board when you get to within 1 rail length from the spot board and sight as before. Then ease out the track on the other side of the spot board, by eye so the run out is gradual.



TRACK FOREMAN'S TRAINING PROGRAM

LESSON 13

INSTALLATION AND MAINTENANCE OF SWITCHWORK

The Railway Educational Bureau

1809 Capitol Ave., Omaha, Nebraska 68102

LESSON 13

INSTALLATION AND MAINTENANCE OF SWITCHWORK

In lesson 2, attention was directed to turnouts and the closely related trackwork layouts known as crossovers. That lesson was devoted to developing an understanding of the principal parts of such trackwork and the features of their design which concern the Track Foreman.

Succeeding lessons have dealt with track maintenance subjects concerning track in general. However, they have been subjects which apply to switchwork, as well as other track. Conditions which cause a cross tie to be defective also apply to switch ties. The foundation requirements for conventional track, ballast, sub-ballast and roadbed, are necessary for switchwork as well. Rail defects can develop within the limits of switchwork, as frequently as anywhere else.

This lesson will be concerned with trackwork that is specific to track layouts such as turnouts, crossovers, crossings and slip crossings. The turnout is, by far, the most common of these track layouts, and many references will be in terms of turnouts, if the principle is applicable to other types of layout as well. Conditions peculiar to the other types will be investigated as necessary.

During the course of his career, a Track Foreman is called upon to perform a wide variety of work on turnouts and other switchwork. This can range from minor adjustments to complete construction of such layouts. Some foremen, whose territories include large terminal interlockings, become highly skilled specialists in the maintenance of the most complex installations. Other foremen may have no more than an occasional wayside turnout with which to be concerned. Regardless of whether switchwork is a major or minor part of a foreman's job, he needs to be prepared to deal with such work at any time.

NEW CONSTRUCTION

The foreman who can efficiently construct a new turnout may not know all of the fine points of turnout maintenance, but with this capability he has a good start. Therefore, such a project will be considered first. There are two basic situations that may exist. One of these involves an entirely new installation. An example of this might be the construction of the ladders for a new yard.

In order to begin such a job, there are two things the foreman needs to have established by engineering forces, as references. One of these is the alinement of the straight or main track side of the turnout, as the case may be. This may be furnished in the form of centerline stakes or possibly offset stakes, located a fixed distance from the centerline or gage of one rail. The other reference he needs is the location of the frog point. The foreman must make certain of the alinement the stakes are intended to indicate. He needs to find out whether the theoretical point of the frog or the actual point has been indicated. (see lesson 2)

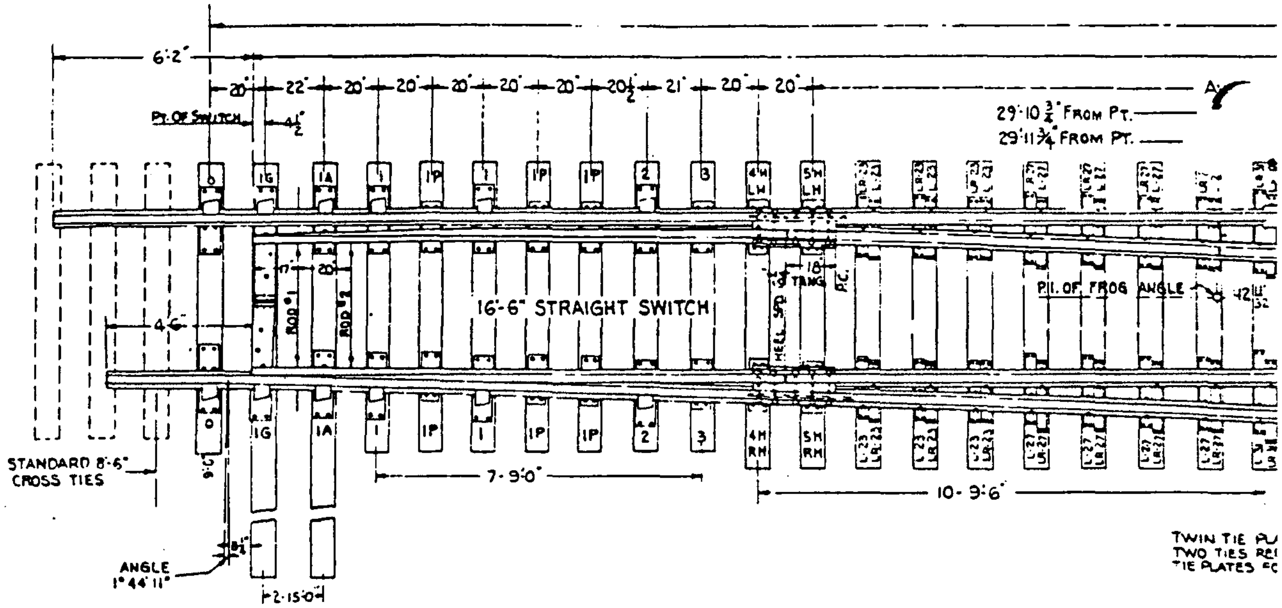
In some cases, final grade stakes may be placed prior to construction. At other times, this may be done later. Once he has determined just what information the stakes indicate, the foreman should take precautions to prevent disturbing them.

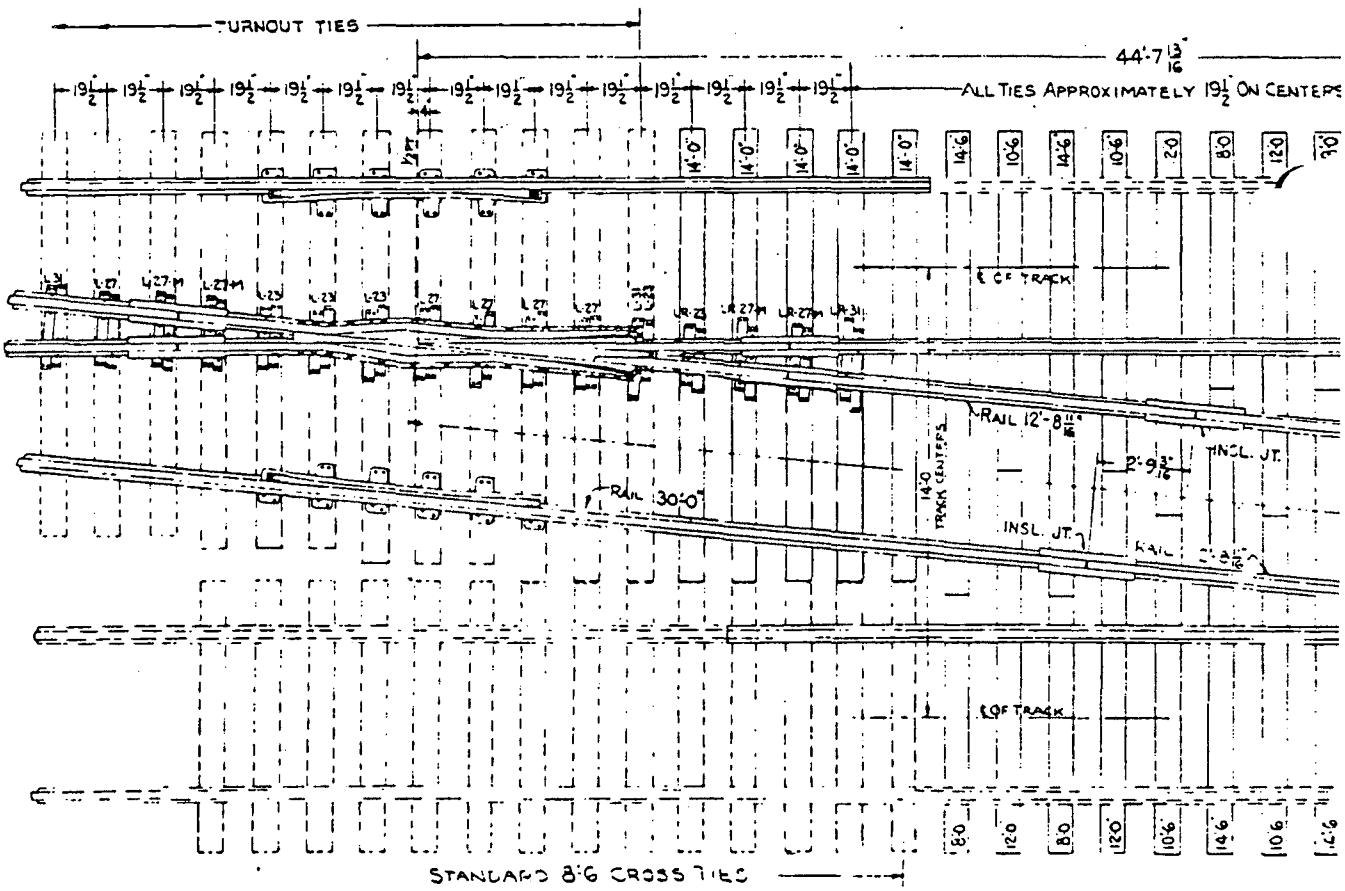
The next thing the foreman will need is a plan or plans of the turnout to be constructed and a bill of material. Your railroad may have a manual with standard plans for turnouts. In this case, A.R.E.A. plans will be used as a reference. Figure 1 contains all information you would need to construct a No. 10 turnout or crossover to A.R.E.A. standards. Figure 2 has been included because it shows details in the vicinity of the switch in a larger scale. Figure 3 shows details in the vicinity of the frog in a larger scale.

Figure 1 includes a bill of track material, which lists all steel parts needed to construct the facility. A separate bill of switch ties is included. If the material has been furnished at the job site, you can check against these lists to be sure all material has been delivered. If part of your responsibility is to obtain the material, these lists will be useful in selecting needed materials from storage points.

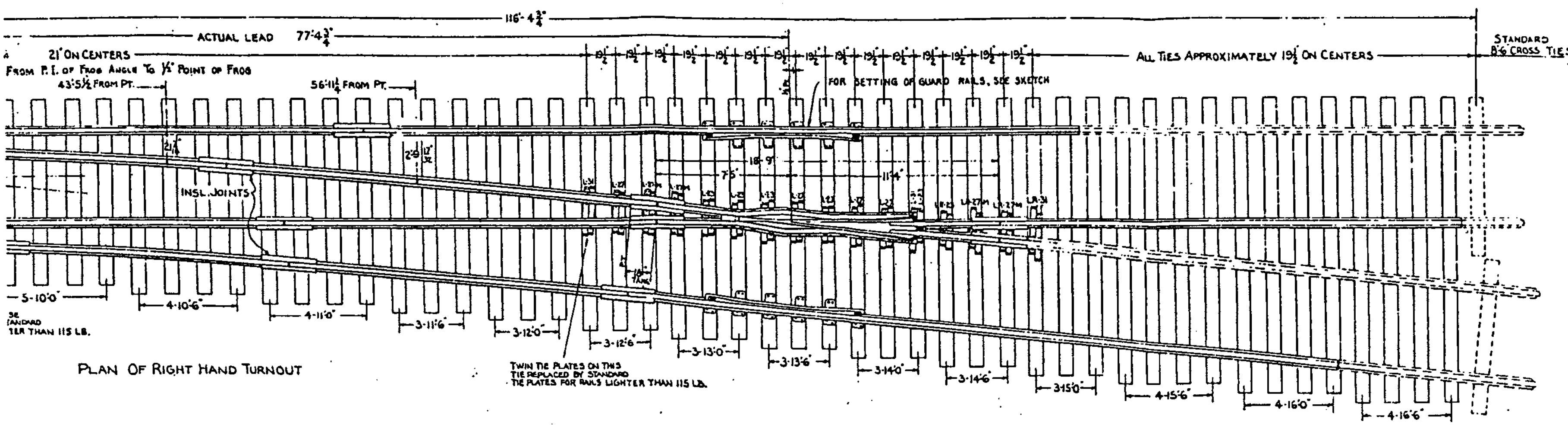
LAYOUT OF SWITCH TIES AND PLATES

Figure 1 shows the layout for the entire set of switch ties. The sub-ballast should be leveled to grade before laying out the switch ties. Once this is done, they can be distributed in proper order, according to length. The spacing between each switch tie is shown on the plan. The ends on the straight side of the turnout can be lined up at the proper distance from the centerline or other alinement stakes which are provided. The location of the entire set can be referenced to either the 1/2 inch point of frog or the point of the switch. The point of the switch can be located by measuring the actual lead distance from the 1/2 inch point of frog. The actual lead is shown at the top of the upper plan in Figure 1, and, in this case, is 77' 4-3/4".





PLAN OF CROSSOVER
14'-0 TRACK CENTERS


116'-4 3/4"
ACTUAL LEAD 77'-4 3/4"
21" ON CENTERS
FROM P.I. OF FROG ANGLE TO 1/2" POINT OF FROG
43'-5 1/2 FROM PT.
56'-11 1/4 FROM PT.
ALL TIES APPROXIMATELY 19 1/2" ON CENTERS
STANDARD 8'-6" CROSS TIES
FOR SETTING OF GUARD RAILS, SEE SKETCH
INSL. JOINTS
18'-9"
7'-5"
11'-4"
5-10'-0"
4-10'-6"
4-11'-0"
3-11'-6"
3-12'-0"
3-12'-6"
3-13'-0"
3-13'-6"
3-14'-0"
3-14'-6"
3-15'-0"
4-15'-6"
4-16'-0"
4-16'-6"
TWIN TIE PLATES ON THIS TIE REPLACED BY STANDARD TIE PLATES FOR RAILS LIGHTER THAN 115 LB.
PLAN OF RIGHT HAND TURNOUT

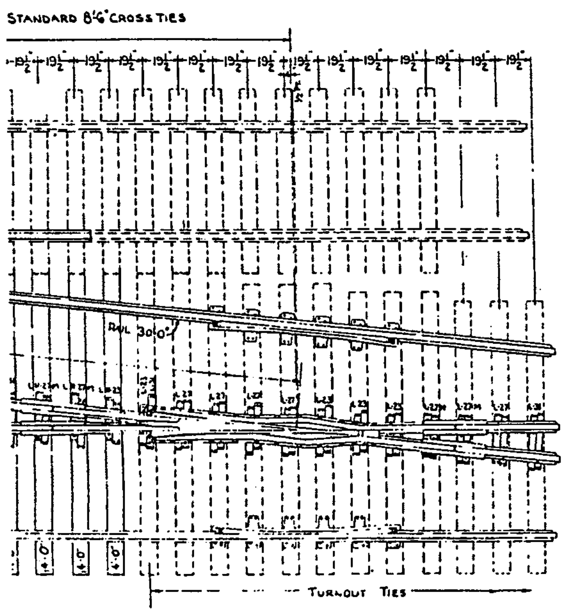

STANDARD 8'-6" CROSS TIES
RAIL 30'-0"
TURNOUT TIES

Fig. 1

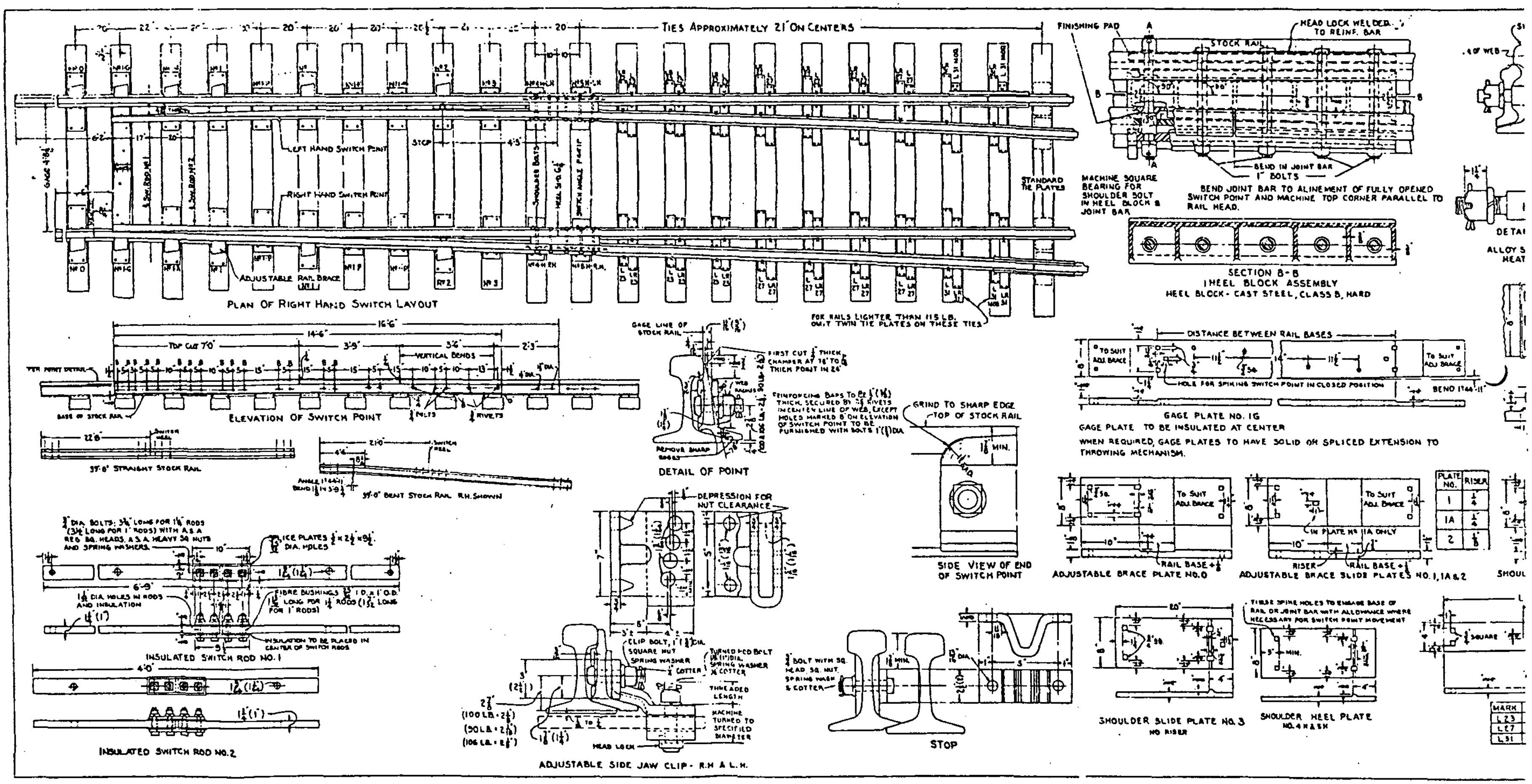
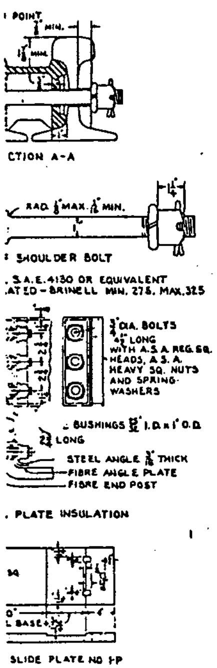


Fig. 2

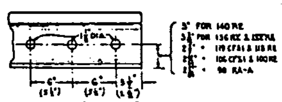


BILL OF MATERIAL—16' 6" INSULATED STRAIGHT SPLIT SWITCH

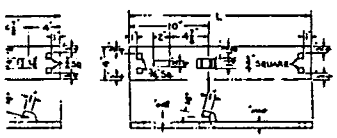
1 Pair 16' 6" switch points complete with reinf. bars, clips and stops attached
2 Insulated switch rods
2 Heel block assemblies, complete
1 No. 1G insulated gage plate
2 No. 0 adjustable brace plate
2 No. 1-A adjustable brace slide plate
4 No. 1 adjustable brace slide plate
2 No. 2 adjustable brace slide plate
6 No. 1-P shoulder slide plate
2 No. 3 shoulder slide plate
12 Adjustable rail braces
2 No. 4-H heel plates (1 R.H. & 1 L.H.)
2 No. 5-H heel plates (1 R.H. & 1 L.H.)
6 L23 hook twin tie plates
8 L27 hook twin tie plates
1 (0) L31 hook twin tie plates
6 LR23 hook twin tie plates
8 LR27 hook twin tie plates
4 (0) LR31 hook twin tie plates
3 (0) L31 mod. hook twin tie plates

NOTES

1—This plan is for use with AREA recommended standard rail sections and drillings from 90 RA-A to and including 140 RE rails. Purchaser shall specify rail section and whether 4 or 6 hole joint drilling is required.
2—In the interest of standardization, above standard rail sections are divided into two groups of rails, namely: A, for rails 115 lb and heavier and B, for rails lighter than 115 lb. This plan is drawn on basis of Group A and when the detail dimensions for Group B are different than for Group A, the dimension for Group B is shown in parenthesis either below or following the Group A dimension.
3—Workmanship and materials, including beveling and hardening rail ends, shall be per current AREA specifications.
4—Adjustable rail braces shown are for illustration only, various efficient designs are available and purchaser shall specify design wanted.

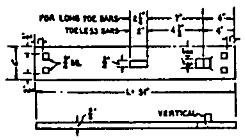


RAIL DRILLINGS



HOOK TWIN TIE PLATES

MARK	L
LR23	23"
LR27	27"
LR31	31"



MODIFIED HOOK TWIN TIE PLATE
MARK L 31 MOD.
(For use with Joint Bars)

American Railway Engineering Association

16'-6" STRAIGHT SPLIT SWITCH

PLAN NO. 10-62 SHEET 2

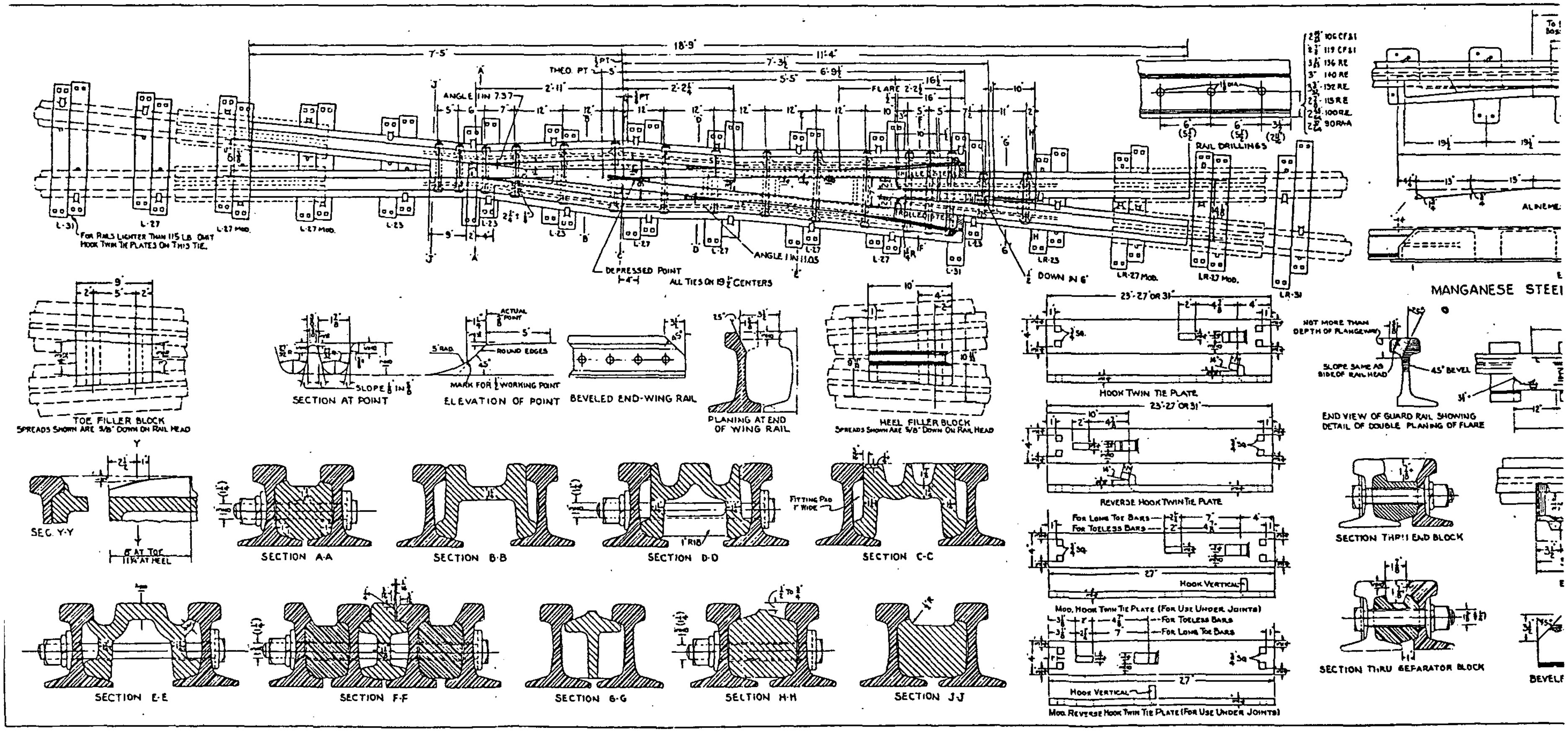
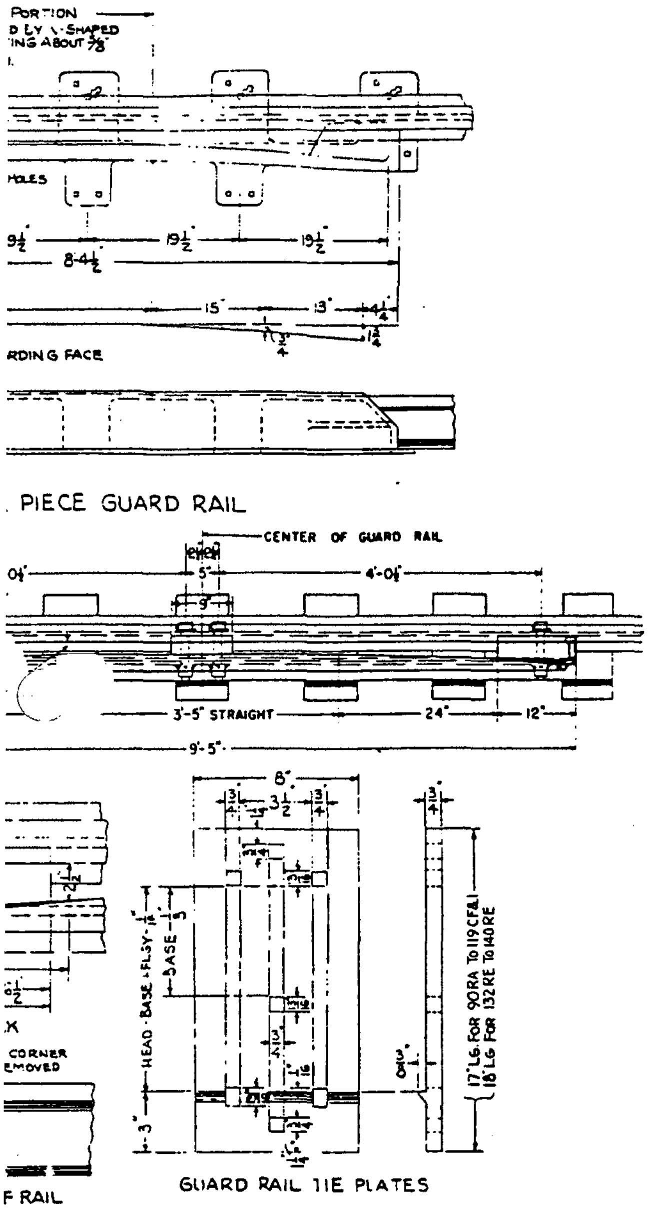

TOE FILLER BLOCK
SPREADS SHOWN ARE 5/8" DOWN ON RAIL HEAD
SECTION AT POINT
ELEVATION OF POINT
BEVELED END-WING RAIL
PLANING AT END OF WING RAIL
HEEL FILLER BLOCK
HOOK TWIN TIE PLATE
REVERSE HOOK TWIN TIE PLATE
RAIL DRILLINGS
DEPRESSED POINT
ALL TIES ON 19½" CENTERS
END VIEW OF GUARD RAIL SHOWING DETAIL OF DOUBLE PLANING OF FLARE
SEC. Y-Y
SECTION A-A
SECTION B-B
SECTION D-D
SECTION C-C
SECTION THRU END BLOCK
SECTION E-E
SECTION F-F
SECTION G-G
SECTION H-H
SECTION J-J
SECTION THRU SEPARATOR BLOCK

Fig. 3



TEE RAIL GUARD RAIL

BILL OF MATERIAL FOR NO. 10 FROG AND GUARD RAILS

1 Rail bound manganese steel frog complete
2 8' 4½" manganese steel one piece guard rails, or 9' 5" tee rail guard rails complete with 12 plates
7 L23 hook twin tie plates
10 L27 hook twin tie plates
4 L27M hook twin tie plates
3 (1) L31 hook twin tie plates
2 LR23 hook twin tie plates
4 LR27M hook twin tie plates
2 LR31 hook twin tie plates

NOTES

1—This plan is for use with AREA recommended standard rail sections and drillings from 90 RA-A to and including 140 RE rails. Purchaser shall specify rail section and whether 4 or 6 hole joint drilling is required.

2—In the interest of standardization, above standard rail sections are divided into two groups of rails, namely: A, for rails 115 lb and heavier and B, for rails lighter than 115 lb. This plan is drawn on basis of Group A and when the detail dimensions for Group B are different than shown for Group A, the dimension for Group B is shown in parenthesis either below or following the Group A dimension.

3—Workmanship and materials including beveling and hardening rail ends, shall be per current AREA specifications.

4—Purchaser shall state whether manganese steel one piece guard rails or tee rail guard rails with plates are wanted.

5—Manganese steel one piece guard rail shown is for illustration only to show standard tie spacing, various efficient designs are available and purchaser shall specify design wanted.

American Railway Engineering Association

NO. 10 RAIL BOUND MANGANESE STEEL FROG AND GUARD RAILS

PLAN NO. 10-71 SHEET 3

After the switch ties have been distributed and checked for proper order, spacing, alinement and squareness, the various types of plates can be distributed on the switch ties. This provides an opportunity to double check for completeness of the set. Figure 1 shows the location of all plates required within the turnout except standard tie plates. Figure 2 shows the special plates required in the switch area in a larger scale. Figure 3 shows the frog plate layout in greater detail. Figures 2 and 3 show a great more detail which is essential to the manufacture of a switch or frog. Most of this information is not necessary for your work.

RAIL REQUIREMENTS

It can be seen, both from the turnout plan and the bill of track material in Figure 1, that rails of specific lengths are to be used throughout the turnout. Standard turnout plans of many railroads have similar requirements. The material, as furnished to you, may include the rails cut and drilled to these exact lengths. If this is not the case, you may have to cut and drill full length rails or random shorter lengths to provide the specified lengths. If so, this should be done with some advance planning to minimize the footage of rail that is wasted. The stock rails may be provided in finished form or it may be necessary to prepare them.

CWR IN TURNOUTS

A different situation will exist if it is the intention to install continuous welded rail (CWR) through the turnout, minimizing the number of rail joints. This may consist of cutting suitable lengths from a string of CWR. In some installations, separate stock rails are maintained. At other times, the stock rails are formed within the CWR.

Sometimes, further elimination of joints is accomplished by thermit welding at locations such as the frog connections and separately installed stock rails. In circuited track, insulated joints will be required unless an alternate electrical system is provided. Aside from these considerations, the only joints which must be provided are the switch heel joints.

In constructing a turnout, there are four lines of rail and fittings to be formed, two for the straight route and two for the curved route. The usual procedure is to form one of these lines of rail first and to secure it to the switch ties. From this, the other three lines of rail and fittings can be referenced by gaging or measuring off sets at certain intervals.

The best line of rail to install first is the one on the straight side of the turnout which does not contain the frog. There are certain advantages to this. All of the rail is conventional tee rail. The straight stock rail can be installed on the switch plates without having to place its switch point at this time. It may be desirable to place the frog guard rail during this operation if plates are common to the guard rail and running rail. In most installations, this will be on a straight alinement. It will be the easiest part to place with a minimum of line irregularities. Also, the switch tie ends adjacent to this line of rail are the ones to be located at a uniform distance from the rail. Installation of this line of rail first will simplify the proper alinement of the switch ties.

Great care needs to be taken in locating the rail joints relative to the reference points. The critical need is to have the stock rail located so that when the switch point is connected to it, the point will be exactly in the right position. Accurately maintaining the actual lead distance between the 1/2 inch point of frog and the point of switch is essential if the rest of the turnout is to be constructed properly. Once this line of rail is installed, spiked with properly placed switch ties and lined to the reference stakes, the remainder of the turnout can be built in relation to its location.

The other straight line of rail and fittings which contains the straight route switch point and the frog can be installed, using a standard track gage to properly locate it in reference to the first line of rail. A portion of the bent stock rail is on this route and it should be installed at this time. Again, care must be taken in locating the stock rail so that the point of the switch is accurately established.

It will be necessary to assemble the heel block for this side of the switch during this phase of the work. In order to more adequately fasten the switch point, it may be decided to install the switch rods at this time. In turn, this will necessitate installing the other switch point (the one on the curved route). Once this is done, adjustment of the switch can progress. This involves getting all switch plates and braces placed so that they provide the support intended by their design. The adjustment must also provide the proper fit for the switch points against their stock rails, which maintain gage, surface and alinement. At this point, the turnout won't be on final grade. Nevertheless, adequate support must be provided for the switch ties under the points to get the switch adjusted.

In new construction, the assembled switch does not have to be connected to the operating rod and switch stand at this point. Proper adjustment of this portion and securing smooth operation can frequently be best done after final surface is attained.

INSTALLING CURVED LEAD

If the frog point and switch points have been properly located, and if the lead rails are of the specified length, there should be no problem in fitting the lead rails and other components together. Should it be necessary to force lead rails into place, should there be excessive gap between rails or if a recheck shows an error in the actual lead distance, the reason for the problem should be determined and corrected. The next phase of work will be to install the rails on the curved lead. Once these are set on the plates and the joint bars are applied, it will be necessary to spike-line these rails to the proper curve. The proper alinement is established at the heel of the switch by the heel block. Likewise, the proper alinement is established at the toe of the frog by the rigidity of the properly placed frog. Between these points it will be necessary to have some intermediate reference points.

Look at the turnout plan in Figure 1. Near the top of that plan and several ties behind the heel blocks there is a dimension indicating 29' 11-3/4" from PT (point of switch). Below that is another dimension shown as 12-11/32". That is the distance between the gage of the straight rail and the gage of the curved lead, at a point on the straight rail 29' 11-3/4" from the point of switch. At this point, the curved lead should be spiked so as to have the proper offset.

Moving further away from the switch, you will find a distance of 43' 5-1/2" from PT. Below you will see that here, there is to be 21-7/16" between gage lines. Further back, at a distance 56' 11-1/4" from the point of switch, the offset between gage lines is to be 2' 9-17/32". By spiking to these dimensions, adequate reference will be established to permit lining by eye between each of the points before spiking.

After the curved lead is spiked in place, the other line of rail can be installed. This will start behind the stock rail and be carried past the frog. Its alinement should be determined by referencing to the curved lead and frog with a standard gage.

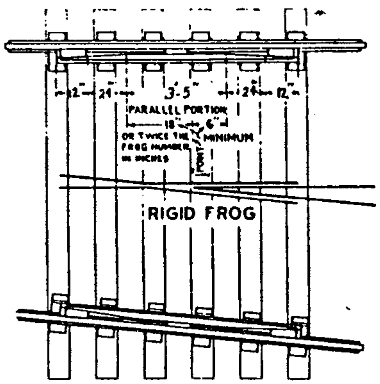
Normally, standard gage of 4' 8-1/2" is used throughout turnouts and other special trackwork. In setting frog guard rails, there is additional gaging to be done. The distance between the gage line of the frog and the guarding face of the guard rail is to be 4' 6-5/8". This is known as the guard check gage. The distance between the face of the frog wing and the guarding face of the guard rail is known as the guard face gage. Standard guard face gage is 4' 4-3/4". The proper placement of frog guard rails is illustrated in Figure 4.

When this basic structure of the turnout is complete, there will be various other items to attend to before the turnout is complete. Sufficient spikes should be provided in all plates, in accordance with your railroad's standards. If a substantial amount of traffic is anticipated on the curved side, additional rail-holding or plate-holding spikes can aid in retaining proper gage.

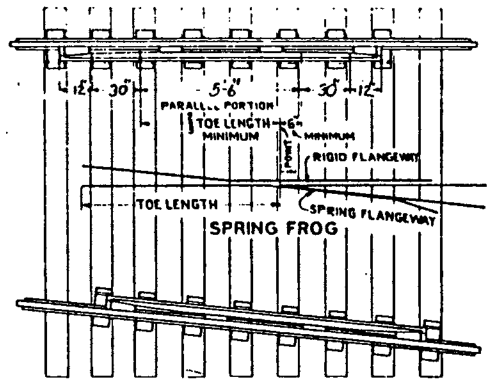
Rail anchors should be applied. It should be recognized that a major need for anchors usually exists just beyond the limits of the turnout. This can prevent the development of line kinks at locations such as the switch heel blocks and at the heel of the frog.

The turnout will have to be ballasted, brought to final grade, tamped and lined. The ballast will have to be dressed, giving consideration to the special requirements of switchwork. Ballast should be kept lower than normal in the cribs between the switch plates on which the switch points slide. This will lessen the possibility of fouling the switch point with ballast or foreign material. Ballast must be kept well clear of the switch rods, in the cribs which the rods occupy. It should be recognized that train crews frequently work around switchwork, often in the dark or under adverse weather conditions. The ballast and adjacent roadway should minimize any potential hazards associated with such work. The headblocks on which the switch stand is placed should be adequately supported with the ballast. A good footing should be provided for personnel who will be engaged in operating the switch.

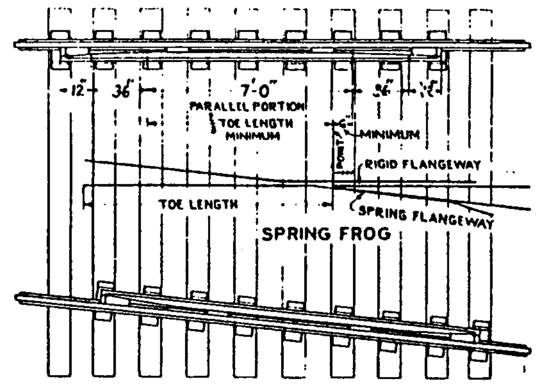
The switch stand and operating rod will have to be installed, as well as locking devices. The switch plates will have to be lubricated. It is essential to check for proper switch point-stock rail fit. The switch should be capable of being thrown without difficulty. The clearance should be checked between each switch point and its stock rail with each point in the open position. This is measured between the gage side of the head of the stock rail and the back of the switch point, at a location directly above the No. 1 switch rod. For A.R.E.A. switches, this distance should be 4-3/4 inches. This is shown in Figure 2.



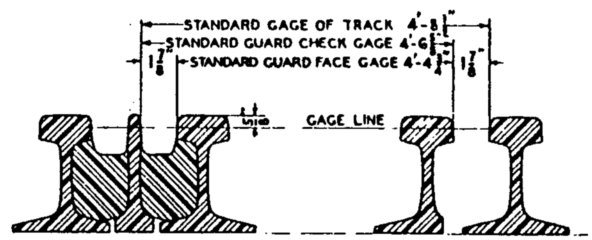
9'-5" GUARD RAIL



12'-6" GUARD RAIL

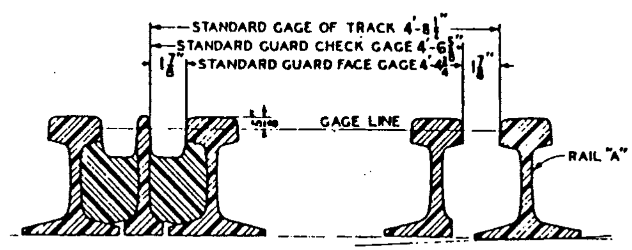


15'-0" GUARD RAIL



TRACK & GUARD RAIL GAGES

ALL RAILS VERTICAL



TRACK & GUARD RAIL GAGES

RAIL "A" CANTED

SETTING OF TEE RAIL GUARD RAILS, PLAN BASIC NO. 504

Parallel portion of Guard Rails to extend:

(a) In back of ½" frog point, not less than 6", for all frogs.

(b) In advance of ½" frog point for rigid frogs and the Guard Rail opposite the spring flangeway of spring frogs:

(1) Not less than (twice frog number in inches) for frogs of smaller angle than No 9

(2) Not less than 18" for No. 9 frogs and frogs of larger angle.

(c) In advance of ½" frog point, not less than (two-thirds times the toe length of the spring rail), for the Guard Rail opposite the rigid flangeway of spring frogs.

MINIMUM LENGTH OF GUARD RAILS CONFORMING WITH ABOVE SETTING

RIGID FROGS

Length of Guard Rails	
9'-5"	No. 4 to No. 14 Frogs
12'-6"	No. 15 to No. 20 Frogs

SPRING FROGS

Opposite Rigid Flangeway

9'-5"	When toe length does not exceed 4'-4½"
12'-6"	" " " " " " 7'-6"
15'-0"	" " " " " " 9'-9"

SPRING FROGS

Opposite Spring Flangeway

Guard Rail may be same length as required for rigid frogs, but when longer Guard Rail is used, it is recommended that the parallel portion be extended in back of ½" frog point, a greater distance than the required minimum.

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SETTING FOR GUARD RAILS

TEE RAIL DESIGN

PLAN NO. 502-71

Fig. 4

CONSTRUCTING A NEW TURNOUT IN EXISTING TRACK (SKIP)

Frequently, it is necessary to install a turnout in existing track. A typical example is to provide rail service to an industrial plant. Such installations have to be made in many types of existing tracks, ranging from high-speed main tracks to industrial spurs. The basic principles are the same as for totally new construction, but some changes in procedure are necessary.

It may be necessary to keep the existing track in service except for very brief periods between trains. At other locations, it may be practical to get complete use of the track for several hours, which can expedite the work. In a few cases, it is possible to remove the existing track from service until the turnout is completely installed. These conditions can change your procedure in constructing the turnout.

The location of the 1/2 inch point of frog and the point of switch are necessary, just as in the previous situation. The alinement of the parent track is already established. If there are any line irregularities in the track in the vicinity of the proposed turnout, these should be corrected before construction begins.

Sometimes, switch ties are installed in their intended position, replacing the cross ties as the work progresses. If traffic must be maintained, the rail will have to be spiked to the switch ties. This will make necessary the removal of spikes when the rail and fittings for the turnout are installed. Many of these spike holes will not be reused. This can have an adverse effect on the life of the switch ties.

Another procedure, sometimes used, is to shift and tamp the cross ties as necessary to permit installing the switch ties in their proper position without spikes. When the new steel is installed, it is spiked to the switch ties and the cross ties can then be removed.

Still another method is to install as much of the rail and fittings as possible on the cross ties. Then installation of switch ties can proceed, removing the cross ties as the work progresses. This can reduce the amount of temporary spiking required in new switch ties.

The installation of rail and fittings can proceed in a similar sequence to that described for totally new construction. When the first line of rail is installed on the parent track side, this can be gaged to the old rail on the other side. The manner in which each segment is progressed may be controlled by the intervals for which track usage is secured. If the intervals are short, possibly only the frog may be installed during one of them. Main track lead rails might be installed during another interval. The main track switch point and its stock rail could go in during a different break in traffic.

Sometimes, after assembly of the complete turnout, a general raise throughout the turnout may be planned. In many installations, it is desired to retain the track at or near the existing grade. Consideration should be given to this prior to installing the switch ties. Should the ballast be badly fouled, it may be advisable to clean it. This can best be done during the installation of the switch ties.

RENEWAL OF STEEL IN EXISTING TURNOUTS (SKIP)

The steel components of turnouts including the rails, switch points, frog, guard rails and the fittings, normally have a relatively long life. Limits on their life are governed by speed and tonnage of the traffic which operates over the turnout as well as the quality of maintenance. Eventually, the condition of the material will require that it be replaced. This may be done incident to a general rail renewal through the territory, or the turnout steel may be renewed as a separate job.

There are some things to consider prior to doing such a job, that differ from new installations. The switch ties are already in place. Make certain that the overall condition is good enough to adequately spike the new material. It could be necessary to replace some switch ties before renewing the steel, but to the extent practical, it is better to replace defective switch ties after the steel has been replaced. Check the alinement, particularly on the straight track side opposite to the side that will be replaced first. This is the alinement that will be reproduced, through the gaging process. If attempts to correct line irregularities are unsuccessful, it may be necessary to spike the first line of rail laid to good alinement. This will produce some temporary variations in gage. If trains will operate before the second side is replaced, make sure the gage is within the acceptable limits.

The job will have to be organized to provide for removal of the old material and preparation for the installation of the new material. The latter includes such operations as plugging of spike holes, adzing of tie plate seats as necessary and removal of excess ballast.

When it is necessary to renew the steel in a turnout on a piecemeal basis account of short work intervals between trains, and when the installation involves a change of rail section, consideration must be given to limitations on the use of compromise joints in a turnout. If there is a difference in the height of the rails, vertical run-offs on switch ties must be made by shims under the tie plates. Compromise joints cannot be used at the heel of switches, insulated joints or frog joints which include filler blocks.

Aside from these considerations, the renewal of steel in a turnout can be carried out in a manner similar to constructing a new turnout. At times, the surface condition within the turnout may be relatively poor, prior to replacement of the steel. A general raise may be planned following the steel renewal, possibly with replacement of switch ties. Make certain that the conditions that exist after the steel is replaced and before the other work is undertaken, do not permit damage to occur to the new steel from excessive wheel impact.

PANEL TURNOUT CONSTRUCTION — SPTC Tracks

Some railroads have developed techniques for installing turnouts in large prefabricated sections, spiked to switch ties. This requires establishing a suitable facility for constructing the segments, providing equipment capable of transporting such bulky loads and adequate lifting capacity to handle them. Such procedures are suitable for turnouts to be used in new construction, for new turnouts in existing track, and sometimes for renewal of existing turnouts.

A well designed panel construction facility with proper jigs for laying out the material, provision for efficient flow of material and mechanized construction operations can produce considerable economies as well as a quality product. There are also advantages at the point of installation in track. One of these is a reduction in manpower requirements.

Use of this method for renewal of existing turnouts can best be justified where a large percentage of the switch ties are at or near the end of their useful life, since all of the switch ties in track will be replaced.

Grading equipment such as a front-end loader can be very useful at the point of installation. After the old steel and ties are removed, such a machine can remove fouled ballast and prepare a well leveled subgrade. Frequently, much better drainage can be obtained in this manner than with conventional switch tie installation.

One of the requirements of panel installation is hoisting equipment of capacity that will handle the panels. In addition, conditions at the job site should be checked out in advance for clearance restrictions or other conditions that might limit the use of this procedure.

Use of turnout panels requires modification of the standard rail joint layout, so that joints will be approximately opposite while the panels are being handled. Sometimes, this situation is changed after the panels are installed, by replacing the joints with field welds. Another procedure is to substitute rails of different length, after other phases of the job are done.

The panel method of turnout construction is not suitable for use under all conditions. Where the proper conditions exist, this method is a very effective one which modern equipment has made feasible.

REPLACING DEFECTIVE SWITCH TIES

When switch ties need to be replaced, the most common situation is that only a portion of the switch ties within a turnout are defective. This situation is similar to the usual one which exists in track supported by cross ties. Unfortunately, mechanization of the renewal of switch ties has proved to be considerably more difficult than with cross ties.

A considerable amount of switch-tie renewals are still done in a manner which is similar to the practices of many years ago. There is a good deal of ballast removed from adjacent cribs using picks and ballast forks or track shovels. The spikes are pulled with claw bars. The old switch ties are removed from track by men using timber tongs. Tie beds are scarified manually. The new switch ties are installed the same way the old ones were renewed. Spiking, tamping and restoration of the ballast are all manual operations.

Lesson 4 contains a discussion on procedures sometimes used to improve upon this method. It would be well to refer to that subject at this point. Further improvement in techniques for renewing switch ties, under a variety of conditions, is one of the major challenges in the field of track maintenance today.

SPECIAL TRACKWORK

It is sometimes necessary for one track to cross another track at grade. The trackwork installation which makes this possible is called a crossing. This is not to be confused with a crossover which was described in lesson 2.

Crossings can be designed to a wide range of angles. Figure 5 illustrates a crossing which is almost, but not quite, at right angles. Actually, the angle between the tracks in this crossing is 85 degrees. The smaller angle is always used in describing a crossing. It can be seen from Figure 5 that the crossing, basically, consists of four frogs. This is necessary to pass two rails of one track over two rails of another track.

Figure 6 shows a crossing at a considerably flatter angle. This is a 30 degree crossing. It is from the shape of such crossings that they are sometimes referred to as "diamonds". In crossings such as this, frogs are referred to as either the "end frogs" or the "center frogs". It can be seen that the shapes of the center frogs are considerably different from the end frogs.

Sometimes, crossings involve multiple tracks. Figure 7 shows various layouts involving a double track line crossing another double track line. Crossings present special maintenance problems. It is necessary for wheels to pass over open flangeways. Inevitably, a good deal of pounding takes place. The stresses placed on the underlying structure are considerably greater than those placed on ordinary, well-maintained track. A study of Figure 7 will show some of the problems involved in providing good tie support for movements on all routes as well as the difficulty of keeping these ties tamped.

The impact of wheels moving over flangeways, frequently causes mud to pump up into the ballast from the roadbed. The layout of crossings reduces the ability to secure lateral drainage, which is the usual goal in maintaining conventional track. Drainage must be directed diagonally, towards the corners. The tendency for ballast to become fouled together with the obstructions caused by the track structure itself, can cause major maintenance problems. This can be particularly true with multiple track crossings, of types such as are shown in Figure 8.

Preference needs to be given to such maintenance jobs as keeping bolts tight within crossings. Worn running surfaces should be restored promptly by welding to reduce pounding. Timbers should not be allowed to deteriorate to the point that they cannot support the crossing as intended.

It is equally important to clean or replace fouled ballast promptly in the vicinity of crossings. Inadequate drainage should be corrected. A crossing can deteriorate quickly if the roadbed and ballast do not adequately support it.

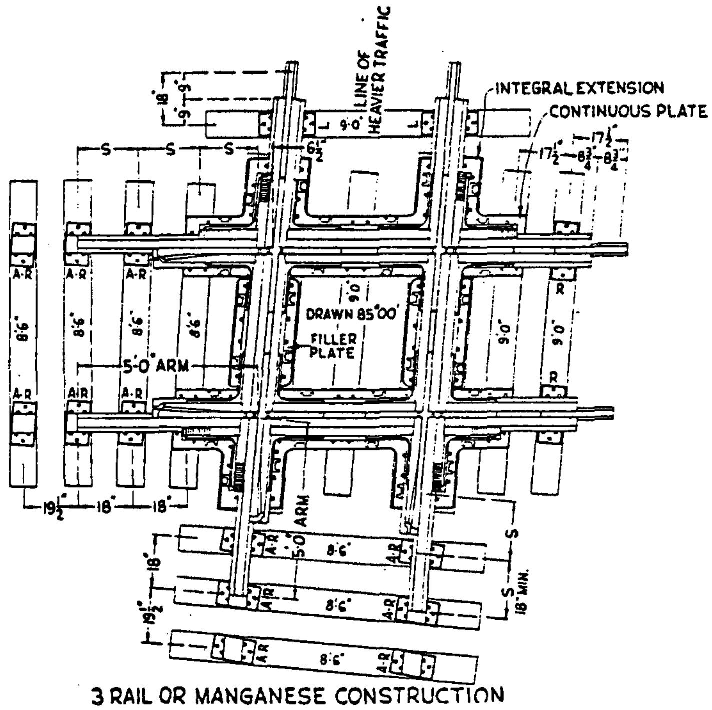

LINE OF HEAVIER TRAFFIC
INTEGRAL EXTENSION
CONTINUOUS PLATE
DRAWN 85°00'
FILLER PLATE
5'-0" ARM
3 RAIL OR MANGANESE CONSTRUCTION

Fig. 5

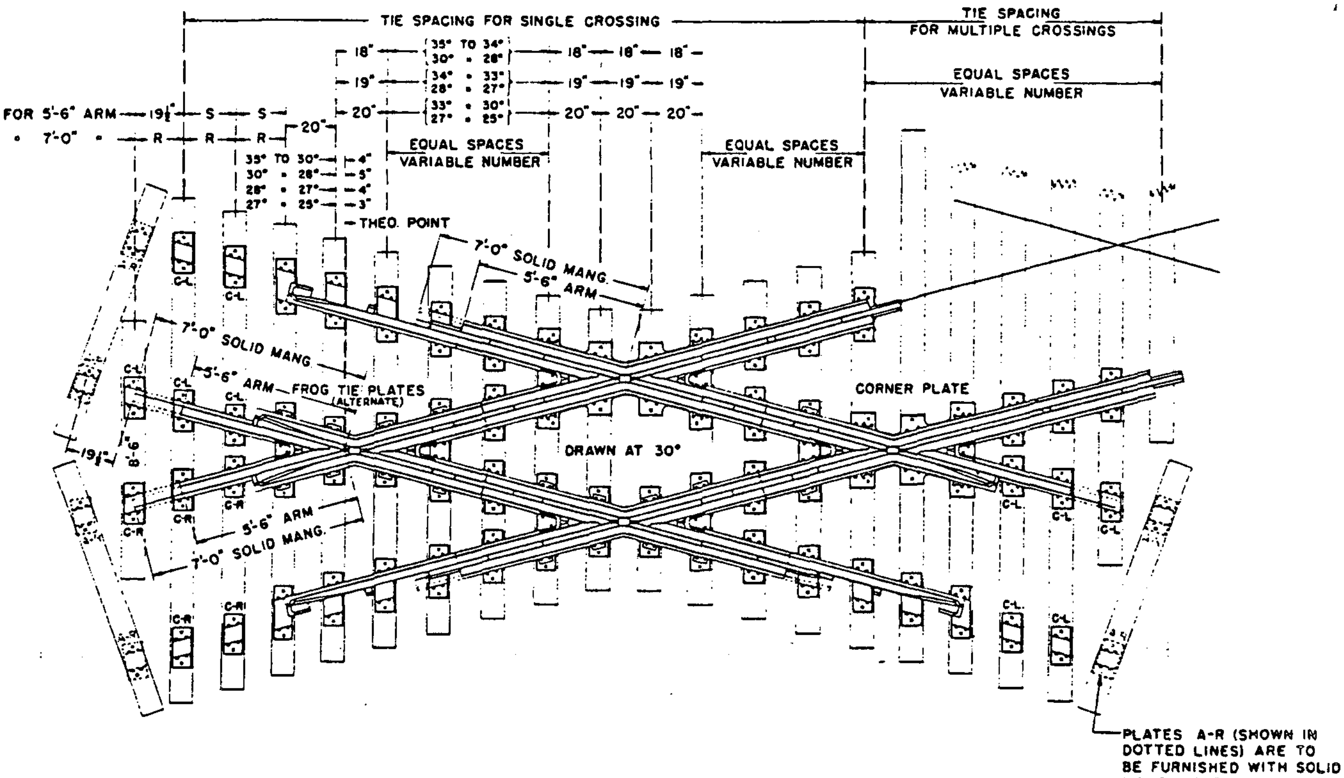
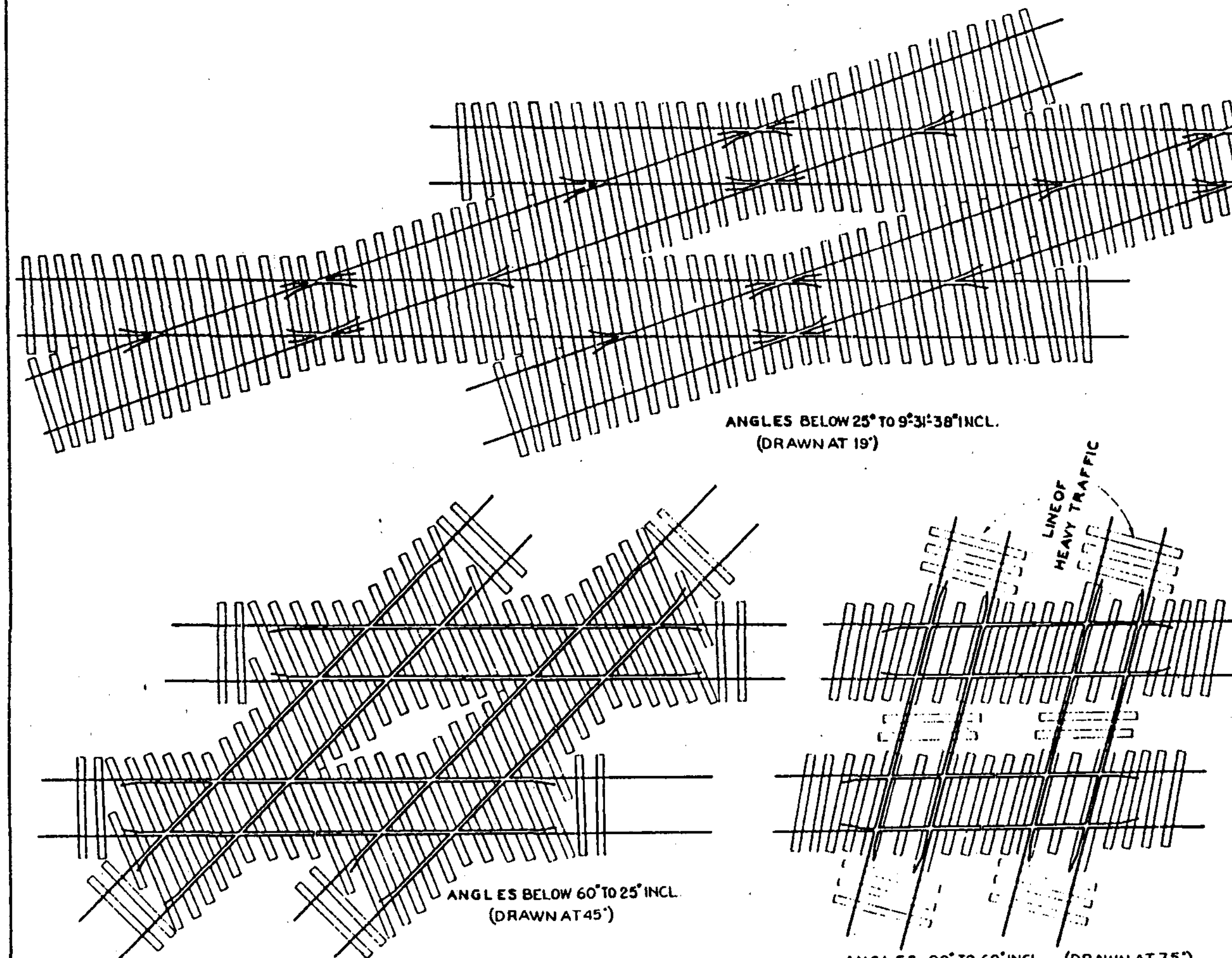

TIE SPACING FOR SINGLE CROSSING
TIE SPACING FOR MULTIPLE CROSSINGS
EQUAL SPACES VARIABLE NUMBER
FOR 5'-6" ARM
THEO. POINT
7'-0" SOLID MANG.
5'-6" ARM
FROG TIE PLATES (ALTERNATE)
CORNER PLATE
DRAWN AT 30°
PLATES A-R (SHOWN IN DOTTED LINES) ARE TO BE FURNISHED WITH SOLID MANGANESE CROSSINGS.

Fig. 6

Fig. 7

21



ANGLES BELOW 25° TO 9°-31'-38" INCL.
(DRAWN AT 19°)

ANGLES BELOW 60° TO 25° INCL.
(DRAWN AT 45°)

ANGLES 90° TO 60° INCL. (DRAWN AT 75°)

NOTES

1--TIE LAYOUT. The tie layouts as shown are only general arrangements for the angle ranges specified and serve as illustrations of the nesting of multiple crossings. For detailed tie layout and plate arrangements for specified crossing angles, see:
Plan Basic No. 700F for crossing angles 90° to 60° incl.
Plan Basic No. 700G for crossing angles below 60° to 35° incl.
Plan Basic No. 700H for crossing angles below 35° to above 14° 15' incl.
Plan Basic No. 700J for crossing angles 14° 15' to 9° 31' 38" incl.

2--DRAINAGE. Crossing installation must be so drained that all water will be diverted away from the roadbed, and adequate subdrainage should be provided.

3--BALLAST. A minimum depth of 12" of rock, slag, or washed gravel is recommended below bottom of tie.

4--TAMPING. Tamping of all crossing ties and timbers must be maintained to provide a full and adequate bearing support for the crossing structure.

5--TIE SPACING. When tie arrangements other than shown on the plans referred to in Note 1 are required, it is recommended that suitable tie spacings (preferably 18" minimum and 22" maximum) be observed and located where possible to provide supported and/or suspended joints.

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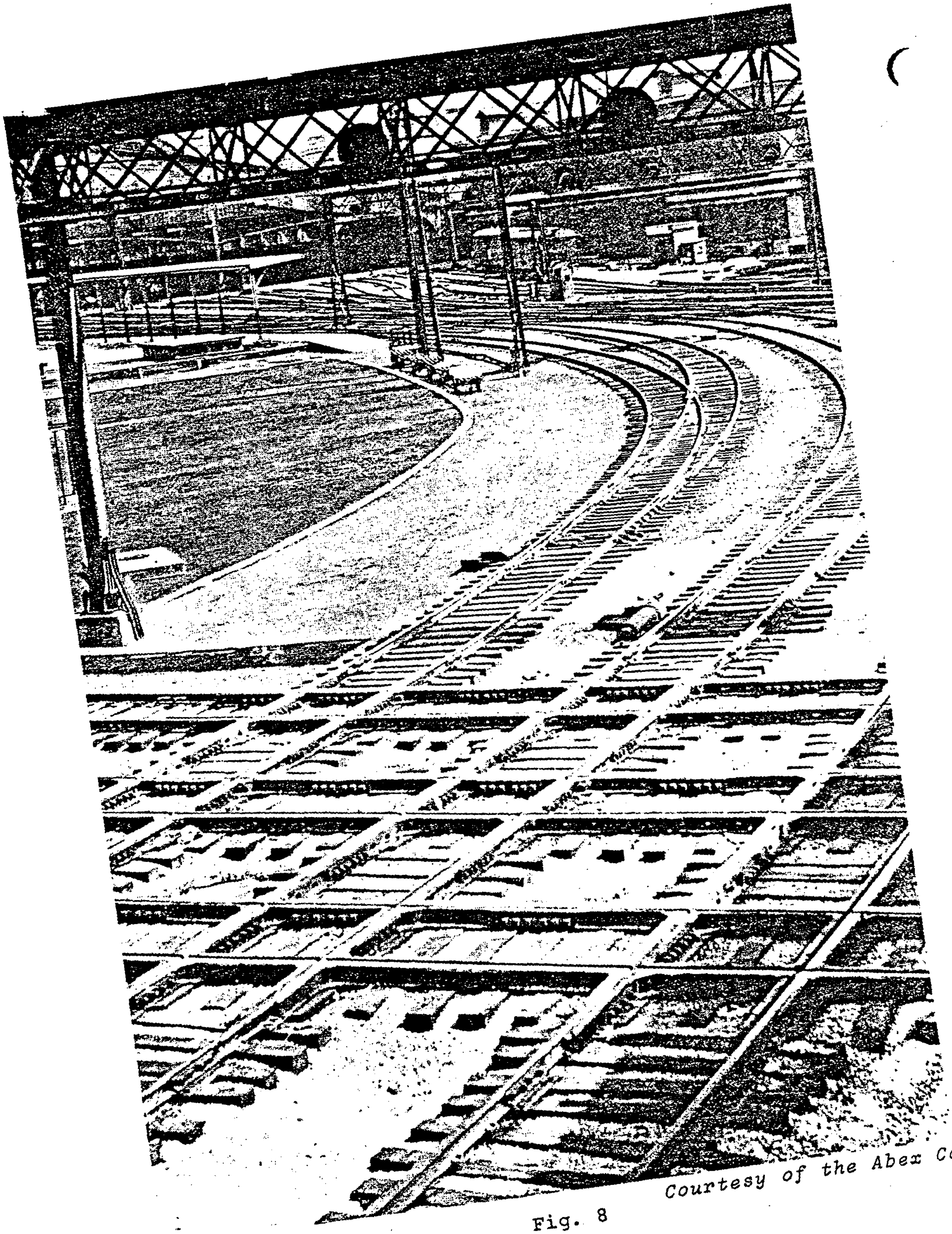
TIE LAYOUT FOR RAILROAD CROSSING

PLAN NO. 719-68



Courtesy of the Abex Corp.-Ra

Fig. 8

Crossings are expensive elements of trackwork. Every effort should be made to get the maximum life out of the steel, consistent with good practice. Since many crossings are specially manufactured to order, it frequently requires an extended period of time to secure a new one. Emergency material is frequently kept available in case of sudden breakage or damage.

MOVABLE POINT AND SLIP CROSSINGS (SKIP)

When two tracks cross at a very flat angle, it is not practical to design the center frogs with adequate protection against the possibility of wheel flanges striking and climbing onto a frog point, or entering the wrong flangeway. When this situation occurs, a different track design is used. Such a layout is called a movable-point crossing. Each of the center frogs is replaced by a knuckle rail and two movable points.

Because of the flat angle between the tracks, where movable points are used, it becomes practical to establish routings for movements from one of the tracks to the other, as well as crossing movements. Figure 9 is a drawing of such a track layout, which is called a double-slip crossing. A double-slip crossing has four switch points at each end of the crossing. The lower plan in Figure 9 shows the layout of switch points and stock rails at one end of a double-slip crossing. Note that in addition to designating these parts as right hand or left hand, it is necessary to designate them as inside or outside switch points and stock rails.

The lower portion of Figure 9 shows two sets of switch rods, arranged so that they do not interfere with each other. A special operating rod is required, which connects to both of the No. 1 rods. This means that all four points must be operated at the same time. Thus, in one position both right-hand points will be closed and both left-hand points will be in the open position. In the other position, both right-hand points will be open and both left-hand points will be closed.

The center portion of a double-slip crossing consists of a movable point crossing. Figure 10 shows the movable point portion to a larger scale than Figure 9. It can be seen that movable center points are quite different in design from switch points. Because of the amount of bend in the knuckle rail, movable center points have a more blunt angle than switch points.

Each pair of movable center points is connected by rods in a manner similar to switch points. The rod closest

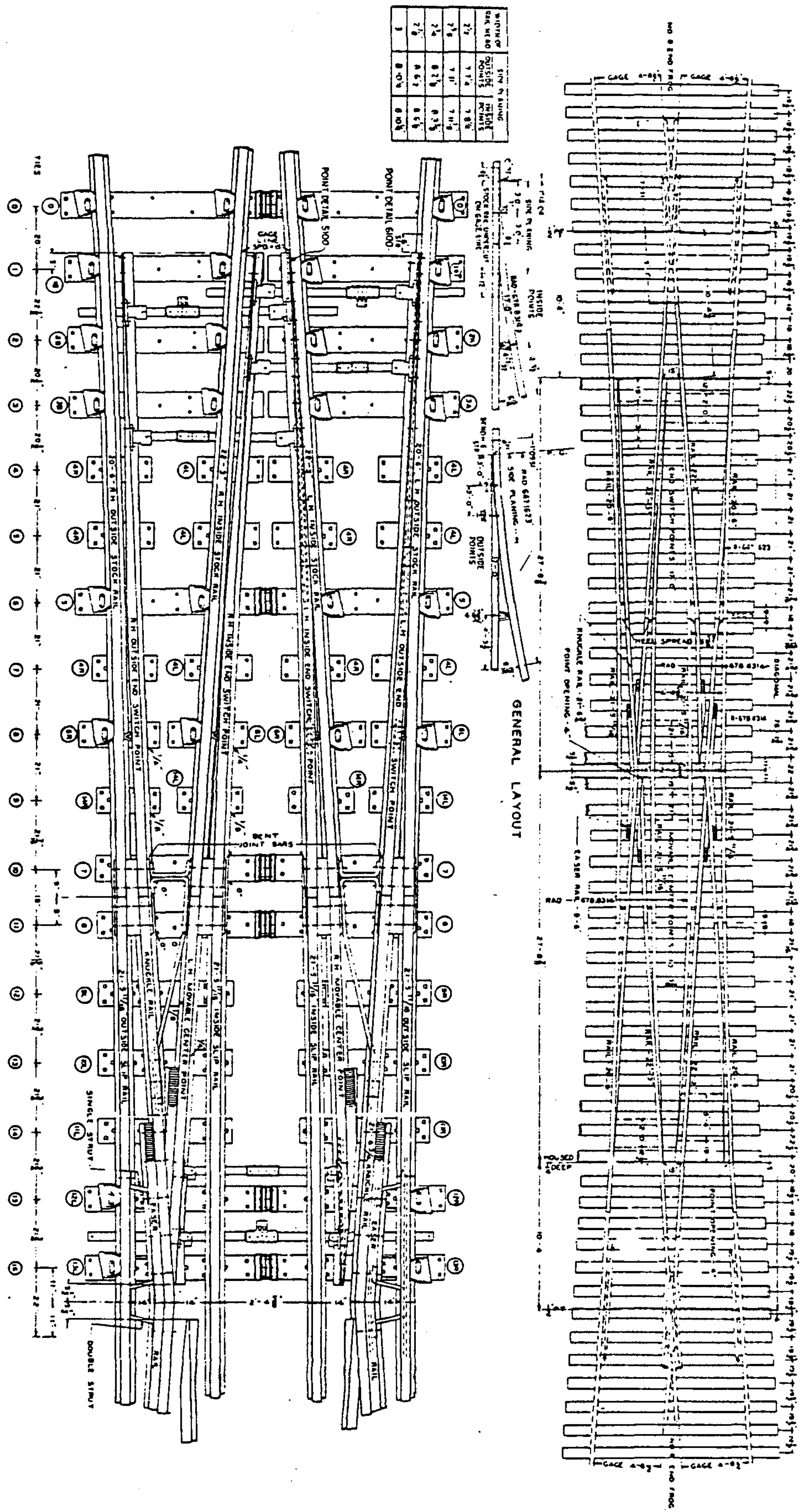


Fig. 9

to the points is connected to an operating rod. Each of the two pairs of movable center points has an operating rod. These operating rods must be interconnected, so that all four movable points move together. This movement must be arranged so that the two pairs of points always go in opposite directions. This is necessary to prevent the possibility of setting up an improper routing.

To complete the track layout of a movable point crossing or a slip crossing, end frogs must be provided at each end of the installation. These are standard frogs, similar to turnout frogs for the crossing angle involved.

If it is desired to have a crossing with only one of the diverging routes available, instead of both, the installation is known as a single-slip crossing. Figure 11 shows two double-slip crossings in the foreground. Beyond these double-slip crossings, a single-slip crossing can be seen. Figure 12 illustrates a movable-point crossing in the foreground, and another one in the upper right portion of the picture.

Most phases of maintenance involving trackwork such as crossings and slip crossings are similar to turnout work. Parts must be kept tightened and adjusted as necessary. Gage, line and surface must be maintained. Parts such as frogs, switch points and stock rail may require grinding or welding at times.

There are certain miscellaneous FRA standards related to turnouts and crossings, to which attention should be called at this point:

§ 213.133 Turnouts and track crossings generally.

(a) In turnouts and track crossings, the fastenings must be intact and maintained so as to keep the components securely in place. Also, each switch, frog, and guard rail must be kept free of obstructions that may interfere with the passage of wheels.

(b) Classes 4 through 6 track must be equipped with rail anchors through and on each side of track crossings and turnouts, to restrain rail movement affecting the position of switch points and frogs.

(c) Each flangeway at turnouts and track crossings must be at least 1½ inches wide.

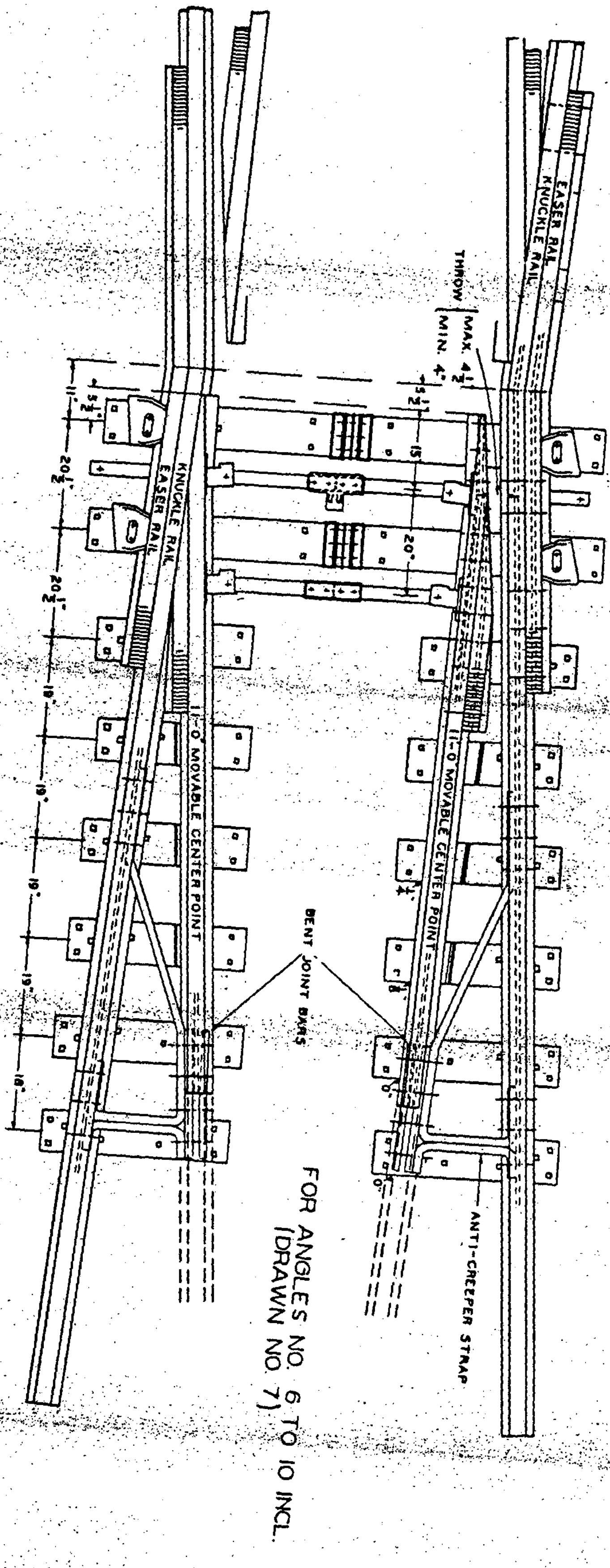
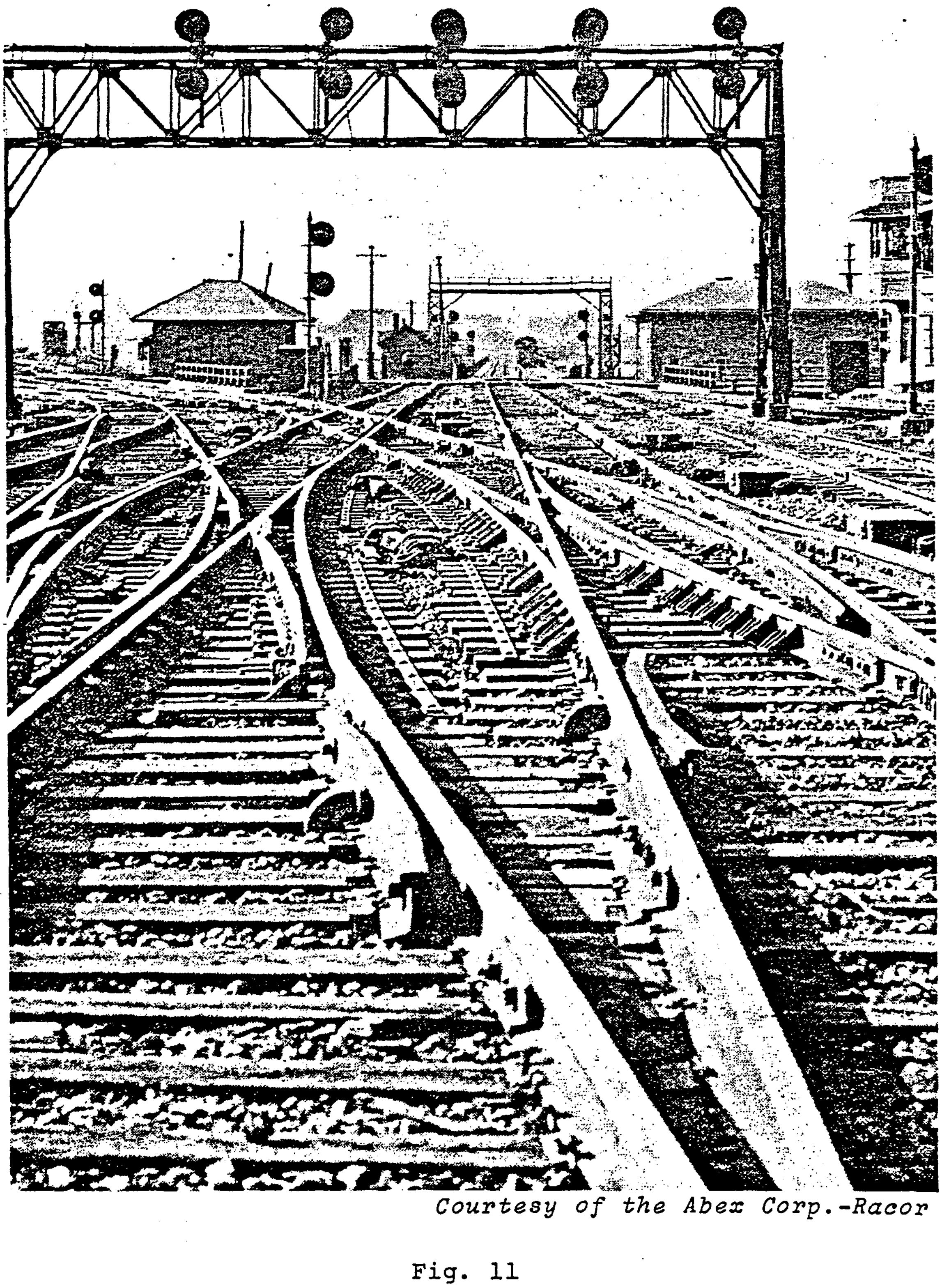
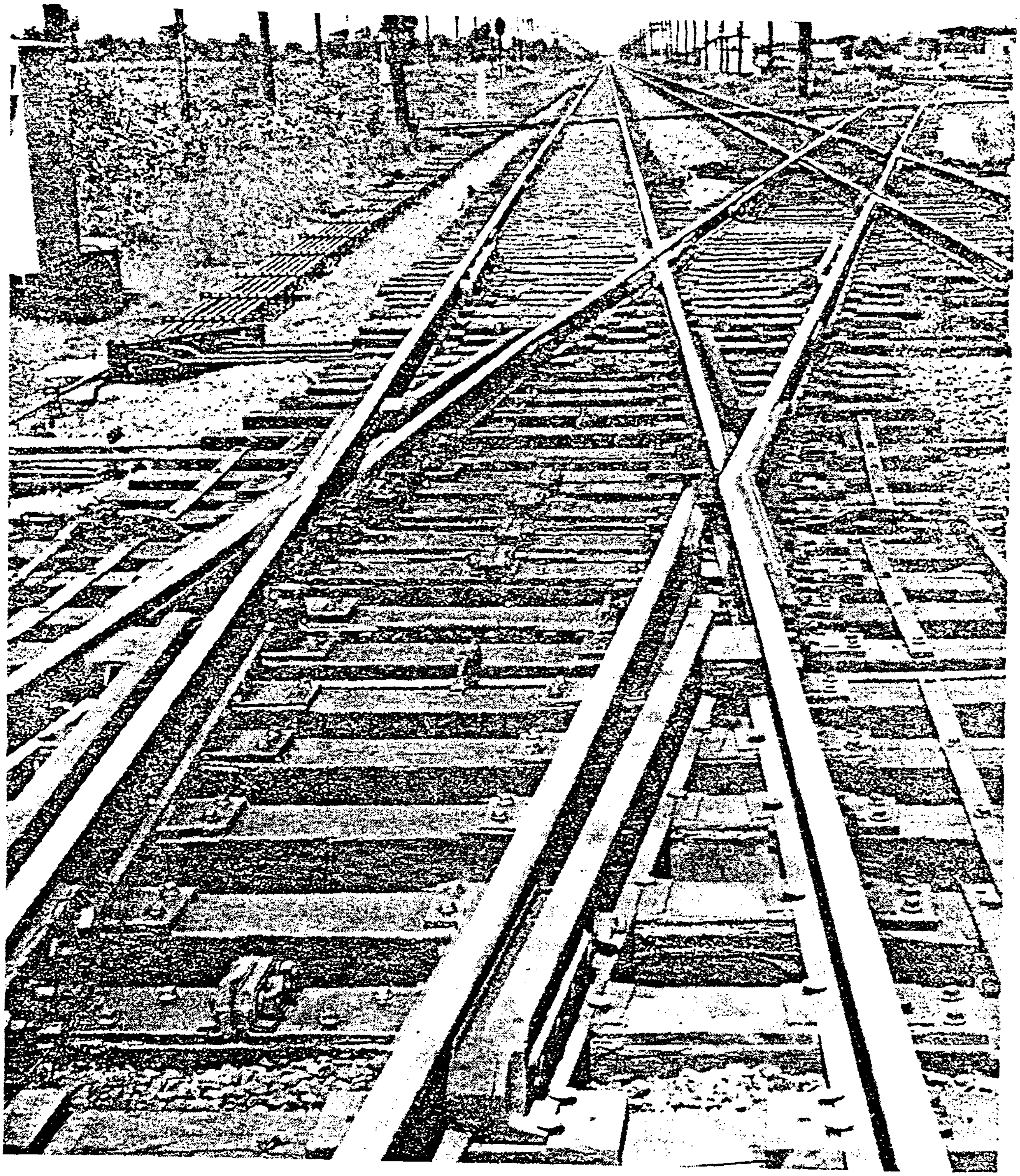

EASER RAIL
KNUCKLE RAIL
THROW
MAX. 4 1/2"
MIN. 4"
1'-0 MOVABLE CENTER POINT
BENT JOINT BARS
ANTI-CREEPER STRAP
FOR ANGLES NO. 6 TO 10 INCL.
(DRAWN NO. 7)

Fig. 10



Courtesy of the Abex Corp.-Racor

Fig. 11



Courtesy of the Abex Corp.-Racor

Fig. 12

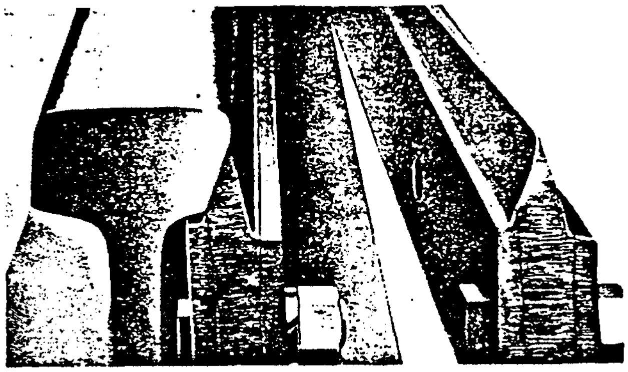
There are a few situations in which the work sometimes becomes more difficult. When necessary to replace major parts, there are, frequently, more connections to disassemble and reassemble. At times, tight clearances make switch tie renewal more difficult. This may require removing portions of the steel in order to renew switch ties. Such situations, usually result in a need for greater periods of time to do a job than may be required in a turnout.

The manner in which renewal of an entire installation, or a major part of one, is carried out can vary. Sometimes limited track usage time is critical. The entire facility might be pre-assembled and installed as one piece. Elsewhere, lifting capacity may be the limiting factor. Piecemeal replacement may be the more desirable approach. Removal and replacement of a double-slip crossing between train movements can be a time-consuming process. In some instances, a new crossing is completely assembled out of track on a new set of switch ties, then lifted into place with heavy equipment such as a wreck derrick.

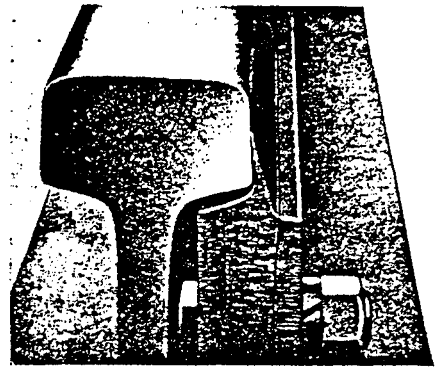
Whenever major projects such as the complete renewal of rigid, movable point or slip crossings are to be undertaken, careful advance planning is needed. Decisions on the method of doing the job should take into consideration the physical conditions at the job site, rail traffic requirements and resources which can be made available for doing the job.

MAINTAINING SWITCH POINTS

The proper maintenance of switch points is one of the most critical jobs associated with the care of turnouts, crossovers and slip crossings. If a switch point fails to guide every wheel of every train to the proper route, a derailment is practically inevitable. There are numerous conditions that can develop which may result in a wheel not being directed to the proper route. There are more potential hazards connected with equipment movements made in the facing direction than in the trailing direction. Whenever any equipment makes a facing movement through a turnout, both wheels of each axle are first moving on the stock rails. One switch point is in the closed position, and the other point is in the open position. The flange of each wheel on the side with the closed switch point must be guided to the proper route by that point. It is essential that each wheel flange make contact with the gage side of the switch point, for this guiding to take place. Figure 13 illustrates the proper fit of both the standard design and the heavy-duty Samson type switch point against a stock rail.



END VIEW OF
SAMSON SWITCH POINT



END VIEW OF COMMON STANDARD
KNIFE-BLADE SWITCH POINT

Courtesy of the Abex Corp.-Racor

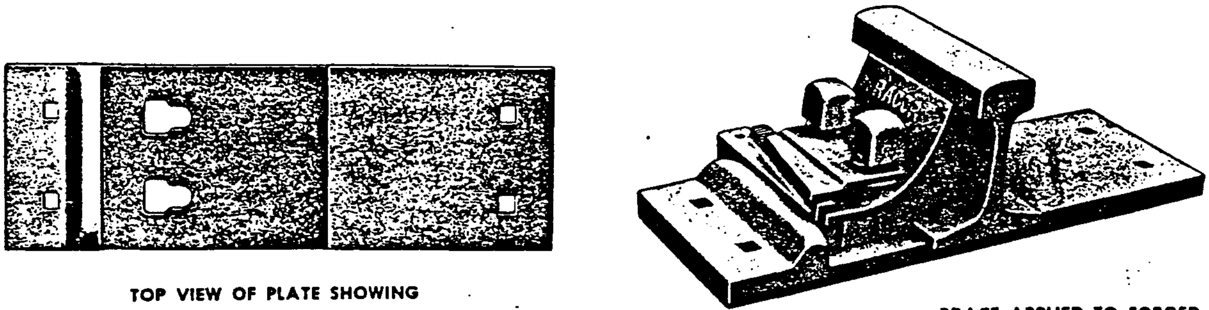
Fig. 13

Should contact be made by a wheel flange with the end of the switch point, rather than the gage side, trouble will result. One of the things that can happen when a wheel flange strikes the tip of a switch point is that it can be deflected so that it goes behind the switch point. If this occurs, the tread of the wheel will continue to ride on the stock rail. When the distance between this stock rail and the other stock rail on which the opposite wheel is riding becomes too great, one or both of the wheels will fall inside a stock rail.

Another possibility when a wheel flange strikes the tip of a switch point is that of the flange climbing onto the top of the switch point. There is a strong chance of derailment occurring in this situation.

There is also a possibility of a wheel flange which strikes the end of the switch point being deflected to the proper route, along the gage side of the switch point. When this happens, the movement will continue without derailment. There are hazards connected with such a situation. The impact of the wheel flanges striking the tip of the switch point can cause rapid deterioration of the point. The end of the point can be battered down, becoming successively more blunt with each impact until a wheel flange does become deflected to the wrong route. A piece of the switch point could break out suddenly, leaving a blunt, exposed surface which a following wheel can climb.

A wheel flange might strike a switch point because it does not fit tightly against its stock rail. In other words, the switch point is said to be "gapping." There are several conditions which can cause this to occur. It may be a case of improper adjustment of the operating rod. The switch stand may not be securely spiked to the head ties. The stock rail braces may be loose or worn. Figure 14 shows a modern adjustable brace assembly, together with its switch



Courtesy of the Abex Corp.-Racor

Fig. 14

plate and a portion of the stock rail. Note that the portion of the plate designed for the switch point provides for raising the head of the switch point above the head of the stock rail. Gage widening may have taken place through movement of the switch plates. Worn switch rod bolts or worn bolt holes in the switch rods can contribute to such a condition. Lips develop on the gage side of the stock rail or back of the switch point which needs to be removed by grinding.

Switch points can become worn thin because of being located on a curve or because of heavy diverging traffic. The top surface of the point can be worn down to a point where the wheel flanges can pass over it. Cracks can develop near the tip of the point. Chips can break off, either at the end of the point or a short distance behind the point of the switch. These conditions can result in a wheel flange climbing onto the top of the switch point, just as with a gapping condition.

Some railroads correct some of these conditions by welding the switch point. If this is the practice on your railroad, find out if there are any restrictions on this procedure. Certain railroads will limit the locations where this practice is followed, perhaps to yard switches. Others do not place restrictions on this practice.

Another method sometimes used is to grind off the head portion of the switch point for several inches from the tip. After the defective portion is removed, the adjacent portion of the head is retapered and shaped by grinding.

You should also find out what practices are recommended on your railroad regarding the grinding of switch points. Welding and grinding procedures will be examined in the next lesson.

Switch points need to be inspected regularly to see if any of these defects are developing. These inspections should include operating the switch, so that the fit of each switch point against the stock rail can be observed. If any of these defects are approaching a dangerous condition, and if the condition cannot be corrected by methods which have been described, it will probably be necessary to replace the switch point.

STOCK RAILS

Usually, when it is necessary to replace a switch point, it is advisable to replace its stock rail as well. Stock rails are subject to various types of wear. The formation of lips on the head of the stock rail is an indication of wear. The gage side lipping effect, which causes problems, can be readily corrected. However, lipping is an indication of metal flow which is lowering the running surface of the stock rail head. If a new switch point is placed against such a worn stock rail, the carefully designed riser feature provided by the switch plates and vertical bending of the switch point will have an incorrect relationship.

Stock rails sometimes tend to develop mashed heads in the area where the wheel loads are transferred from the switch point to the stock rail on trailing movements. This can lead to severe impact on the switch structure. Switch points are generally more costly than stock rails. It is good practice to work towards extending switch-point life, even if at the expense of some potential stock-rail life. Many stock rails can be reused as an ordinary rail in a lower class of track.

OPERATION OF SWITCH

The operation of any switch, whether manual or power operation is used, requires that the switch points slide laterally on the surface of the switch plates. Because of this, there is always frictional resistance to the operation of a switch. Also, there are several ways in which various types of obstructions can interfere with the operation of a switch.

It is standard practice to lubricate switch plates for the purpose of reducing friction. The two principal materials, in general use, are oil and graphite. Oil can be applied quickly and does an effective job immediately after its application. There are several disadvantages to oil as a switch plate lubricant, however. Applications need to be made at frequent intervals, particularly, when there are periods of inclement weather. Oil tends to retain dirt and other foreign materials with which it comes in contact. This can lead to the necessity of thoroughly cleaning the switch plates. Frequent application of oil, with the inevitable slopping that takes place, can adversely affect the life of the switch ties.

Graphite applications require that the switch plates be well cleaned before the initial application. A properly graphited set of switch plates normally requires follow-up applications at less frequent intervals than oiled switch plates. Graphited plates tend to stay cleaner than oiled plates.

Oil should not be applied to switch plates that have been graphited, as the graphite will be destroyed. Graphite cannot be reapplied in such situations, until the switch plates have had all of the oil removed. Proper lubrication, with either material, requires application to each switch plate with the switch point in both the open and closed position.

SWITCH LATCHES AND LOCKS

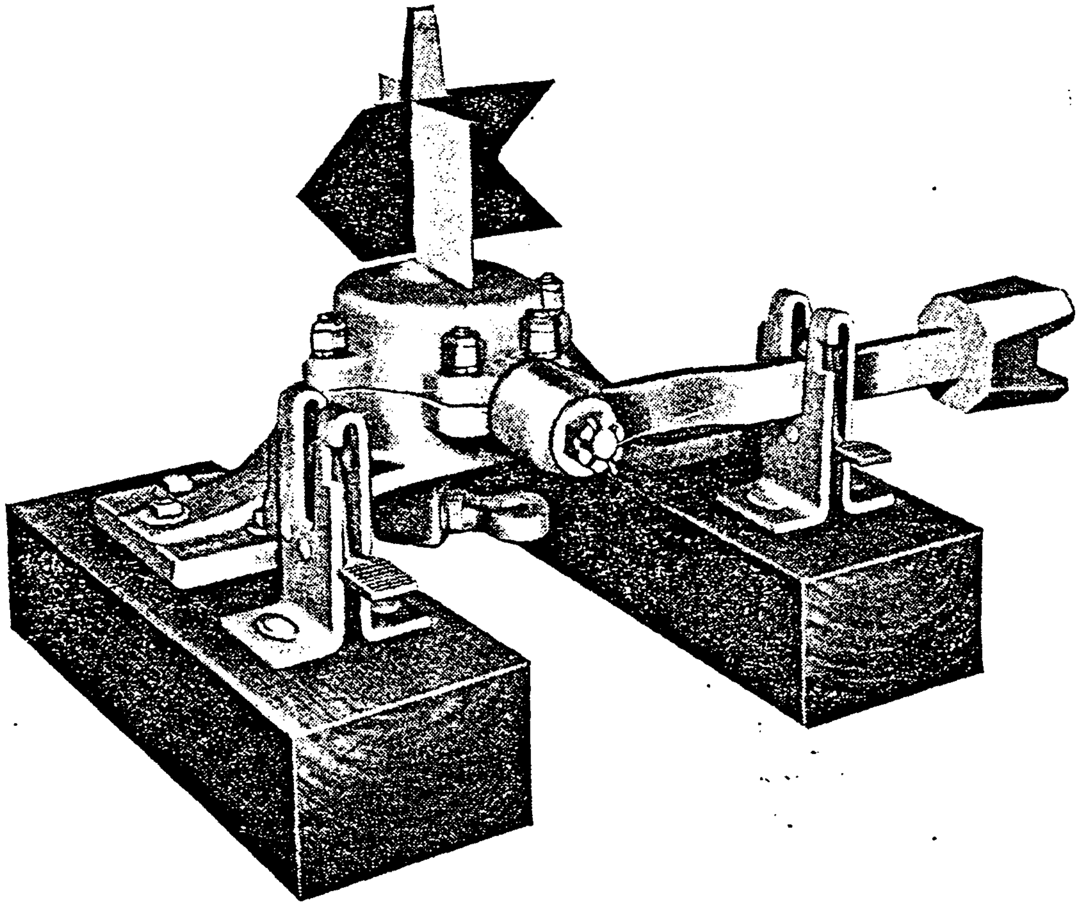
Power-operated switches have a built-in mechanism which locks the operating rod so that the closed switch point will not be able to open under moving wheels. For manually operated switches a means is frequently provided to restrain the lever of the switch stand in its extreme position, thereby enabling the operating rod to hold the closed point tightly against the stock rail. This is done for both the normal and reverse position of the switch.

The devices which restrain the lever so the switch point will remain closed are called switch latches. One of the things that a switch latch must do, is to prevent the lever from becoming free of the latch unless it is opened. Also, latches must work freely, and not tend to jam, which would make it difficult to operate the switch. Latches should be inspected periodically, to make certain that such defects don't exist.

Whenever a switch is located where train movements can be anticipated at a speed where the train may not be able to stop short of the switch if not properly lined, provision must be made for keeping the switch locked. Switches can be left in the improper position either erroneously by an employee who used it previously, or deliberately by someone intent on malicious mischief. Latches used in this situation, provide for attaching a switch lock, so the switch cannot be operated by anyone without a switch key.

To protect against the possiblity of someone inadvertently locking the switch in the reverse position after using it, some railroads require that the latch used for the reverse position not be capable of having a lock attached to it. Another procedure frequently used is to attach a short chain to the switch lock, and to fasten the other end of the chain to the tie on which the latch to be locked is located.

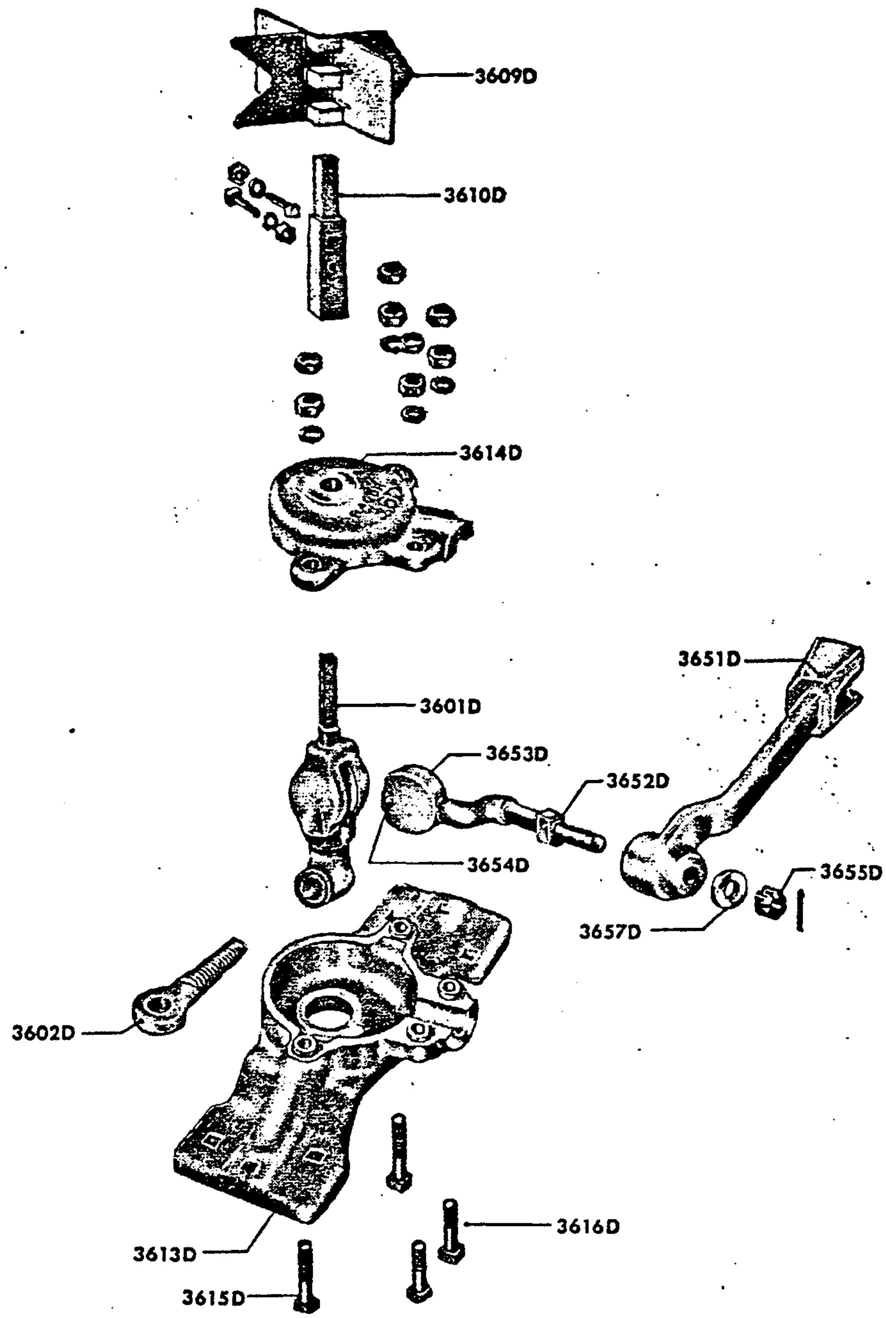
Figure 15 is a picture of a switch stand with latches. Each latch provides for attaching a switch lock, which will prevent tripping of the latch.



Courtesy of the Abex Corp.-Racor

Fig. 15

Figure 16 shows the parts included in the switch stand pictured in Figure 15. There are many different designs of switch stand in use. You will probably only have to work with a few. You should become familiar with their parts, so that you will be able to make repairs when necessary.



SWITCH STAND—FIGURE 36-D—PARTS LIST		
3601D—Spindle 3602D—Crank Eye 3609D—Interlocked Targets 3610D—Lamp Tip and Bolts 3613D—Base	3614D—Top 3615D—Long Bolts and Nuts 3616D—Short Bolts and Nuts 3651D—Hand Lever With Weight	3652D—Crank 3653D—Crank Bushing 3654D—Washer 3655D—Nut 3657D—Washer

Courtesy of the Abex Corp.-Racor

Fig. 16

SWITCH SURFACES

Excessive friction can develop in a switch because of poor surface. Under some conditions, most of the load may be carried on a few switch plates. This can result in one or both of the switch points binding, and being difficult to throw. Particular attention needs to be given to the switch heel joints. Whether or not heel blocks are used, these are hinged joints, and the support they provide is somewhat less effective than with conventional joints. Heel joints need to be watched for a tendency to become low spots in the surface of the track. Loose ties in this area can cause excessive friction on switch plates closer to the point of switch.

There is another hazard caused by loose ties at the heel joints. When a wheel passes over the heel joint and causes further depression, the tip of the switch point can rise up in relation to the stock rail. Depending on wheel spacings in relation to the length of the switch point, a following wheel can come into contact with an improperly exposed switch point.

FRA standards deal with various phases of switch maintenance. They are:

§ 213.135 Switches.

(a) Each stock rail must be securely seated in switch plates, but care must be used to avoid canting the rail by overtightening the rail braces.

(b) Each switch point must fit its stock rail properly, with the switch stand in either of its closed positions to allow wheels to pass the switch point. Lateral and vertical movement of a stock rail in the switch plates or of a switch plate on a tie must not adversely affect the fit of the switch point to the stock rail.

(c) Each switch must be maintained so that the outer edge of the wheel tread cannot contact the gage side of the stock rail.

(d) The heel of each switch rail must be secure and the bolts in each heel must be kept tight.

(e) Each switch stand and connecting rod must be securely fastened and operable without excessive lost motion.

(f) Each throw lever must be maintained so that it cannot be operated with the lock or keeper in place.

(g) Each switch position indicator must be clearly visible at all times.

(h) Unusually chipped or worn switch points must be repaired or replaced. Metal flow must be removed to insure proper closure.

FROGS

Crossing frogs, in which the tracks cross at 90 degree angles, or other large angles approaching 90 degrees, have open gaps for the opposing flangeways, which wheels must jump. These flangeways are about 1-7/8 inches in width. This has a similar effect to the condition where a piece is broken out of the end of a rail, leaving the same opening. The impact can be considerable, increasing with the loads on the wheels and the speed of the movement. The situation is somewhat different for flat angle frogs, including turnout frogs. The open flangeway is on a rather flat diagonal angle. For a wheel of a given contour, it is possible to develop a frog design for which the wheel load will be transferred gradually from the wing portion to the point portion of the frog on a facing movement.

A problem develops since not all wheels have the same contour. Any frog will carry wheels in all stages of wear. As a wheel wears, the shape changes.

In allowing for variations in wheel shapes, it is necessary to design frogs so that they are protected against the possibility of wheels striking the tip of the point portion of the frog. Excessive impact on this relatively narrow part of the frog structure, can produce cracking and breakage in a short period of time. There are two ways in which this can be avoided. One is to build the frog with a slight vertical taper at the point. This results in the tip of the point being somewhat lower than the adjacent wing portions, on which the outer edges of the wheel treads ride. The other way is to keep the point portion level, but to raise the wings in the vicinity of the tip of the point. It is from this design that the wing portions of a frog are sometimes referred to as the "risers".

The primary purpose of either design is to protect the tip of the frog point. Neither design can provide a perfectly smooth transition of the load across the flangeway for wheels in all stages of wear. Some impact will inevitably occur. This can produce batter, cracking, chipping or breakage on either the point portion or the wing on which the predominant traffic moves.

Deterioration of these portions of the running surface of the frog increases the amount of impact, which accelerates the failure of the steel surfaces. This impact also produces excessive wear on the ties under the frog and the track surface. This, in turn, speeds up the general breakdown.

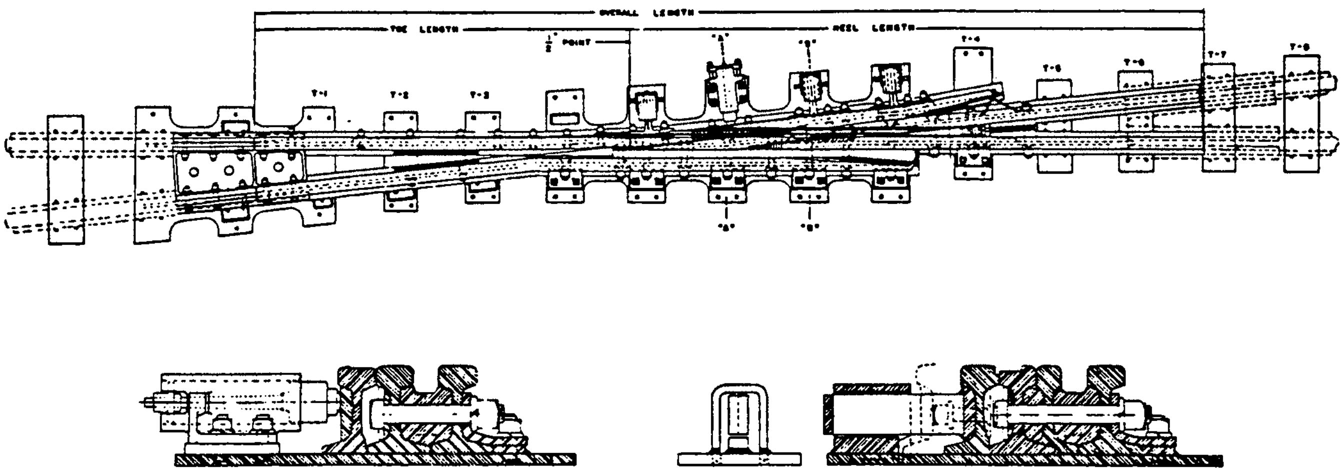
The deterioration of the running surfaces can be restored by welding and grinding, except in extreme cases. If the breakage is not too deep, this work can be done under traffic, without removing the frog from track. In more severe cases, it is necessary to replace the frog, but sometimes the frog can be restored to good condition by welding after it is removed from track. Welding and grinding of frogs will be examined in the next lesson.

Severe wear on the point and wing of a frog, can introduce the possibility of the flangeway not being deep enough for wheel flanges. The minimum required depths are specified by the FRA.

SPRING FROGS

Spring frogs are suitable for main-line use where a smooth ride is desired on the main-track side, but where only light traffic uses the turnout side. This is accomplished by an arrangement which keeps the wing rail on the heavily used side, tight against the frog point when not in use. This means that there is no open flangeway to be bridged on this route. When a wheel passes over the frog on the lightly used side, the wheel flange spreads the wing rail, opening the needed flangeway. This is permitted by a spring arrangement, which closes the wing rail after the wheel has passed by.

When well maintained, this principle does provide the smooth ride which is intended. It should be pointed out, though, that this introduces moving parts into the frog structure. If not properly maintained, they can be a source of problems. One of the greatest potential hazards which exists with spring frogs, is the possibility of the movable wing rail rising above its intended height in relation to the point. Spring frogs are equipped with hold-down devices intended to prevent this. If such a device becomes loose, worn or broken, there is a potential for the wing rail to rise. When this condition exists, a wheel trailing through the frog on the heavily used side may fail to ride onto the wing portion. The outside edge of the wheel tread might force the raised wing outward. If this continues, when the wheel proceeds past the tip of the frog point, it will fall inside the wing rail and derail. Needless to say, close inspection and high standards of maintenance of hold-down devices are essential. A plan of a spring frog with details of the spring and hold-down features is shown in Figure 17.



SECTION A-A SECTION B-B

Fig. 17

SELF-GUARDED FROGS

Self-guarded frogs are subject to defects similar to those in other cast frogs. Their use, however, is generally in low-speed territory. A condition which occurs only with self-guarded frogs, is wear on the raised guards. This may not exceed 3/8 inch.

FRA STANDARDS

The FRA standards cover various conditions related to frogs, reasons for which have either been explained or are self-evident. The FRA frog standards are:

§ 213.137 Frogs.

(a) The flangeway depth measured from a plane across the wheel-bearing area of a frog on class 1 track may not be less than 1⅜ inches, or less than 1½ inches on classes 2 through 6 track.

(b) If a frog point is chipped, broken, or worn more than five-eighths inch down and 6 inches back, operating speed over that frog may not be more than 10 miles per hour.

(c) If the tread portion of a frog casting is worn down more than three-eighths inch below the original contour, operating speed over that frog may not be more than 10 miles per hour.

§ 213.139 Spring rail frogs.

(a) The outer edge of a wheel tread may not contact the gage side of a spring wing rail.

(b) The toe of each wing rail must be solidly tamped and fully and tightly bolted.

(c) Each frog with a bolt hole defect or head-web separation must be replaced.

(d) Each spring must have a tension sufficient to hold the wing rail against the point rail.

(e) The clearance between the hold-down housing and the horn may not be more than one-fourth of an inch.

§ 213.141 Self-guarded frogs.

(a) The raised guard on a self-guarded frog may not be worn more than three-eighths of an inch.

(b) If repairs are made to a self-guarded frog without removing it from service, the guarding face must be restored before rebuilding the point.

FROG GUARD RAILS

Minimum safe guard check gages and maximum safe guard face gages for the various classes of track are specified by the FRA, and are:

§ 213.143 Frog guard rails and guard faces; gage.

The guard check and guard face gages in frogs must be within the limits prescribed in the following table:

Class of track	Guard check gage: The distance between the gage line of a frog to the guard line[1] of its guard rail or guarding face, measured across the track at right angles to the gage line,[2] may not be less than—	Guard face gage: The distance between guard lines,[1] measured across the track at right angles to the gage line,[2] may not be more than—
1..........	4′ 6⅛″	4′ 5¼″
2..........	4′ 6¼″	4′ 5⅛″
3, 4........	4′ 6⅜″	4′ 5⅛″
5, 6........	4′ 6½″	4′ 5″

[1] A line along that side of the flangeway which is nearer to the center of the track and at the same elevation as the gage line.

[2] A line ⅝ inch below the top of the center line of the head of the running rail, or corresponding location of the tread portion of the track structure.

It is necessary not only to install frog guard rails to the proper guard check gage, but also to be certain that both the guard check gage and the guard face gage are maintained within the acceptable limits. This may require plugging and respiking of the guard rails, the running rails or the frog. Should this be inadequate, switch ties will have to be replaced.

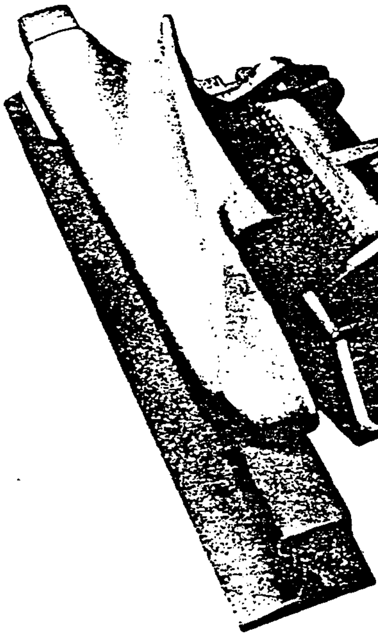
Tee-type guard rails, attached to the running rails by bolts and filler blocks or with clamps and wedges require attention to keep the fastenings tightened.

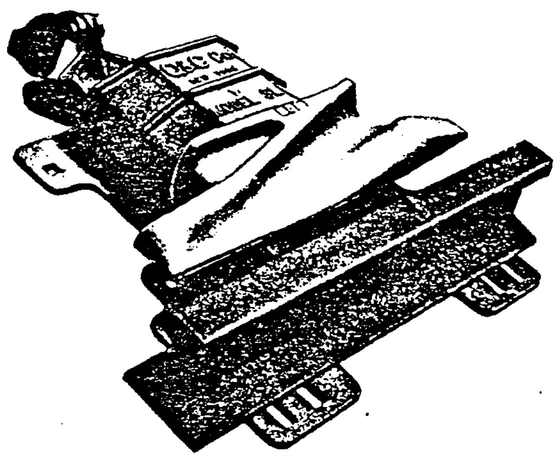
Wear on the guarding face of guard rails is not a serious problem in the majority of installations. Where it is a problem, there is usually a combination of curvature and heavy traffic present. Occasionally, excessive guard-face gage may be involved. Wear on a guarding face can be a source of concern if it develops to the point that gage limits are threatened or if the mechanical action which produces it loosens the guard-rail fastenings.

DERAILS

Derails are an accessory to many turnouts. Their purpose is to prevent the uncontrolled movement of equipment from a side track onto a main track. The hazards of a possible collision of such equipment with a train on a main track is so great, that it is preferred to deliberately derail uncontrolled equipment before it blocks the main track.

There are two basic types of derail in general use. The most common type is placed on the head of one of the rails of the side track. This device raises the wheels above the rail so that the wheel flanges can be directed diagonally across the rail head. As each wheel flange passes beyond the field side of the rail head, it derails. This, in turn, causes the other wheel on the same axle to fall of the other rail, to the gage side. Figure 18 shows such a derail in both the derailing and non-derailing position.





MODEL SL DERAIL

MODEL HL DERAIL
(Left Hand)

Courtesy of Western-Cullen Div., Federal Signal Corp.

Fig. 18

This type of derail is normally attached to the rail of the side track, farthest from the main track. It must be located so that the equipment will not infringe upon the main-track clearance, either before or after derailing. Occasionally, there are instances where this type of derail is not completely effective. Reasons for this include improper adjustment on the rail head and deteriorated ties which permit the derail to be torn loose. Even without these conditions, a heavy car which has picked up considerable speed, prior to contacting the derail, occasionally tears one loose.

Sometimes, where this possibility is anticipated, such as with a substantial descending grade toward the main-track connection, a switch point derail is installed. Usually, this is a single switch point and stock rail, located in a similar position to the rail-head type of derail. Figure 19 illustrates a switch point derail.

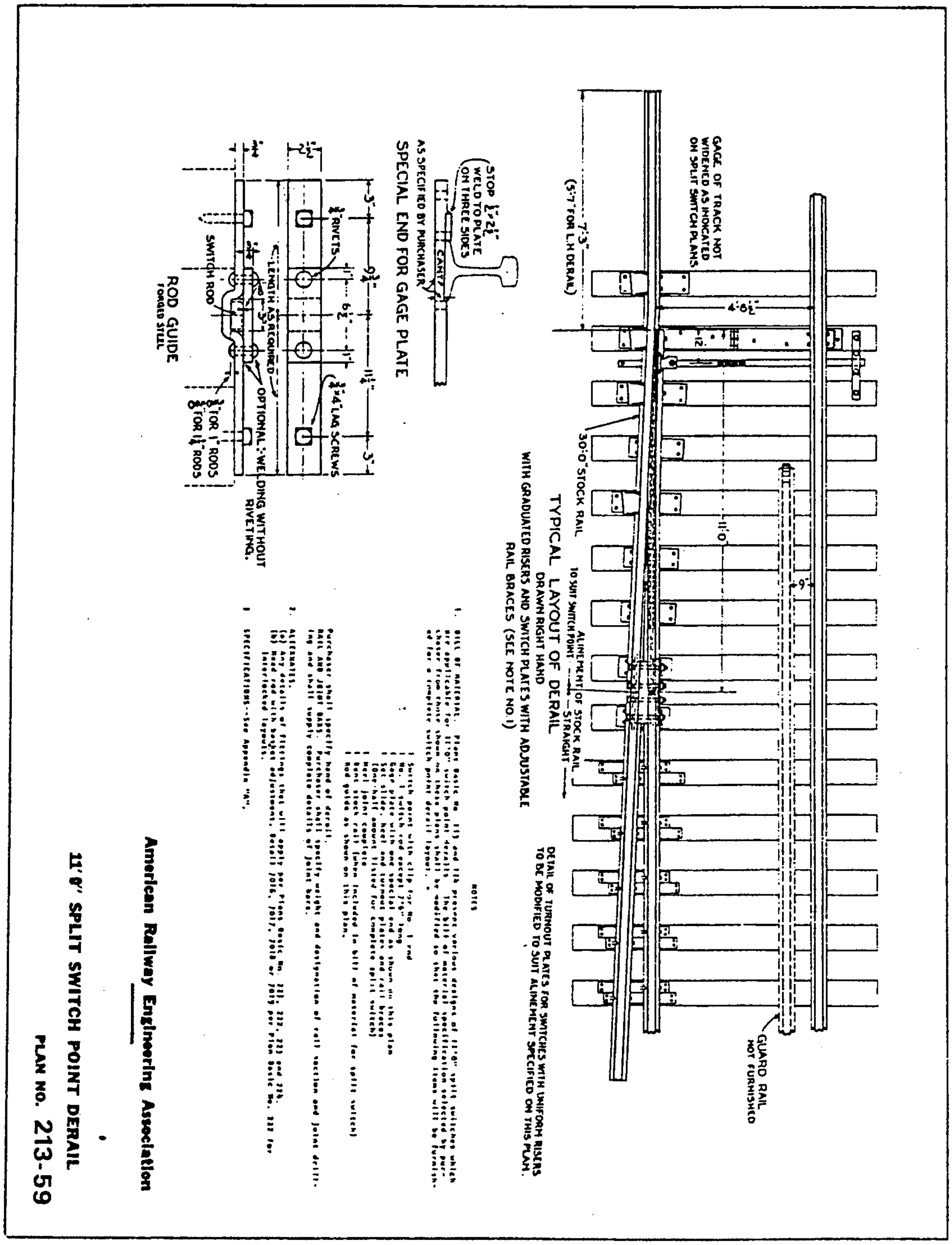


Fig. 19

It may be necessary to locate a derail near the clearance point. If there is a possibility of derailed equipment fouling the main track, a deflecting rail may be used. This is a length of scrap rail spiked to the ties in a diagonal position between the running rail. This is intended to guide the wheels, which have derailed on the gage side of the rail, away from the main track.

Derails are normally kept set in the derailing position. It is necessary to operate a derail so that it will be in a non-derailing position when movements are to be made into or out of the side track.

There are various ways in which derails may be operated. The rail-head type is sometimes grasped directly and moved to or from the rail-head. This type may be guided by a hinge or sliding mechanism.

Either type of derail may be attached to a switch stand, located adjacent to the derail. These derails are operated by throwing a switch lever, just as switches are operated. Sometimes, the derail is connected by a system of pipes, cranks and rollers so that when the switch is operated, the derail is operated, also. Where switches are power-operated, the derails are also power-operated.

Where derails are operated separately from the switch, conditions at many locations require that the derail be kept locked in the derailing position with a switch lock, except when equipment is moving to or from the side track. It is essential that such a lock will eliminate the possibility of moving the derail to a non-derailing position.

It is essential that derails be readily visible to train crews working in the vicinity. This is sometimes accomplished by a lamp or banner, similar to those used for switches, but displaying the colors prescribed for derails. Sometimes, the procedure with the rail-head type is to paint the derail itself, again using the color prescribed by the individual railroad. It is also necessary to control vegetation, so that it does not obscure the derail.

The FRA standards for derails are:

§ 213.205 Derails.

(a) Each derail must be clearly visible. When in a locked position a derail must be free of any lost motion which would allow it to be operated without removing the lock.

(b) When the lever of a remotely controlled derail is operated and latched it must actuate the derail.

MISCELLANEOUS MAINTENANCE

Most turnouts, crossovers and slip crossings have substantial curvature on the diverging route. The nature of these track layouts makes it impractical to provide superelevation on the curved route. These conditions severely limit the speeds at which equipment can safely be operated over such a route. In most installations, only a relatively small amount of excess speed can place considerable stress on the track.

At locations where such tendencies exist, one part of the turnout which must be watched carefully, is the curved lead. Under severe usage, a curved lead can develop severe flange wear on the gage side of the rail head. The outward thrust of the wheels can also tend to cause an outward movement of the rail, particularly if the switch ties are nearing the end of their useful life.

Where there are indications of these conditions, the lead area needs to be watched closely for the development of wide gage. Most leads have a rail joint somewhere between the heel of the switch and the toe of the frog. This is frequently the most critical location if wide gage is a problem.

Turnouts and other special trackwork are a variety of sizes and types of bolts. In addition to regular track bolts, there may be frog bolts, guard rail bolts, heel block bolts, stock rail brace bolts, switch clip bolts and switch rod bolts. Each must be properly maintained to perform its function. Periodic tightening and lubrication should be performed. If any bolt breakage is taking place, replacements should be installed promptly and efforts made to correct the cause of breakage.

The types of trackwork which have been investigated in this lesson usually cost several times as much to install or replace as an equivalent footage of conventional track. Sound practice dictates that such facilities should receive preferential treatment, if necessary, to secure a proper return on such investment. Also, these installations can potentially present many more ways in which train operations can be interrupted than conventional track.

This lesson has dealt with a wide variety of maintenance and construction functions. You most certainly will not have to make use of all the information which it contains at once. It is recommended that you do not set this lesson aside and wait for the day you will have to perform a specific job. Study the types of facilities in your areas. Look for signs of defects which this lesson has discussed. Consider how you will carry out various operations when the time comes, knowing what facilities will probably be available for your use.

LESSON 13

EXERCISE QUESTIONS

1. What is the distance called between the point of switch and the 1/2 inch point of frog, in a turnout?

2. In new construction of a turnout, what is the preferred line of rail to install first?

3. What is standard guard check gage

4. What is the maximum permitted guard face gauge for Class 4 track?

5. In what areas should ballast in tie cribs be kept lower than normal?

6. It is planned to replace several defective switch ties in a turnout and to replace the steel parts of the turnout as well. Which should be replaced first?

7. What are two locations where compromise joints cannot be installed?

8. What is the name of the trackwork part that movable points fit against?

9. What is the minimum required width of flangeway at turnouts and track crossings?

10. What are two methods sometimes used to restore worn switch points?

11. On a spring frog, what is the maximum clearance permitted between a hold-down housing and the horn?

12. What is the preferred type of derail where the possibility of a fast moving runaway car exists?

Answer the following questions TRUE or FALSE

13. When installing a new turnout in an existing track, any line irregularities can best be corrected after the turnout is installed.

14. The panel method of turnout construction requires the use of non-standard turnout rails.

15. On an A.R.E.A. design double-slip crossing, one operating rod connects to two No. 1 switch rods.

(Exercise questions continued on next page)

16. Frogs which do not have wing risers are designed with depressed points.

17. The raised guard on a self-guarded frog may not be worn more than 3/16 inch.

18. In class 3 track, the flangeway depth must be at least 1-3/8 inches.

19. The minimum permitted guard check gage in Class 2 track is 4'6-5/8".

20. A lip on a stock rail may cause its switch point to gap.

Submit your answers to these questions to The Railway Educational Bureau in the prescribed manner. Be sure to include your name, file number, address, company's name and lesson number in the upper right hand corner of your paper.

CP Rail

Maintenance of way training

Lesson 82
Subject: CUTTING & DRILLING A RAIL

First issued: 79-08-23
Revised: 80-02-12

CUTTING AND DRILLING A RAIL

Introduction

The only way to cut and drill a rail is to cut and drill it right the first time. Rail is very expensive and must not be wasted by making a poor cut or by drilling the holes in the wrong place.

1. Hand Tools and Safety Supplies

- 50' tape - 39' rail.
- 100' tape - 78' rail.
- Marking crayon.
- Pocket tape
- Template.
- Centre punch.
- Hammer.
- Rail tongs or hoist.
- Lining bars.
- Sledge hammer.
- Rail chisel.
- Goggles.
- Gloves.
- Safety boots.

2. Rail Saws

There are two types of rail saws commonly used today:

1) Blade saw.
2) Abrasion saw.

The two common makes of blade saws are the Racine and the Stumec.

2.1 The Racine Model 155

This saw supports itself on the rail and is held securely by its own weight. It weighs about 225 lbs.

To set up the saw, hook the rail clamps over the head of the rail so the notched portion in the front of the saw base fits on the flange of the rail base. The rail clamps are adjustable for any rail weights - 80# to 136#. Attachments are available for cutting lighter rails, down to 60#.

The saw should be set so the base of the machine is approximately parallel to the rail base when cutting the rail and it should not be supported on the ties, the ground or other objects when cutting rails.

To cut the rail:

1) Check to see that the oil level is OK then start the motor.

2) Lower the blade to its cutting position by raising the frame slightly and pulling the finger release lever forward.
3) With the lever pulled forward, lower the frame carefully until the blade contacts the rail.
4) Allow the coolant to trickle onto the rail near the cutting point.
5) When new blades are used no weight is needed on the blade, however when the blades are dull it is best to slide the weight ahead. (It is also best to slide the weight ahead when cutting the base, because of its larger area.)
6) When the cut is completed, raise the saw frame high enough for the finger release lever to fall under the saw arm to lock it in the raised position, then shut off the motor.

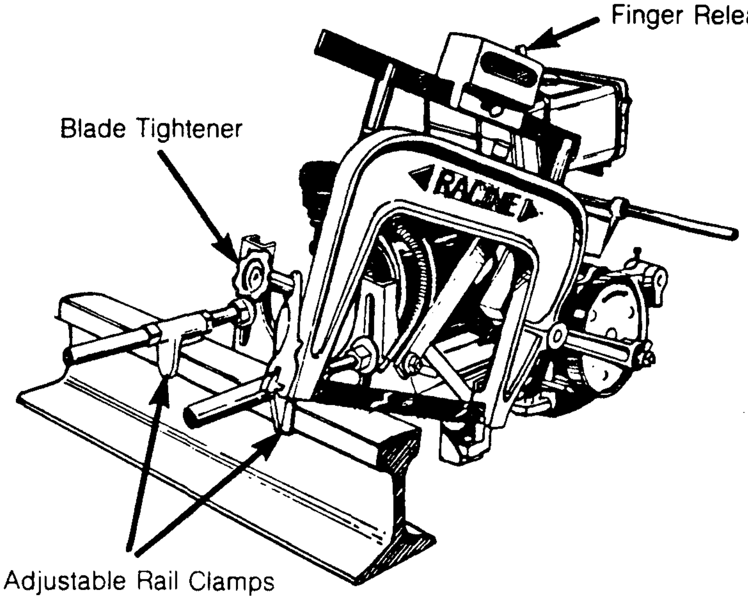


Fig. 1 – Racine Model 155

Always raise the saw frame to the supported position before moving the machine and for safe operation never move the rail saw with the motor running.

2.2 The Stumec Saw

This saw is a blade saw similar to the Racine Saw, but is lighter, weighing 174 lbs. It can cut all weights of rail up to 136#.

- To set up the saw, place it on the rail close to the desired location. Then tighten the handle (reference - 1 on Figure 3) to fasten the saw against the web or the rail.
- Level the saw by tightening the handle (reference - 2 on Figure 3) on the support leg.
- Loosen the counter nut, (reference - 4).
- Adjust the location for the cut by turning the nut (reference - 3).
- When the exact location of the cut is set, retighten the counter nut (reference - 4).

- Start the motor and then put the saw blade in motion by increasing the speed of the motor.
- Then gradually lower the saw against the rail, avoiding rough contact between the blade and the rail, by holding the handle (reference - 5) and pushing the knob (reference - 6).
- The cut is water cooled by the hose (reference - 7).

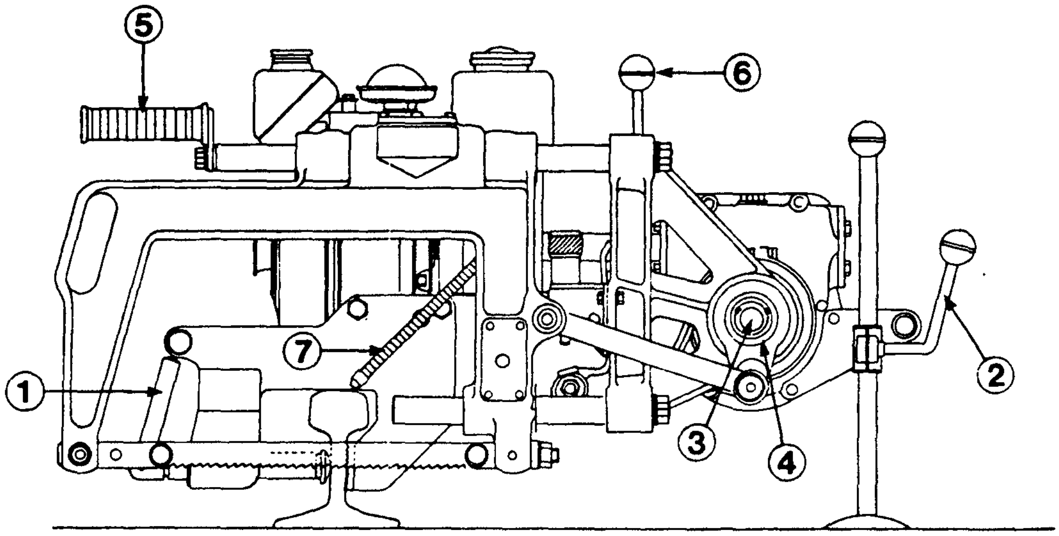


Fig. 2 – Stumec Rail Saw

2.3 Friction or Abrasion Saws

These saws are gradually replacing the blade saws.

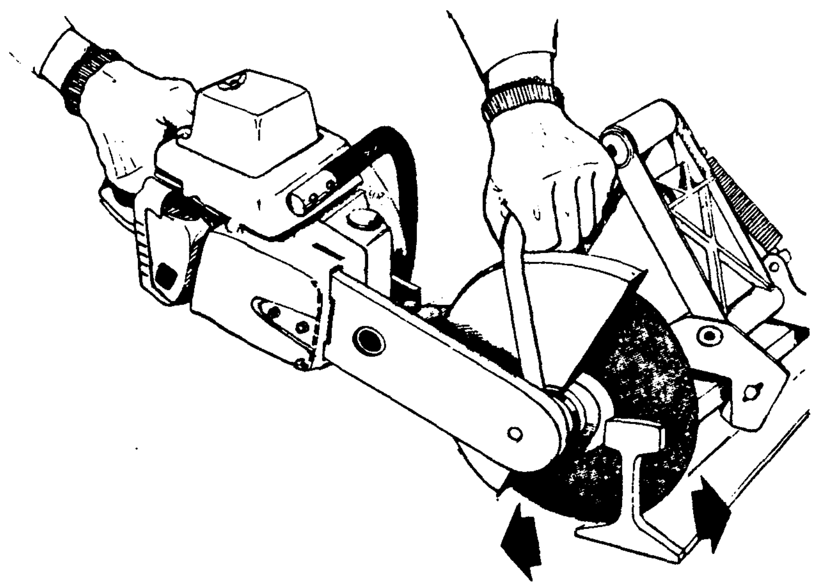


Fig. 3 – Friction or Abrasion Saw

They are quite light, about 50 lbs., and cut rail in 3 to 4 minutes instead of 7 – 15 minutes taken by the blade saws. These saws use a cutting wheel, which turns at 4800 R.P.M.

They are a two-part unit, one part is the work head and the other is the support arm clamp that holds it tightly to the rail in perfect alignment. The drive mechanism is similar to a chain saw except that instead of using a chain they use a circular abrasive blade.

It is very important that you cut with a to-and-fro movement, otherwise the blade edge will become smooth and will not cut. If the blade does get smooth, stop the motor, then take an object such as a spike and gently strike the edge of the blade in several places to roughen it, then start cutting again.

2.4 Bevelling of Rail Ends

After cutting a rail the end must be bevelled with a grinder to ensure there are no lips or sharp edges that would put higher pressures in a small area of the joint bar and cause the joint bar to crack.

Rail end bevelling is to be done on all the rail ends in turnout and crossing components, such as the heels of switch points, frog heels and toes, bent and straight turnout rails. On solid manganese turnout and crossing frogs the surfaces which would bear on a joint bar must be bevelled.

The bevels must be run out smoothly so that there are no inside corners where cracks might start.

The standards for bevelling are:

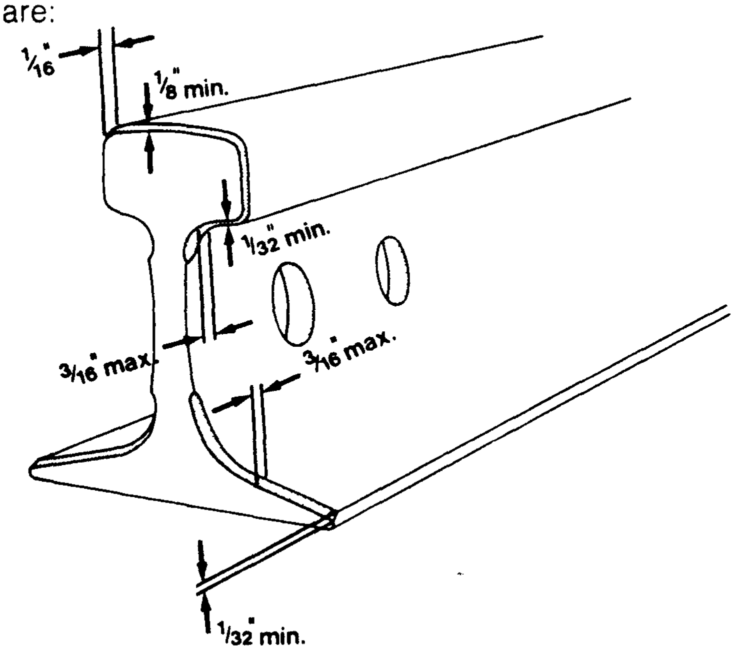


Fig. 4 – Bevelling of Rail Ends

2.5 Cutting Rail with a Torch

When cutting a rail to length a rail saw or a chisel must be used. However, some times it is necessary to cut a rail with a cutting torch.

The heat of a cutting torch causes small cracks behind the cut face of the rail which will in time work back and cause a broken rail. Therefore, when a torch cut rail is to be left in the track, the torch cut end must be cut off with a saw at least six inches back of the torch cut.

3. Power Rail Drills

The most common rail drills are the Nordberg, the Stumec and the Racine. They are very efficient.

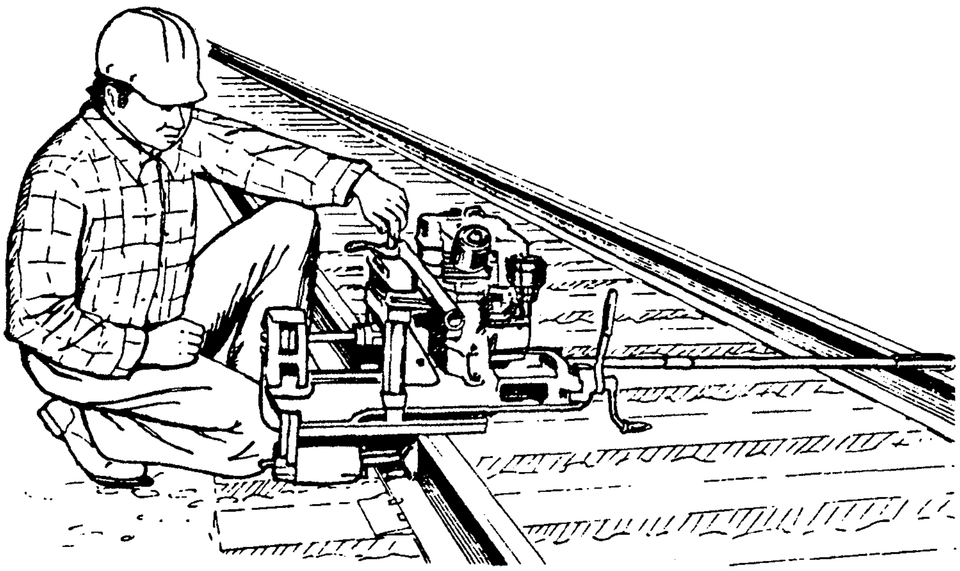


Fig. 5 – Nordberg Rail Drill

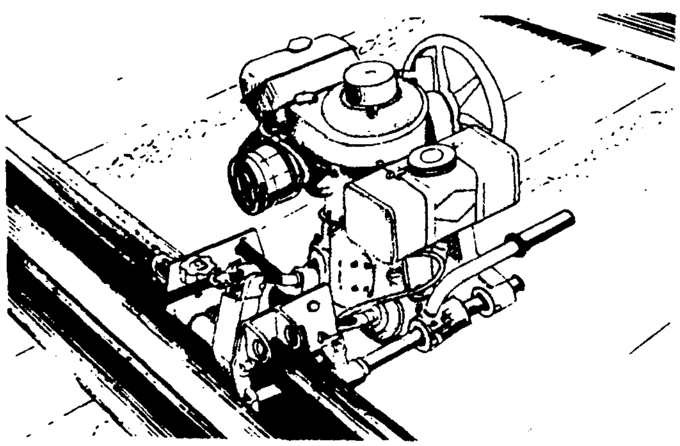


Fig. 6 – Stumec Rail Drill

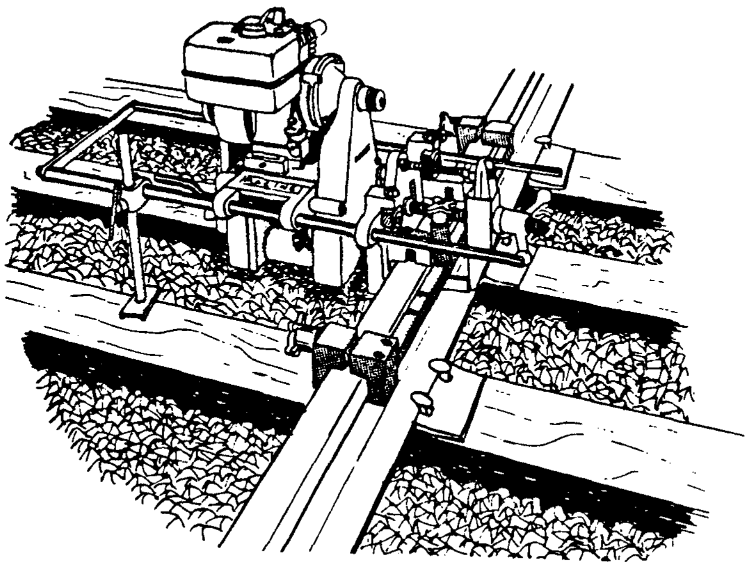


Fig. 7 – Racine Rail Drill

A rail should never be drilled through the joint bar, as it is important to make holes of the correct diameter in the rail, because the rail holes are always larger than the holes in the joint bar. If an undersized bit is used, so it will go through the joint bar holes, frozen joints, damaged bolts and bolt failures in the rail can result.

Never use a cutting torch to make bolt holes in rails to be used in the track, because this causes heat cracks at the bolt hole which will spread, the same as with a torch cut rail end. For the same reason, high speed drills are not used on rails because they also cause heat cracks which become bolt hole breaks.

There are two ways to mark the location of the holes for drilling.

1) To measure with a tape, which is difficult and slow.
2) The easiest way is to use a template, this will eliminate the risk of error in positioning.

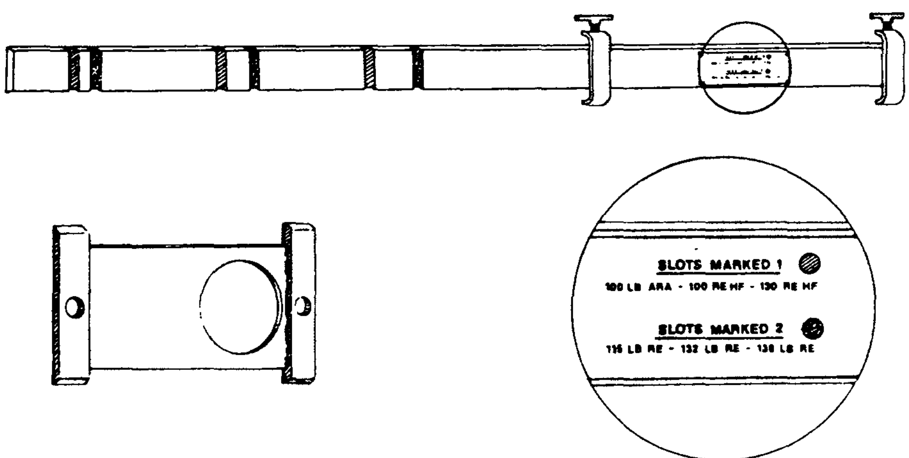


Figure 8

Punch mark the rail at the right location and drill the holes to the proper size as shown on the Standard Rail Drilling Table.

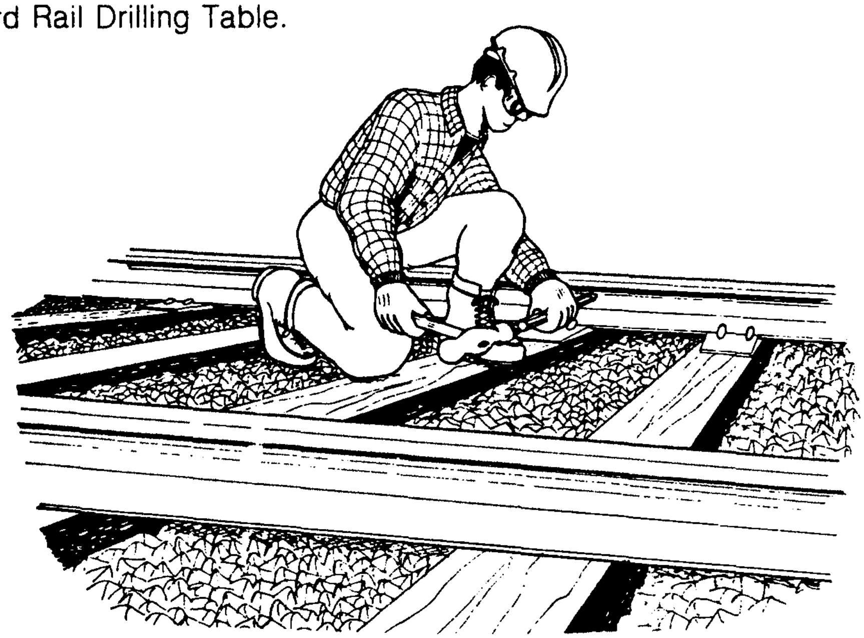
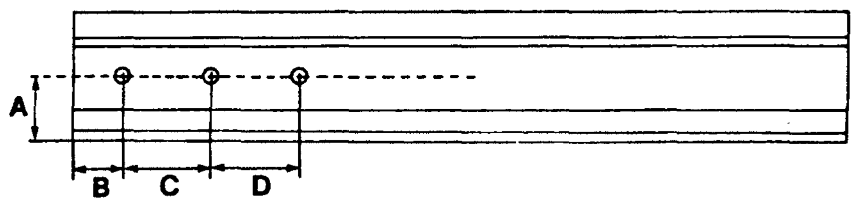


Fig. 9 – Centre Punch



weight and section	A	B	C	D	drill hole	bolt size
136 LB.	3 3/32"	3 1/2"	6 "	6 "	1 1/4"	1 1/8"
132 LB.	3 3/32"	3 1/2"	6 "	6 "	1 1/4"	1 1/8"
130 LB.	3 1/16"	2 11/16"	5 1/2"	5 1/2"	1 1/4"	1 1/8"
115 LB.	2 7/8 "	3 1/2"	6 "	6 "	1 1/8"	1 "
100 LB.	2 45/64"	2 11/16"	5 1/2"	5 1/2"	1 1/8"	1 "
80 & 85 LB.	2 11/32"	2 1/2"	6 1/2"	——	1 1/16"	7/8"

Fig. 10 – Standard Rail Drilling Dimensions

4. Choosing the Correct Rail

When you have to replace a single rail in the track, the replacement rail must match the rail being replaced.

5. Cutting by Hand

We have talked about cutting rail the easy way, by using a power rail saw. What do you do if you must cut a rail when you do not have a power rail saw on hand or if the one you have fails? You will have to cut it manually by using a sledge hammer and a track chisel. To do this:

1) Put a joint bar under the rail.
2) Lay the rail on its side score the base and web of the rail as shown, moving the chisel about ½ inch after each blow.

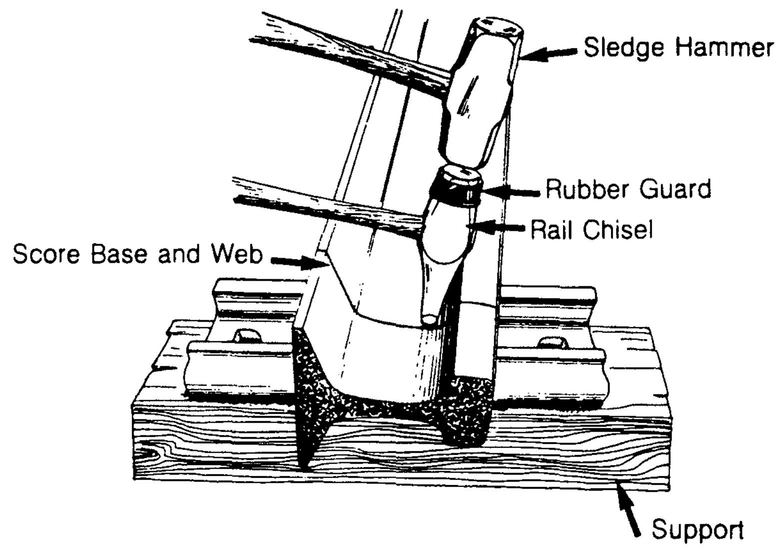


Fig. 11 – Cutting a Rail by Hand – Step 1

3) Turn the rail over and score the same as on the first side.

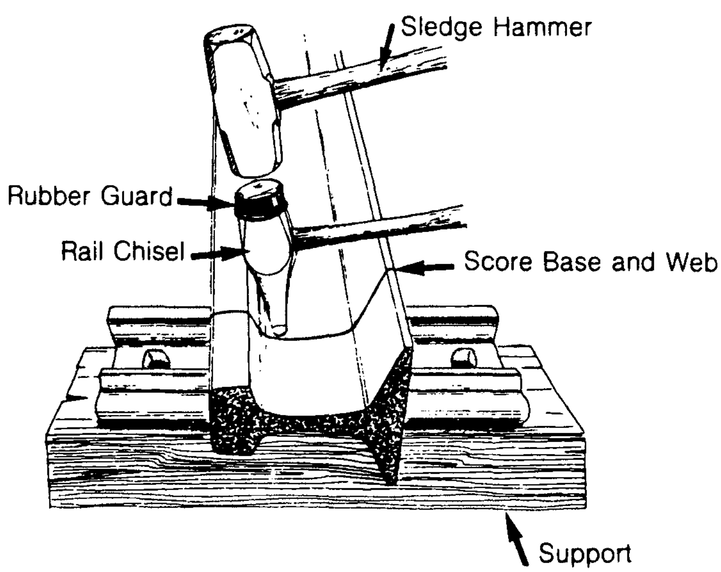


Fig. 12 – Cutting a Rail by Hand – Step 2

4) Support the rail on the head with the joint bar directly under the cut and make a heavy cut along the base, continue striking until the rail breaks. The rail must not be dropped to break it.

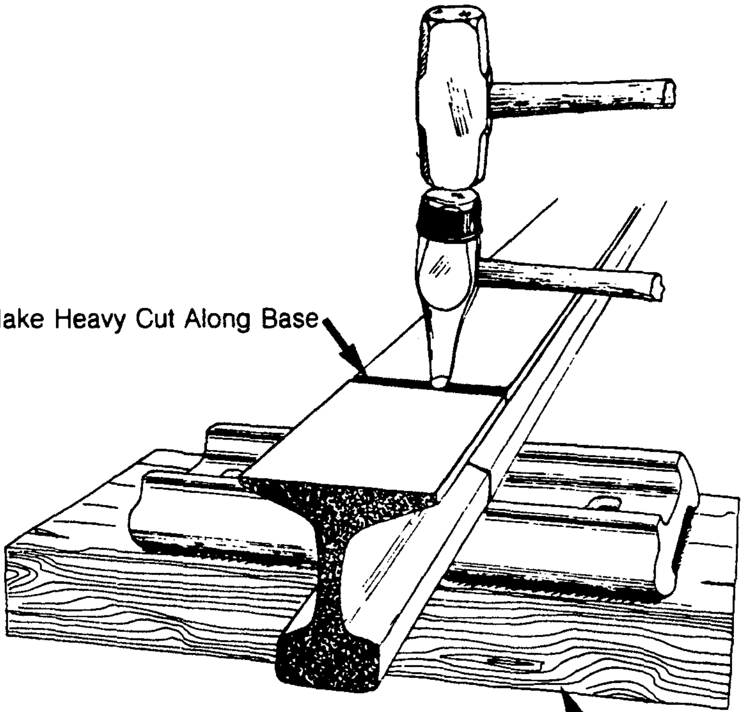


Fig. 13 – Cutting a Rail by Hand – Step 3

Using a chisel it is very hard to cut off a short length of rail less than, say, 6', as the break is likely to go crooked, and it is almost impossible to fix a crooked break unless it is recut with a power saw.

5.1 Drilling a rail by hand is still being done, but hand drills are becoming scarce and most drilling is done by machine.

6. Safety Precautions

- Wear goggles, gloves and safety boots.
- Work with your arms and body covered.
- Never use a spike maul, always use a sledge when cutting by hand.
- Be careful of fire from sparks when using the abrasive saw.
- Keep clothing clear of moving parts.
- Shut off the motor when moving a saw or drill.

- Keep on-lookers away.
- Make sure there is a rubber guard on the track chisel.
- Make sure the handles are straight and secure on the sledge hammer and track chisel.

References

Regulations:

U.C.O.R.	Nil
R.T.C.	Nil
Railway Act	Nil
Provincial	Nil

Technical References:

M/W Rules	Nil
S.P.C.'s	10.13, 10.14
Standard Plans	R-14-8-3-7, X-10-16-156
Other	Nil

CP Rail

MAINTENANCE OF WAY TRAINING

Lesson no.: 18

Subject: RAIL MAINTENANCE IN C.W.R.

First issued: 79-11-12

Maintenance of way training

INTRODUCTION

The increasing use of C.W.R. and its differences from bolted rail make it important that you learn to work with it. This knowledge will help you to ensure your safety and the safety of your men and will allow you to do better maintenance on C.W.R.

SUMMARY OF MAIN POINTS

- What is C.W.R.?
- C.W.R. and chromium rail.
- Advantages and disadvantages of C.W.R.
- The location of each string.
- Special buffer rails.
- Excessive rail temperature.
- Rail thermometer.
- How C.W.R. is laid.
- How to repair pull aparts.
- How to repair buckled rail.
- Transposing C.W.R.
- Bolt maintenance.
- Safety precautions.

PRESENTATION:

1. WHAT IS C.W.R.?

To be considered C.W.R. a rail must be longer than 400'. The usual length of C.W.R. is 1440 ft. C.W.R. can be made from new or from relay rail and when made from relay rail the worn ends are cropped before the rail is welded.

Butt welding is done as follows:

1) Both ends of rails are heated to a high temperature by electric currents;
2) The rail ends are struck together several times and then forced together by great pressure;
3) The rails are cooled; and then,
4) The metal overflow is ground off.

Thermite Welding: Can be done either in a welding plant or in the track. In track, thermite welding is very common and is done by pouring a super heated steel into a mold that surrounds the gap between the two rails. The molten metal hardens into a weld that holds the rail ends together.

There are two types of thermite weld charges, the standard carbon rail thermite weld charge and the special chromium rail thermite weld charge. The standard carbon charge is used to join carbon rail to carbon rail and chromium rail to carbon rail. The special chromium charge is used to join chromium rail to chromium rail.

2. C.W.R. AND CHROMIUM RAIL

C.W.R. can be laid in all curves. Chrome rail is to be laid in all curves over 4° 30' and in curves over 3° where traffic is more than 18 million gross tons per year. Joints in C.W.R curves must be field welded by thermite welding. Chrome rail can also be laid in other places, if approved.

C.W.R. AND CHROMIUM RAIL (Cont'd)

In 132 lb. RE territory, C.W.R. in 136 lb. RE rail section, is laid in all curves. The 136 lb. RE and 132 lb. RE rail must be joined using six hole compromise rail joints, and a 132 lb. chrome buffer rail is to be used so the compromise joint will be in chrome rail. The buffer rail is to be between 24 ft. and 39 ft. long.

When put in a curve, chrome rail must be laid in the curve and in both spirals. It may extend up to 78 feet into the tangents and any left over rail is to be used in other curves or in turnouts. In adjacent curves it may be laid on the connecting tangent provided the tangent is 400 feet or less.

3. ADVANTAGES AND DISADVANTAGES OF C.W.R.

Advantages:

It eliminates most of the rail joints and thus:

- It reduces the battering of rail ends.
- It reduces the need for bolt tightening.
- It reduces the oiling of joints.
- It reduces joint pumping action.
- It reduces tamping and lining of joints.
- It reduces the wear of ties at joints.
- It reduces the correction of the gauge of the track in joint areas.
- It reduces the need for bond wires.
- It reduces rail end welding and slotting.
- It provides a better riding quality of track.

Disadvantages

C.W.R. also has some disadvantages.

- It requires more work and more planning for work.
- Maintenance work must never be done when the rail temperature is more than 10°F above the laying temperature therefore the

3. ADVANTAGES AND DISADVANTAGES OF C.W.R.

Disadvantages (Cont'd)

time available for working on the track in hot weather will be reduced.

- Therefore in the summer months work should be done in the early morning.
- In very cold weather you should wait until the warmest time of the day to do repairs unless it is an emergency.
- As the cribs must be kept full of ballast at all times, extra work is required to keep them full.
- Ballast shoulders must be kept one foot wide, at all times and must be repaired whenever found incorrect.
- More attention must be given to look for rail moving lengthwise. This can be seen when the anchors are not tight to the ties or by a mark made on the rail by the moving anchors. Check to make sure the ties are straight where anchors are installed. If they are not straight it means the track is moving with traffic.

4. LOCATION OF C.W.R. STRINGS

4.1 When There are No Obstructions

If there are no obstructions, each string will end at 1440 feet. One buffer rail must be laid between every second string unless the strings are to be field welded.

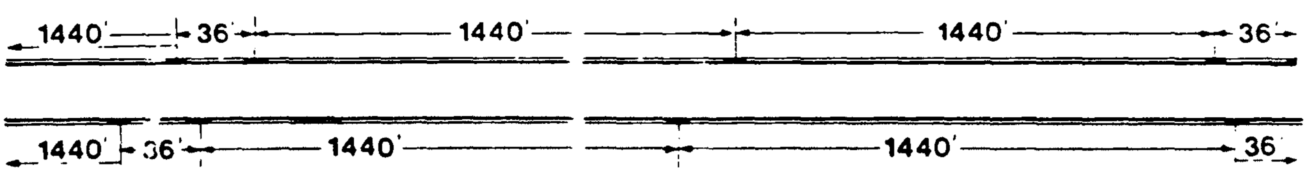


FIG. 1 - C.W.R. STRINGS

4.2 On Signal Territory

In areas with insulated joints, the end of the string must be at the joint. One buffer rail is put on each side of the joint.

.2 On Signal Territory (Cont'd)

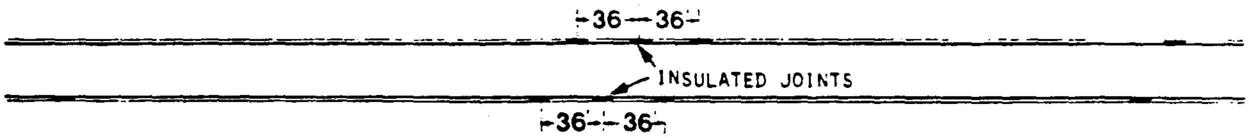


FIG. 2 - STRINGS END AT INSULATED JOINTS

If the location of the signal is 1174' into the string, after the string is cut for the insulated joint the 1174' will be a string and the buffer rails and the 194' section will not. However, if a glued insulated joint is used the joint is considered the same as a weld and the string would be C.W.R.

- When the string is cut for a non-glued insulated joint, 2 buffer rails are to be used, one on each side of the joint.
- It could be that the insulated joint is located 670' from one end of the string, then both parts will be considered a string.

4.3 At Turnouts

Strings must also end at turnouts. Three buffer rails are used at each turnout, one ahead of each switch point and one behind the heel of the frog.

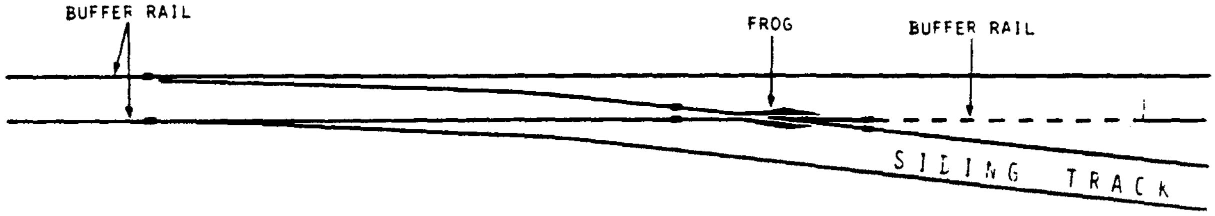


FIG. 3 - BUFFER RAILS AT TURNOUTS

4.4 At Diamond Crossings

Strings also must end at Diamond Crossings, where four buffer rails are used, two on each side of the crossing as shown.

4.4 At Diamond Crossings

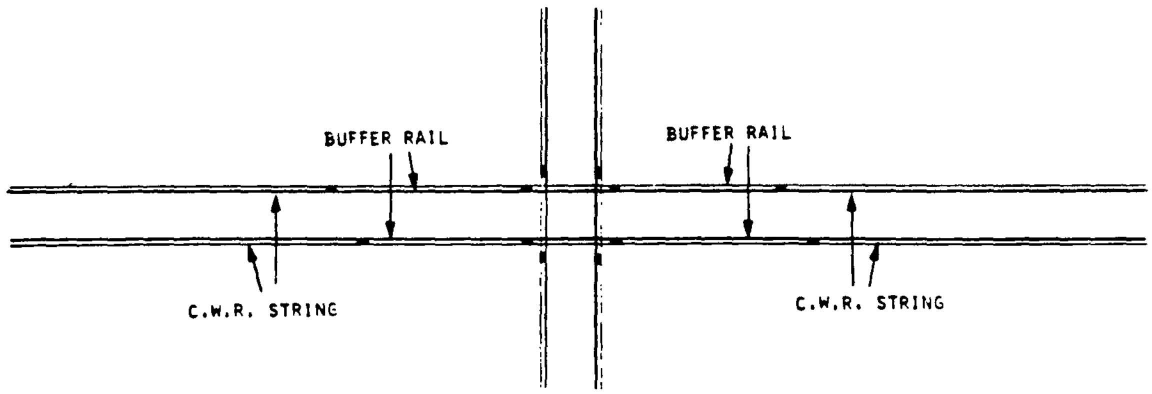


FIG. 4 - BUFFER RAILS AT DIAMOND CROSSINGS

4.5 Other Locations Where C.W.R. Strings End

C.W.R. strings must also end at changes in rail sections and at changes in the metal type of the rail where the joint is not thermite welded.

5. SUMMARY OF BUFFER RAIL

A buffer rail is used to let us adjust the length of a C.W.R. string without having to cut the string. When a buffer rail is required it should be end hardened and less than 39' long but not shorter than 24 feet. They will be laid at the following locations:

- One between every second string.
- On both sides of non-glued insulated joints.
- Behind the heel of frogs at turnouts.
- Ahead of each switch point.
- On both sides of diamond crossings. (Only on the track that you are laying).

6. C.W.R. On Bridges

- C.W.R. shall not be laid on bridges without special permissio of the Chief Engineer.

6. C.W.R. On Bridges (Cont'd)

- You may however lay 78 ft. rails on bridges less than 150 ft. in length and on ballasted deck bridges.

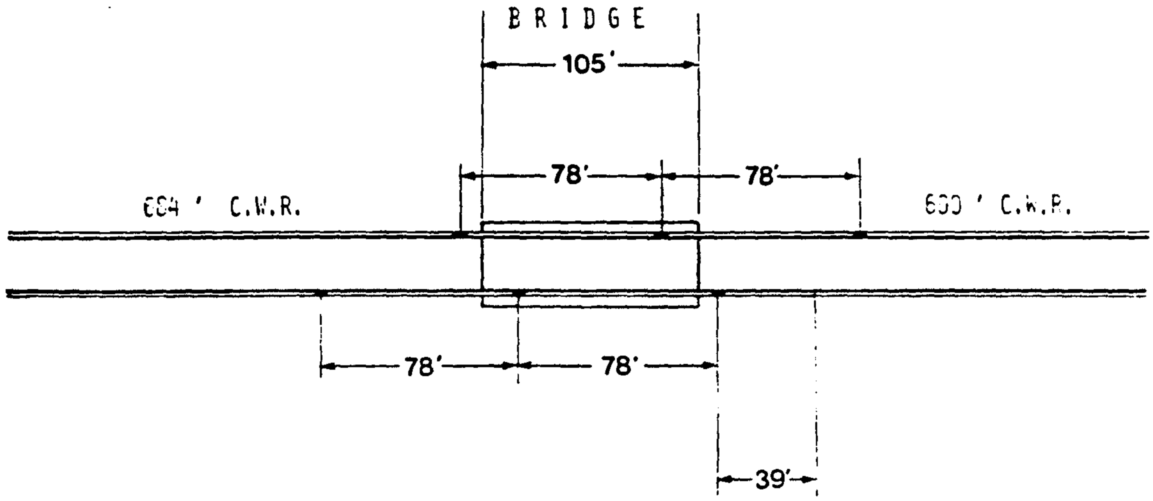


FIG. 5 - LAYING RAIL ON BRIDGES LESS THAN 150'

- 39 foot rail must be laid on open deck bridges over 150' long. Example: Let us assume that while laying C.W.R. we come to a bridge which measures 210' and is located 780' from the beginning of the last C.W.R. string. The rails will be laid as shown.

6. C.W.R. On Bridges (Cont'd)

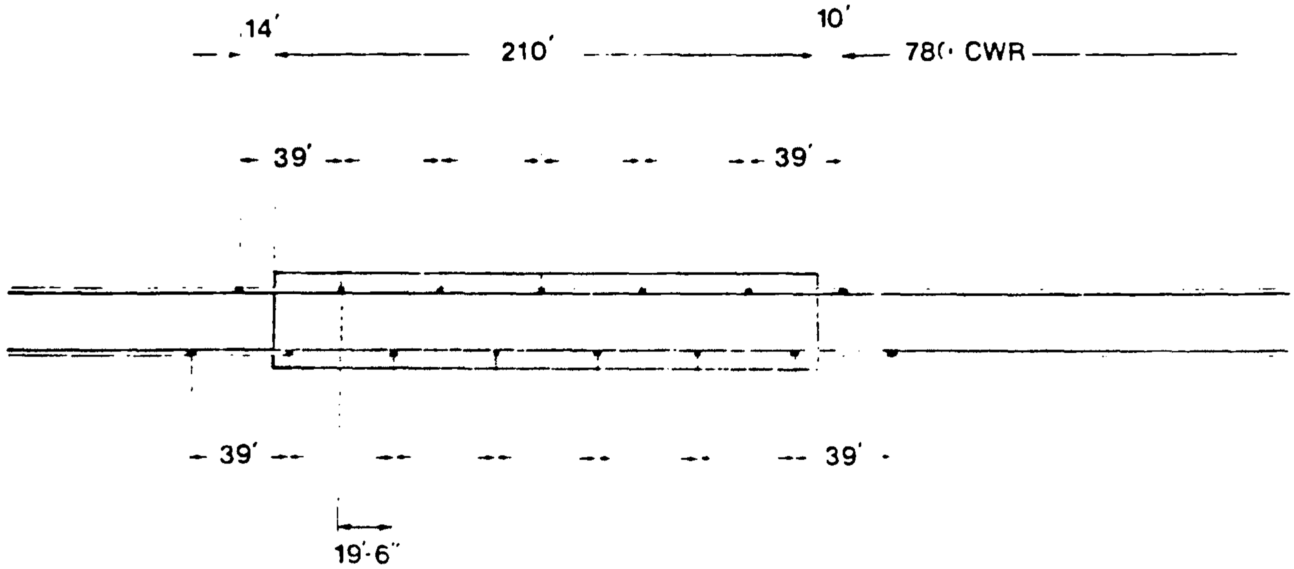


FIG. 6 - LAYING RAIL ON BRIDGES OVER 150'

7. RAIL TEMPERATURE

A C.W.R. string gets longer when it gets hot and shorter when it gets cold. A C.W.R. string laid at 95°F would be about 8" shorter at 20°F if it wasn't held in place by the rail anchors.

If the push against the rail anchors is too strong in hot weather we can get buckled track and in cold weather it may pull apart at a joint or snap at a weld or even between welds. To keep the push or pull from getting too strong we lay or adjust the rail so it is held as if its temperature is between the extremes of hot and cold.

7.1 Preferred Laying Temperature

The laying or adjusting temperature that keeps the push or pull from getting too strong is called the preferred laying temperature. The Division Engineer works out the preferred laying temperature for each track. This should be posted in your

..1 Preferred Laying Temperature (Cont'd)

toolhouse. The preferred laying temperature may be a single temperature (80°) or it may be a temperature range (75°-85°). If a single temperature is given, then 5° above it to 5° below it is the preferred temperature range.

There are two other temperatures we must know when we are doing maintenance in C.W.R., the laying temperature and the adjusting temperature.

7.2 Laying Temperature

This is the temperature of the rail steel at the time the rail was laid. This should be a temperature in the preferred temperature range. Often we can't lay the rail at the right temperature and we will have to come back later and adjust the string. When we first lay the string the laying temperature will be the temperature of the rail steel when laid and later when we adjust the string the laying temperature will be a temperature in the preferred laying temperature range.

7.3 Adjusting Temperature

When we come back to adjust a string that could not be laid at the right temperature, we adjust and re-anchor the rail so that it is as if it had been laid at the right temperature. This is called the adjusting temperature.

Later in the lesson we will explain how to adjust C.W.R., but for now if the rail is adjusted without heating it must be adjusted when the rail temperature is within the preferred laying temperature range and the adjusting temperature will be the rail thermometer temperature at the time of adjusting. If the rail is adjusted by heating or by using the rail puller, then the adjusting temperature is not the rail thermometer temperature but is the temperature for which the rail was adjusted.

7.4 Temperature Tags

The laying or adjusting temperature is stamped on stainless steel tags. When the string is laid or adjusted one tag is put on a track bolt at both ends of each string.

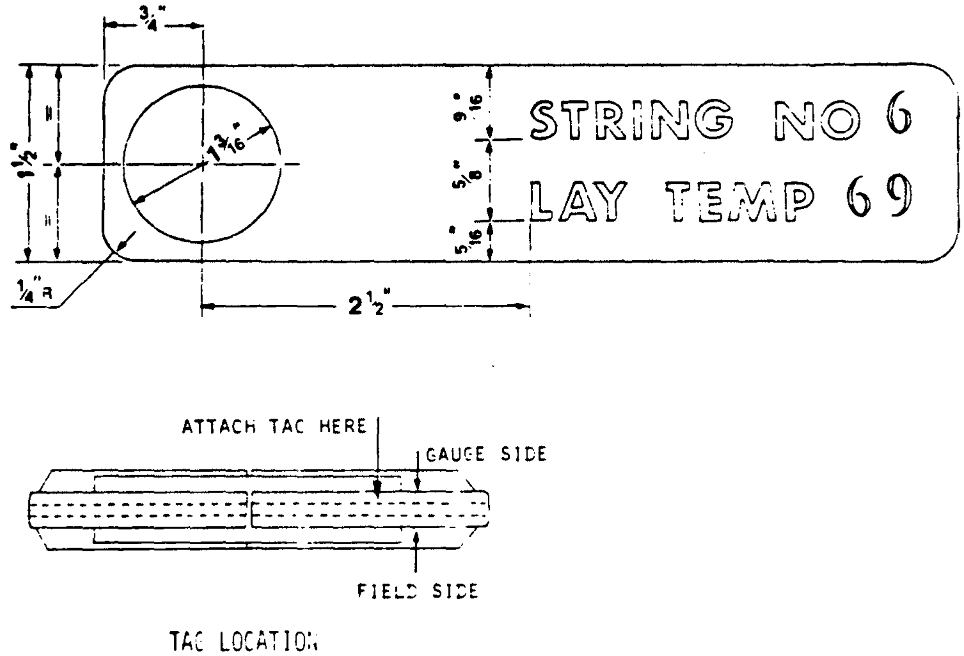


FIG. 7 - C.W.R. STRING AND LAYING TEMPERATURE TAG

The Track Maintainer Foreman must keep these tags clean and readable and he must replace them if they get damaged.

In this lesson we will call the temperature on the tag the <u>tag temperature</u>. The tag temperature is either the actual measured temperature on the rail when it was laid and anchored, or it is the adjusted temperature if the rail was adjusted while or after it was laid.

The idea is to get the tag temperature on each C.W.R. string within the preferred laying temperature range. A list of the tag temperatures for each string must be recorded and forwarded to the Regional Engineer, the Division Engineer and the Roadmaster

.4 Temperature Tags (Cont'd)

The re-adjusting of strings to the preferred laying temperature is usually done by the regional rail gangs, however, the Track Maintenance Foreman may have to adjust a string when fixing a pull apart or a buckled rail.

8. RAIL THERMOMETER

Before working in C.W.R. the foreman must always check the present rail temperature and compare it to the rail laying temperature.

- At each end of a C.W.R. string the tag shows the rail laying temperature. Do not surface, correct line, ballast, renew ties or change rail if the rail temperature is more than 10°F (5°C) above the rail laying or adjusting temperature. Gauging and shimming may be carried out at temperatures lower than the laying temperature.

8.1 Use of a Rail Thermometer

- The type recommended is very accurate. It is the ALNOR PYROCON Model 4000A. It must be used, before any work is performed in C.W.R. territory and also when working, to check the rail temperature. When the temperature is changing fast the rail temperature must be checked often. The temperature is taken by placing the thermometer on the base of the rail on the side opposite the sun. Leave it on the rail for at least ten minutes to get a true temperature.

8.1 Use of a Rail Thermometer (Cont'd)

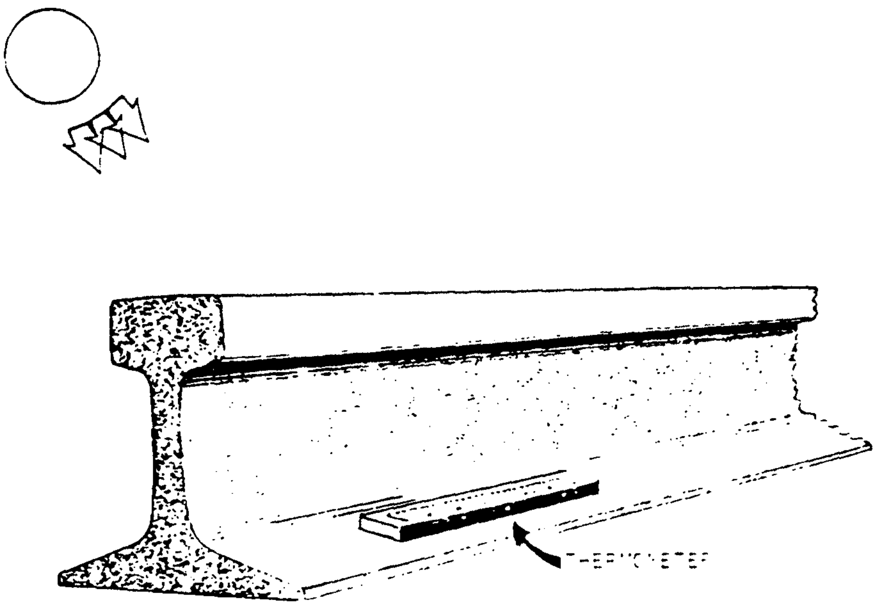


FIG. 8 - PLACING A RAIL THERMOMETER

8.2 Storage of the Thermometer

The thermometer comes in a case, and after each use it must be put in its case. Store it in a safe place on the motor car, so it will not be broken by other tools and where it will not get a lot of vibration. Remember this tool can be easily damaged.

9. OTHER PROBLEMS FROM EXCESSIVE RAIL TEMPERATURE

Excessive rail temperature can cause many track defects, the most obvious being buckled rail. The pressure is tremendous, so chances are that if the rail is not properly fastened and anchored to the ties, or if the ballast section is not up to standard, buckled rail will occur. High temperature can also cause poor line, poor surface, as the track moves and is unable to settle into one place. Poor gauge happens when the rail is anchored, fastened, and spiked correctly and the rail either cuts or bend the spikes. Other factors which could lead to problems are:

9. OTHER PROBLEMS FROM EXCESSIVE RAIL TEMPERATURE (Cont'd)

1) When the rail is not laid within the preferred laying temperature range, and the rail is not later re-adjusted.
2) When making repairs to C.W.R. the rail is not well secured.
3) The combination of cold, brittleness and added pressure makes C.W.R. more likely to break under a broken flange or wheel.

10. ADJUSTING C.W.R.

While we would like to lay C.W.R. within the preferred laying temperature range, it is not always possible to do so, and sometimes the rail is laid either above or below the preferred laying temperature range. In these cases the rail will have to be adjusted. We have three ways to adjust C.W.R.

1) We can wait until the rail temperature is within the preferred laying temperature range and then adjust the string.
2) We can wait until the rail temperature is below the preferred laying temperature and then heat the rail to adjust the string.
3) We can wait until the rail temperature is below the preferred laying temperature and then use a rail puller to adjust the string. (This can be done on tangents only).

We cannot adjust the string when the rail temperature is above the preferred laying temperature because we have no practical way of cooling the rail.

When adjusting C.W.R. in either of the first two ways we must be sure that the whole length of the string is at a neutral position. To do this we remove the joint bars at the buffer rail and all of the rail anchors. Then use a rail vibrator or a babbit hammer to make sure it moves as much as needed.

10. ADJUSTING C.W.R. (Cont'd)

To better understand what happens when we adjust a string, we will look at the length of the rail when;

1) The string is laid - the tag temperature
2) We remove the rail anchors to let the rail move to its neutral position - the rail temperature
3) The rail is adjusted - the adjusting temperature.

10.1 Adjusting With No Heating

1) When the string was laid above the preferred laying temperature range we wait until the rail temperature is within the preferred laying temperature range to adjust.

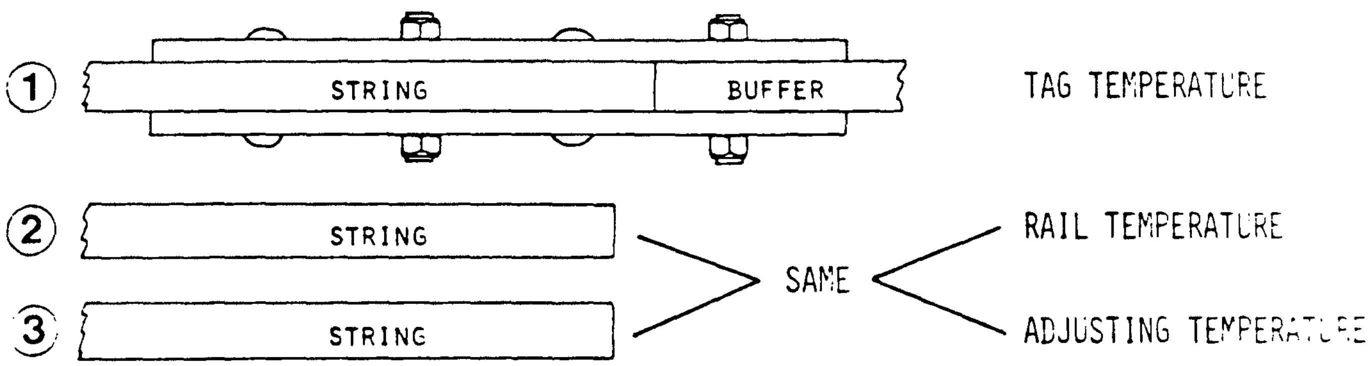


FIG. 9

When the anchors are removed the string will shorten. The new tag temperature will be the rail temperature at the time of adjusting. A longer buffer rail will be used.

2) When the string was laid below the preferred laying temperature range, we wait until the rail is within the preferred laying temperature range to adjust.

.1 Adjusting With No Heating (Cont'd)

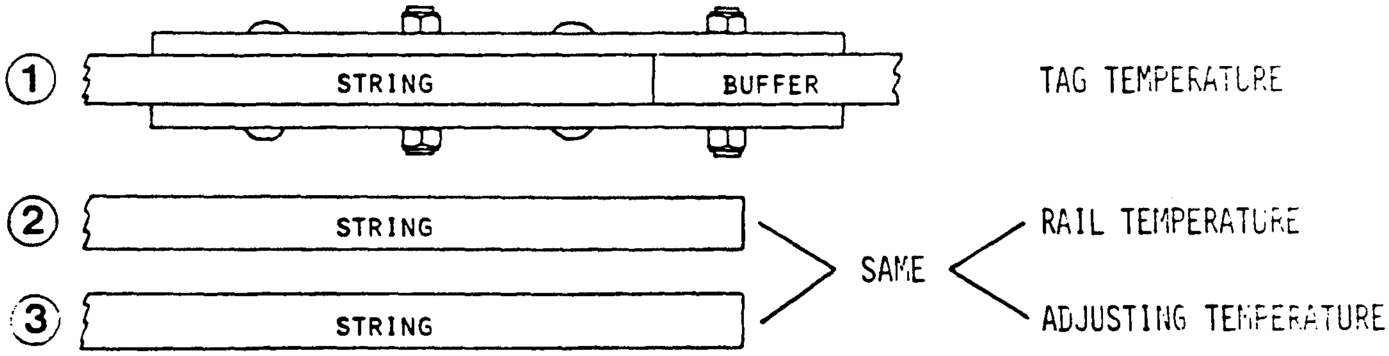


FIG. 10

When the anchors are removed the string will lengthen. The new tag temperature will be the rail temperature at the time of adjusting. A shorter buffer rail will be used.

).2 Adjusting with Heating

1) When the string was laid above the preferred laying temperature range and at the time of adjusting the rail temperature is below the preferred laying temperature range.

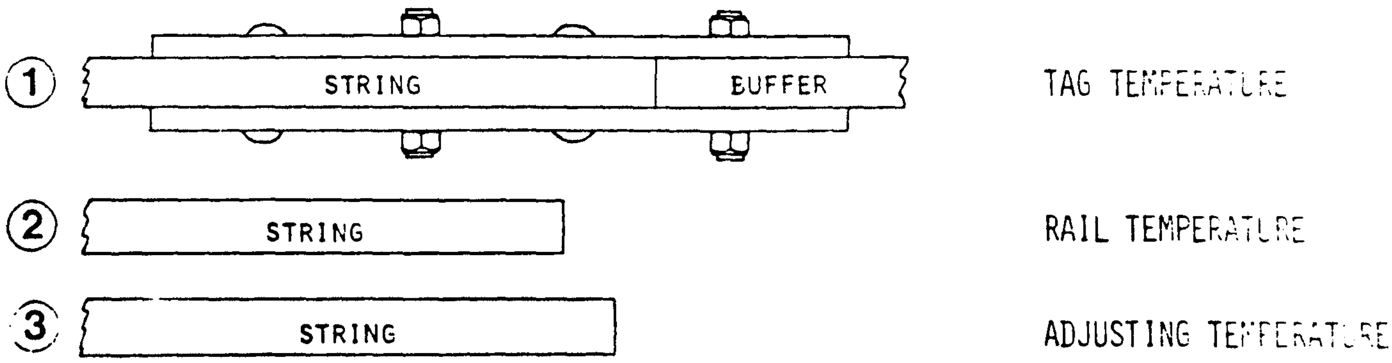


FIG. 11

10.2 <u>Adjusting With Heating</u>

When the anchors are removed the string will shorten. The string will lengthen when adjusted and the new tag temperature will be the adjusting temperature. A longer buffer rail will be used.

2) When the string was laid below the preferred laying temperature range and the rail temperature at the time of adjusting is lower than the tag temperature.

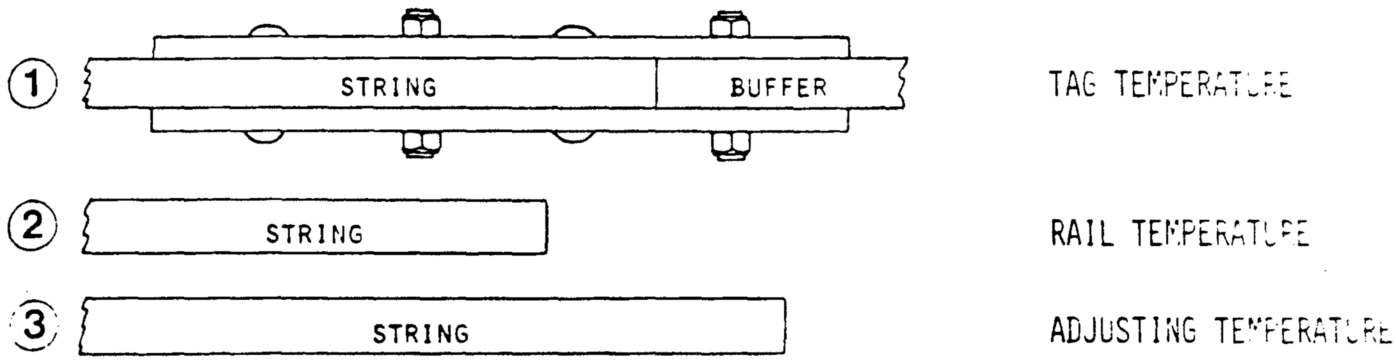


FIG. 12

When the anchors are removed the string will shorten. The string will lengthen when adjusted and the new tag temperature will be the adjusting temperature. A shorter buffer rail will be used.

3) When the string was laid below the preferred laying temperature range and the rail temperature is still below the preferred laying temperature range but is higher than the tag temperature.

...2 Adjusting With Heating (Cont'd)

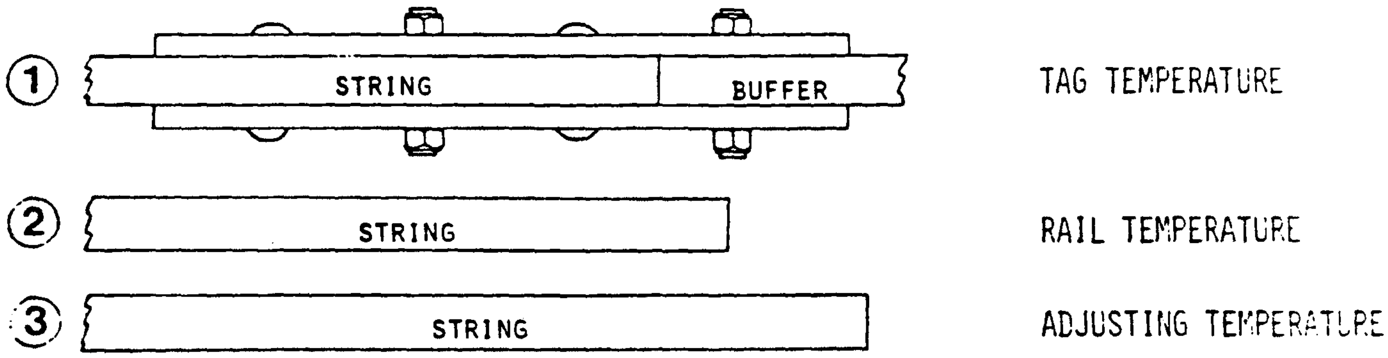


FIG. 13

When the anchors are removed the string will lengthen. The string will lengthen more when adjusted and the adjusting temperature will be the new tag temperature. A shorter buffer rail will be used.

10.3 Adjusting with a Rail Puller

A rail puller is only used to adjust on tangent track.

When the string was laid above the preferred laying temperature range and the rail temperature is below the preferred laying temperature range, a rail puller can be attached to the buffer and the string and used to control the shortening of the string to adjust the string. This is the only case where the rail does not move to its neutral position.

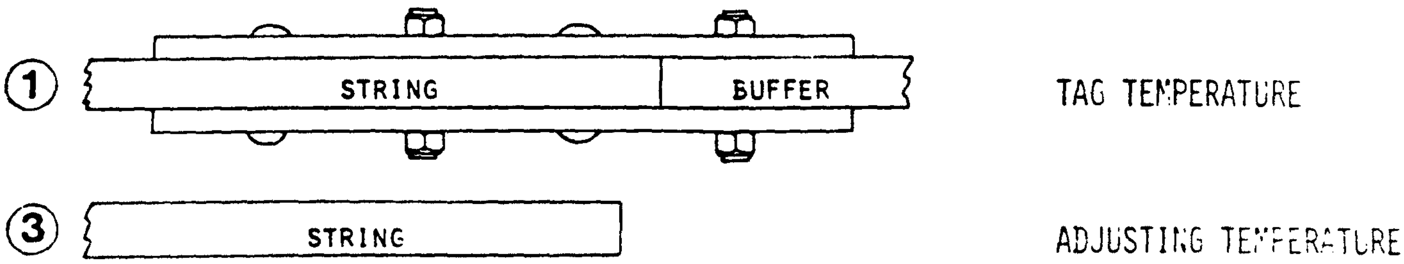


FIG. 14

10.3 Adjusting with a Rail Puller (Cont'd)

When the anchors are removed the string is controlled so it only shortens to the adjusting temperature. The adjusting temperature will be the new tag temperature and a longer buffer rail is used.

10.4 Adjusting When No Heating is Needed

1) Remove the buffer rail.
2) Remove all rail anchors on the string being adjusted.
3) Let the rail move to the neutral position. If needed use a rail vibrator or a babbit hammer to get the rail to move to its neutral position.
4) Re-apply all rail anchors. If the string on the other side of the buffer rail needs adjusting do it before putting in a new buffer rail.
5) Put in a new buffer rail of the right length, (with no gap).
6) Make new laying temperature tags and put one at each end of the string. The temperature of the rail is the new laying temperature.

10.5 Adjusting When Heating is Needed

1) Remove the buffer rail.
2) Working from the buffer rail, remove the anchors.
3) Let the rail move to a neutral position. Use vibrators or a babbit mallet to shake the rail. Make sure spikes or tie plates are not holding the rail from contracting.
4) Mark the rail base and a tie plate at four equal points along the string.
5) Take the rail temperature and subtract from the preferred laying temperature to get the temperature differential.
6) Use the Expansion Segment Table on page 12-9 of the S.P.C.'s to find how much the rail should move at each quarter point.
7) Start the rail heater at the far end from the buffer rail and move toward the buffer rail at a speed so that the rail mark moves the distance needed for each quarter segment.
8) Put rail anchors on right behind the heater.

10.5 Adjusting When Heating is Needed (Cont'd)

9) Do the same with the rail on the other side of the buffer rail.

10) Put in a new buffer rail.

11) Put on new temperature tags showing the adjusting temperature.

- Suppose the preferred laying temperature is 80° and the rail temperature is 40°. The expansion should be 4½". Supposing you only get 4¼". Then it seems that the expansion you got is for about half way between 40° and 35°, or about 38°. Therefore your adjusting temperature is 40° + 38° or 78° and the new tag temperature should be 78°, not 80°.

10.6 Adjusting with a Rail Puller

- When you have a rail puller

AND

- the string is on tangent track

AND

when the tag temperature is above the preferred laying temperature

AND

the rail temperature is below the preferred laying temperature.

- You can use the rail puller to control the shortening of the rail.

1) Calculate the shortening in the same way as you would calculate the lengthening.
2) Mark the quarter segments.
3) Put on the rail puller.
4) Take off the anchors.
5) Back off the rail puller and let the rail shorten the right amount.
6) Vibrate the rail so the quarter segments all have the right movement.

10.6 Adjusting With a Rail Puller (Cont'd)

7) Re-apply the anchors.

8) Put on new buffer rail and tags.

11. REPAIR OF A PULL APART LESS THAN 3" WIDE

A pull apart happens when both rails at a joint shorten, usually because of cold weather. The pulling pressure causes the bolts in the joint to shear off and the rails to pull apart.

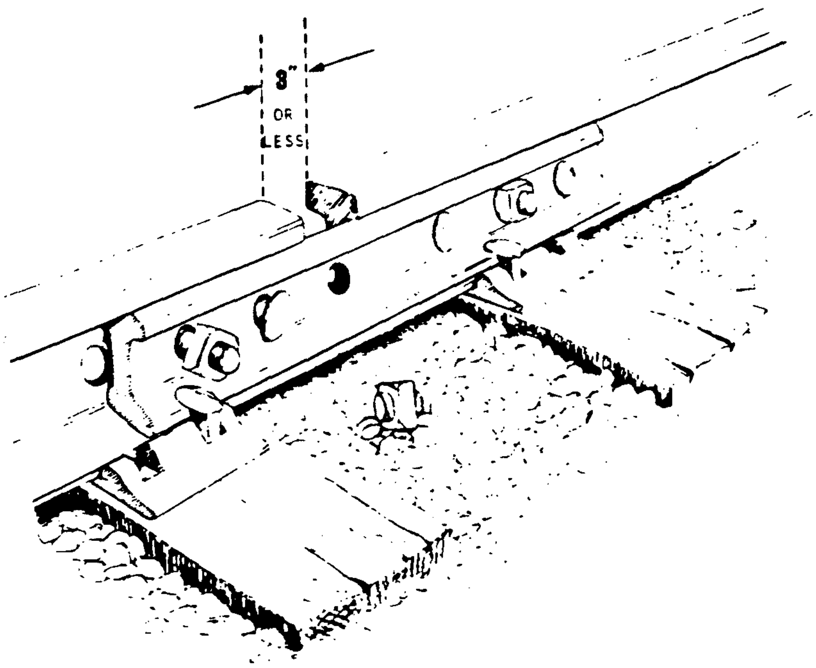


FIG. 15 - PULL APART

- A pull apart may also happen at a weld failure or at a defect in the rail.
- (A pull apart is a separation of rails, usually not more than 3 inches, at a bolted joint, caused by shearing off the track bolts. The term is sometimes loosely used to mean any separation of rails in cold weather, including broken rails, broken welds, bolt hole breaks and splice bar failures; but both the cause and the cure of each of these is different and

.1. REPAIR OF A PULL APART LESS THAN 3" WIDE

it is important that things be called by their proper name if there is to be any understanding of how the problem can be fixed.)

- The rail ends can be brought back together by heating, or if on tangent track by using a rail puller. Heating is done by burning oil-soaked asbestos ropes laid along the base of the rails.

A foreman must use the following procedures to repair the pull apart:

- First set-up protection.
- Decide how it will be fixed. Either using a rail puller or an asbestos rope.
- Decide if help will be needed from other sections.
- Make sure all tools and materials are on hand.
- When removing joint bars, special care should be taken if some of the bolts are loose, the pressure may cause the others to break.
- Remove rail anchors for a distance of 390' on each side of the joint on both strings. (If a 3" pull apart)
- If less than 3" shorten the distance for removing anchors.
- Place asbestos ropes onto the base of the rail between the spike head and the web of the rail on both strings. Then make a mark on the base of the rail at the edge of the tie plate; about 195' from the joint on both strings. They will be used later to measure the movement of the rail.
- Soak the rope with kerosene, diesel fuel, or stove oil and light it to heat the rail (Check to make sure the ties are not burning). As soon as the rail begins to move re-apply the rail anchors on both strings.
- You may need to have a second oil soaked rope ready to place on the rail and light, if you can't get the anchors back on in time.
- Once the opening is closed, grease joint area, install joint bars, tighten bolts and respike joints.

11. REPAIR OF A PULL APART LESS THAN 3" WIDE

- Check rail anchors in both directions to ensure that they are all tight and boxed properly.
- If using a rail puller (on tangent only) remove the joint bars.
- Install the rail puller.
- Remove anchors for 390' on both strings.
- Close up by pulling the rail with the rail puller. The rail puller or expander is not used on curves because the rail binds in the tie plates and you can't get even movement throughout the rail.
- Reapply the rail anchors.
- Remove the puller, install and tighten joint bars, and spike the joint area.
- Clean up.
- Remove protection.

11.1 Precautions

- Do not use asbestos rope on bridge ties.
- Use asbestos rope with great caution if there are dry weeds that could spread a fire away from the track.
- In dry weather, have sand or water available to put out fires on the ties.

12. REPAIRING A PULL APART WIDER THAN 3" OR IF A DEFECTIVE RAIL IS FOUND

- First protect against traffic.
- Make sure the required tools are on hand. (A rail saw, a rail drill, and a rail puller are also needed).
- For a pull apart 3" or more and for a break in the weld zone a new closure rail must be put in the track. It should be not less than 24 feet long.
- Obtain a good rail from the rail rack. The rail should be chosen so that the wear matches the wear of the rail in the track.

REPAIRING A PULL APART WIDER THAN 3" OR IF A DEFECTIVE RAIL IS FOUND (Cont'd)

- Mark the C.W.R. where the cut should be made for the new closure rail to fit. Cut the rail with a rail saw and drill the holes.

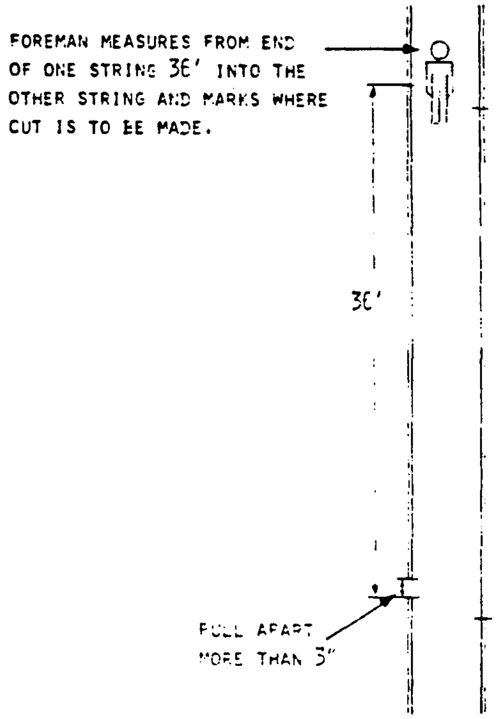


FIG. 16 - MARKING CUT LOCATION

- Remove the spikes and rail anchors on the rail to be removed then remove it from the track.
- Then plug the holes and put a new closure rail into the track.
- Make sure the joint area is greased, then put on the joint bars and bolts, tighten bolts, respike the rail and apply the rail anchors.
- If the rail is laid below the preferred laying temperature, the closure rail must be laid with the maximum possible end gap. If laid above the preferred rail temperature it must be laid tight with no gap.

12. REPAIRING A PULL APART WIDER THAN 3" OR IF A DEFECTIVE RAIL IS FOUND (Cont'd)

- As the closure may need adjusting at a later date, keep a record to remind you that it must be adjusted.
- Always check that spikes are well driven into the ties and that the rail anchors are properly boxed on both strings.
- Both strings must be anchored every tie for 195' and the closure rail must be anchored every second tie.
- If there is a buffer rail at the pull apart, you should always make the repair in the buffer rail, not in the string.
- If a pull apart happens between two strings you should cut into one string only.
- If a weld breaks, cut about 5" to 6" on both sides of the weld and hold the samples until instructions are received for disposition. The gap where the cut was made will be repaired in the same way as for a pull apart wider than 3". Report the pull apart on Form 15½.

13. HOW TO REPAIR A BUCKLED RAIL?

- First of all you must protect. When this is done, find out if a temporary or permanent repair must be made. If it can be temporarily lined, set up the proper protection and line to a passable position. (The lining procedure is outlined in lesson 110.) If permanent repairs must be made immediately you must first decide where it can be repaired. Buckled track can occur at either the end of a string or anywhere else within a string, so if the buckle occured close to the end of a string near a buffer rail, it should be repaired at the buffer rail if possible.

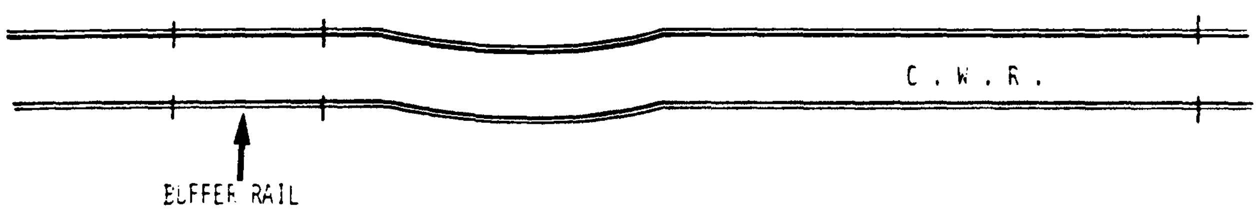


FIG. 17 - BUCKLED RAIL

<u>HOW TO REPAIR A BUCKLED RAIL?</u> (Cont'd)

If the buckle is near the centre of the string: it should be repaired away from the worst part of the buckle.

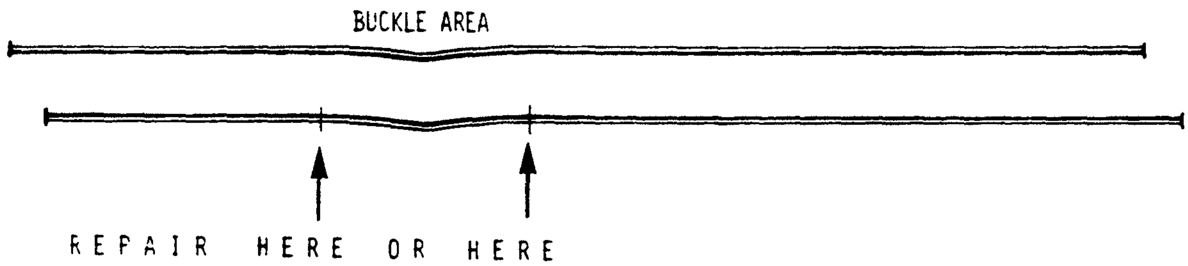


FIG. 18 - BUCKLE AREA

Now, how are permanent repairs made? Let's take the example of a buckled track close to a buffer rail. In order to release some of the pressure, line the track out a bit farther at both ends of the buckle. Then dismantle the joint at the far end of the buffer rail.

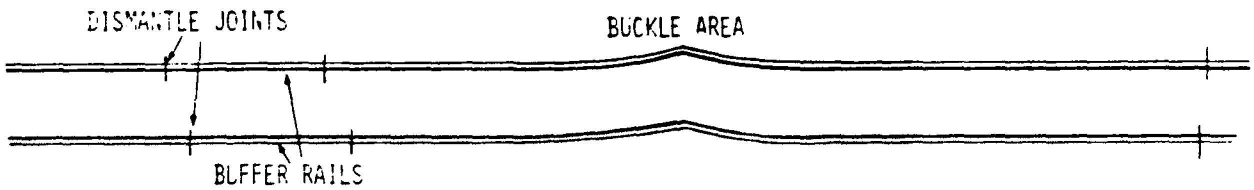


FIG. 19

When dismantling tell the men about the precautions that should be taken such as standing clear of wherever the rail wants to go. If you have to stand near the track, then stand on the ties in the centre of the track. Watch for bolts breaking off and flying. If the track is well anchored ahead and behind you may be able to disengage both rails with lining bars where the joint

13. HOW TO REPAIR A BUCKLED RAIL? (Cont'd)

bars have been removed. Most of the time you will have to burn a 1" to 2" piece off the buffers in order to disengage it. Once it is disengaged remove some of the anchors so that the rail can be lined easily. Then line the buckled area to its proper location. If the rail is still tight this must be done carefully. Be sure that no man is on the side of the rail where it might jump when it is lifted clear of the tie plates. You may have to line the buckle out farther to get enough pressure off to separate the rail.

Saw the excess rail on the buffer. If cutting at the first bolt hole will not be enough it is better to remove the buffer rail and cut a new closure rail to fit.

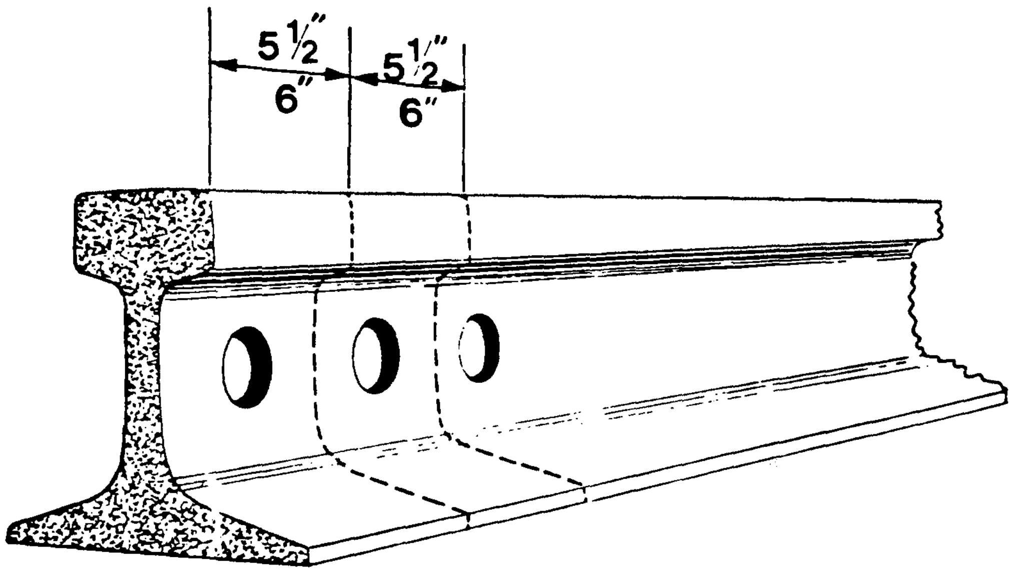


FIG. 20 - SAW CUTTING RAIL

Check both strings to make sure all rail anchors are in good condition, if not, replace with new ones. Trim the ballast, especially in the buckle area. When you are satisified that the track is safe, remove the protection.

HOW TO REPAIR A BUCKLED RAIL? (Cont'd)
When buckled track occurs in a string decide where cuts or burns will be made. When done re-line the track to it's proper position. When both sides have been realigned: saw cut the rail overlap to fit; drill the bolt holes and put on the joint bars; next fill in the tie cribs and the ends of the ties.

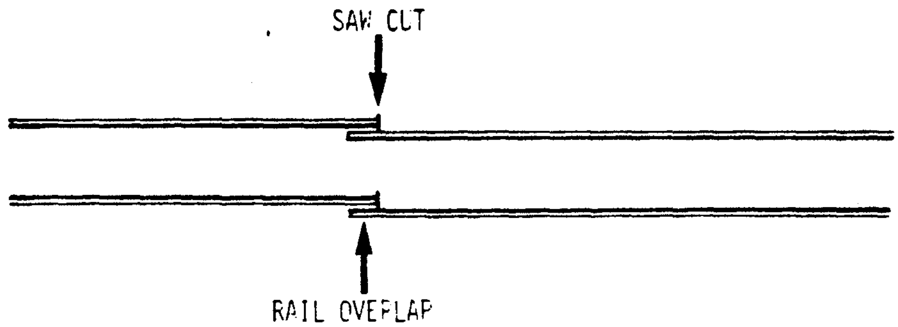


FIG. 21 - CUT RAIL OVERLAP

Anchor every tie for 195' in both directions on both rails. Make a record of the work location, the laying temperature and the length of rail cut out, as it will be needed when the rail is readjusted later.

14. TRANSPOSING C.W.R.

As a foreman it is your duty to make sure the following is done:
- The proper protection is provided.
- As a long time is needed to transpose a curve, make sure that enough time is available before you begin the work.
- Be certain that all concerned know what you will be doing, such as dispatchers.
- Make a check of the area to be transposed a couple of days ahead to see what you will need, or what will have to be done, such as:

14. <u>TRANSPOSING C.W.R.</u> (Cont'd)

1) Decide where each string will be saw cut at both the entrance and the leaving end of the curve. The contour of the low and high rail must match at these places.
2) Check the line of the curve, if found incorrect it should be corrected.
3) Check the gauge of the track. If found incorrect, correct it when respiking, after the rails have been transposed.
4) Check to make sure that enough track material is available in case it is needed.

- For the procedures on transposing C.W.R see Lesson 104.

15. <u>MAINTENANCE OF BOLTS AND JOINTS IN C.W.R.</u>

a) All joints must be lubricated and fully bolted and the bolts must be kept tight at all times.
b) All bent bolts must be replaced as soon as possible.
c) Bolts in C.W.R. must be inspected and tightened every spring when the rail gaps are closed. If defective bolts are found they should be replaced one at a time.
d) The conditions of fibres in insulated joints must be watched carefully and if damaged they must be replaced as soon as possible.
   - This work should be done when the rail temperature is within 10° of the laying or adjusting temperature.
   - Before any bolts are removed all anchors for at least 300 ft. on either side of the joint must be checked and adjusted if necessary. A rail expander can be used for this work.
e) Flowing metal at the rail ends must be ground before the hot weather comes around (slotting).
f) Good surface must be maintained at all joints.

16. <u>SAFETY PRECAUTIONS WHEN WORKING IN AND AROUND C.W.R.</u>

Safety precautions must be taken at all times when working in and around C.W.R. with particular attention given to the following:

SAFETY PRECAUTIONS WHEN WORKING IN AND AROUND C.W.R. (Cont'd)

Surfacing

- No surfacing should be done unless there is enough ballast, so that cribs can be filled and shoulders trimmed to 1 foot from the end of the tie.
- When raising the track you must never raise it any more than necessary.
- When surfacing out of face both rails must be lifted together so that cross level is not disturbed.
- A mechanical tamper should be used.
- You must never surface on C.W.R. if the rail temperature is more than 10° above the laying or adjusted temperature.

Tie Renewals

- No more ballast than necessary may be removed from the tie crib or shoulder.
- You should not disturb the track line.
- Always make sure that at least three ties ahead and behind are spiked and anchored properly before you remove the spikes from a tie that is to be removed.
- Where heavier tie renewals are needed they must be done in two or more passes.
- Sufficient time must be allowed between passes to ensure the new ties are firmly embedded in the ballast.
- If changing switch ties, or installing a new switch, the same applies as for changing cross ties.
- The ballast section must be trimmed and the cribs filled as soon as possible.
- Again you must never change out ties if the rail temperature is more than 10° above the laying or adjusted temperature.

Lining

- If lining with jacks or with lining bars, you must make sure that the track is not lifted.

16. SAFETY PRECAUTIONS WHEN WORKING IN AND AROUND C.W.R. (Cont'd)

Lining (Cont'd)

- If the ends of the ties were dug out they must be filled in as soon as lining is completed.
- Spike lining in C.W.R. should be avoided and under no circumstances is it permitted when the rail temperature is above the temperature shown on the temperature tags.
- No lining is to be done if the rail temperature is more than 10° above the laying or adjusted temperature.

Shimming

- When shimming is needed, the spikes should be removed from every second tie only. The spikes on alternate ties must not be raised more than is absolutly necessary to insert the shims and the tie plates on the ties being shimmed.
- Shims should then be installed, ties respiked and anchors re-applied where necessary.
- The in between ties can then be shimmed and re-spiked.
- If a train is to go over a piece of track where every second tie has been shimmed the train must not be permitted to exceed a speed of 10 M.P.H.
- When removing shims you must follow the same procedure as for installing shims.
- No shims are to be removed if the rail temperature exceeds the laying or adjusting temperature.

Gauging

- Gauging in C.W.R must not be done unless the rail temperature is at or below the laying or adjusting temperature.

Rail Anchors

- Rail anchors must be applied on C.W.R. as follows:
  - The beginning and end of each string must have boxed anchors at every tie for 195'.

SAFETY PRECAUTIONS WHEN WORKING IN AND AROUND C.W.R. (Cont'd)

Rail Anchors (Cont'd)

- The centre section must have boxed anchors on every 2nd tie.
- The buffer rail between strings must be box anchored every 2nd tie.
- Defective rail anchors must be replaced immediately.
- When replacing rail anchors the rail temperature must be within 5° of the laying or adjusted rail temperature, except as required for maintenance of joints.
- When adjusting rail anchors they must be removed from the rail and re-installed at their proper position. Never drive an anchor along the base of the rail to its proper position.
- Remember that working with C.W.R. is much different than working with jointed rail. So more attention and more thought must be given before a decision is made on what to do and how to do it.

REFERENCES

Regulations:

U.C.O.R.	Nil
R.T.C.	Nil
Railway Act	Nil
Provincial	Nil
Labour Code	Nil

Technical References:

M/W Rules	Nil
S.P.C.'s	12, 24, 28
Standard Plans	X-10-16-194-1, X-10-16-205 to 209
Other	Safety Rules and Regulations 1124, 1126, 1127, 1128, 1130, 1610, 1611, 1613

CP Rail

MAINTENANCE OF WAY TRAINING

Lesson no. 15

Subject GAUGING

First issued 79/03/08

Maintenance of way training

GAUGE OF TRACK

The standard gauge of the track is 56-1/2" inches measured between the rails, at a point 5/8" below the top of the rail. If the distance between the two rails increases to more than 56-1/2", it is called wide gauge, and if the distance decreases to less than 56-1/2", it is called tight gauge. The gauge of the track, on tangents and on curves up to 12° must never be less than 56-1/4" or more than 56-3/4". However, if the gauge varies at a rate not exceeding 1/4 inch in 10 feet, the gauge need not be corrected until it exceeds 1/2 inch wide.

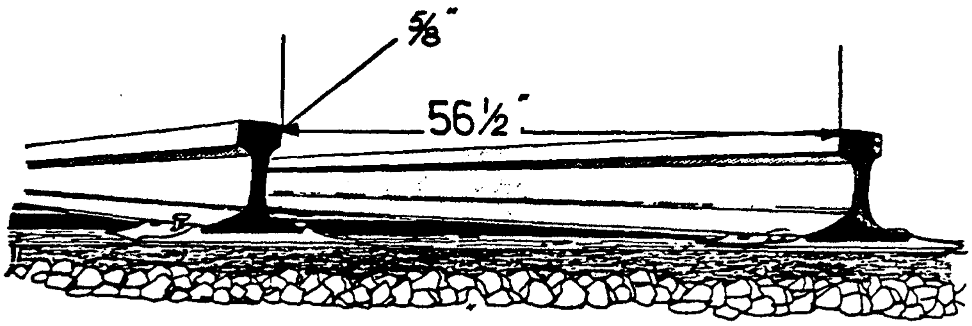


FIG. 1 - GAUGE OF TRACK.

1.1 Track Gauge

A track gauge is a standard track tool. It is built of strong material so that its condition and accuracy are easily maintained.

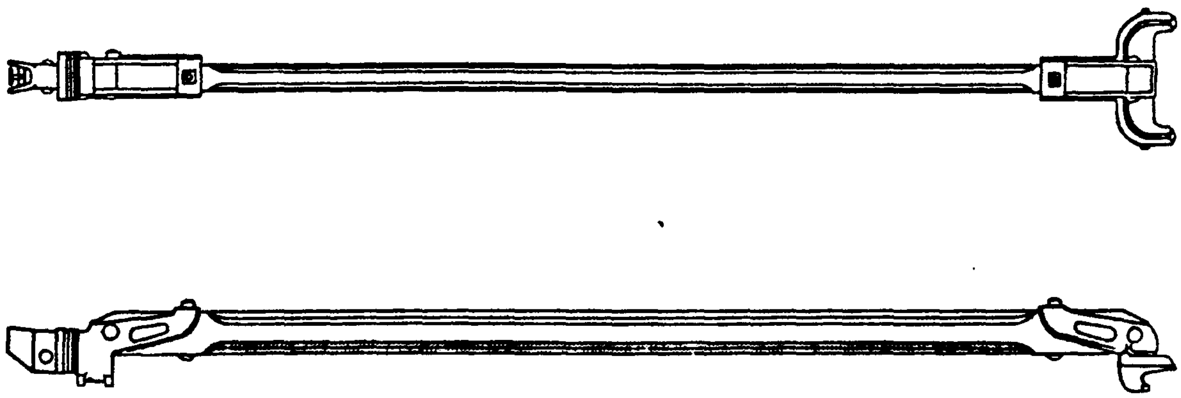


FIG. 2 - TRACK GAUGE.

1. TRACK GAUGE (Cont'd)

The center part of the track gauge, as shown in figure 2, is made of hardwood and is bolted to two metal pieces called lugs. The lug at the right end is "T" or fork shaped and is called the "Tee lug casting". This lug is shaped to fit over a small amount of rail overflow. The single lug at the other end is called the "rail lug casting". The rail lug casting contains four revolving shims used for gauge widening.

The gauge of the track can be checked with the Roadmaster's inspection track gauge or with a tape measure. The Roadmaster's Inspection Track Gauge is used for gauge inspection by the Roadmaster, but it should never be used for holding rails to gauge while spiking.

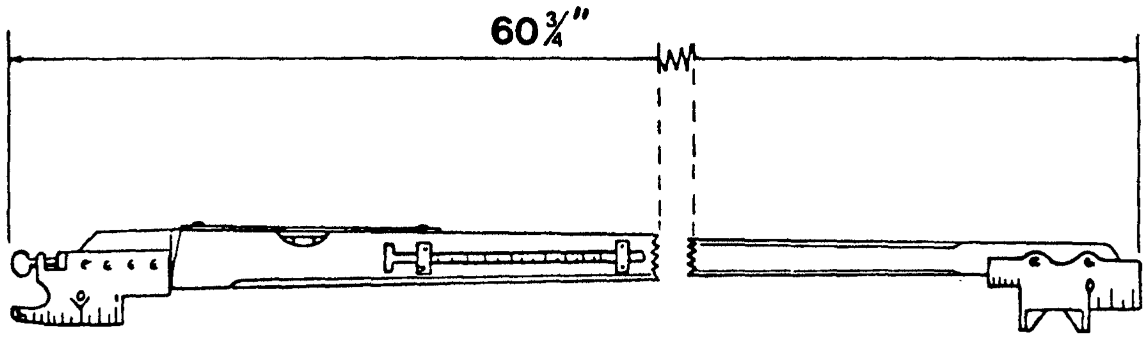


FIG. 3 - ROAD MASTER'S INSPECTION GAUGE.

The tape measure is used to measure the gauge of track when the track gauge does not fit due to excessive overflow of the rail.

When checking the gauge of the track, a track gauge should be used, and the gauge must be measured at a right angle to the rail, at a point 5/8" below the top of the rail. If it cannot be measured at the 5/8" level due to excess overflow, a tape measure must be used.

TRACK GAUGE (Cont'd)

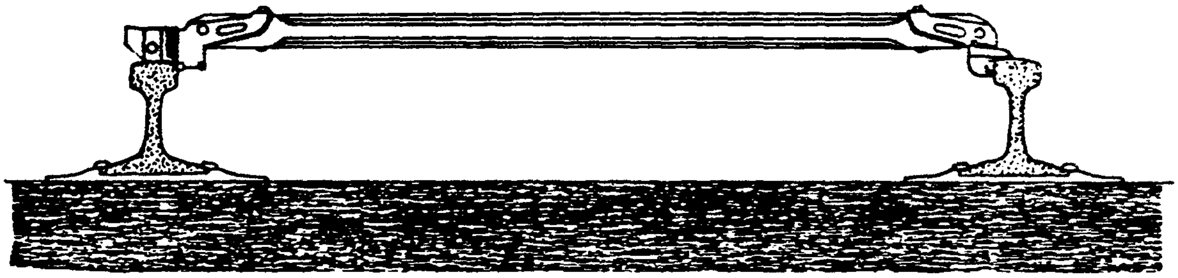


FIG. 4 - GAUGING TRACK.

How to Check the Accuracy of A Track Gauge and How Often

To make sure that the track gauge is in good condition and is accurate, it should be checked by the Roadmaster every six months, and by the foreman before using it. The accuracy of a track gauge is checked using a straight edge and a tape measure. The straight edge is placed across the lugs at the "Tee" end and the distance from the centre of the straight edge to the rail lug should be 4' 8-1/2".

In the case of an emergency where a straight edge is not available, a tape measure only can be used to measure the distance from lug to lug. While doing this make sure the tape measure is level. If the measurement is not 4' 8-1/2", a new track gauge is required and should be ordered immediately.

2. CAUSES OF WIDE GAUGE

Heavy loads moving over the rails are absorbed by the track structure, that is, the road bed, the ties, the ballast, the rail, etc. These loads, in time, wear and breakdown the parts of the track and the rail can then move, causing wide gauge.

2. CAUSES OF WIDE GAUGE (Cont'd)

Changing temperatures cause the rail to expand (lengthen) and contract (shorten) which also leads to wear and breakdown of the parts of the track and then to wide gauge.

In the next section, the defective track conditions which lead to wide gauge will be talked about in more detail.

When the load conditions (forces) are heavier than those for which the track was built, the wear and breakdown of the track parts will take place much sooner causing spread track. These larger forces can be caused by: Excess speed, particularly through curves; defects in the running gear of locomotives and cars; and poor train handling, such as braking in curves.

3. VISUAL SIGNS INDICATING THE TRACK IS OUT OF GAUGE

Worn Rails

Figure 5 shows a rail worn on one side.

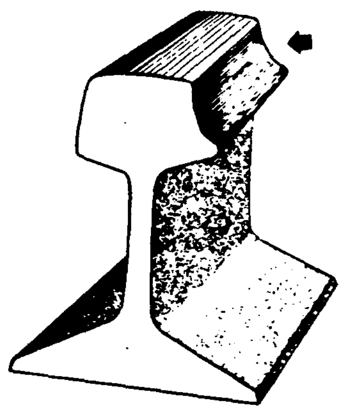


FIG. 5 - WORN RAIL.

VISUAL SIGNS INDICATING THE TRACK IS OUT OF GAUGE (Cont'd)

When trains go through curves faster than the super-elevation allows the high rail is worn by the car wheels crowding the outside rail. On the other hand, slow trains put extra weight on the low rail causing the rail to flow and form a heavy lip. At such places the gauge should be checked and any out of gauge condition corrected.

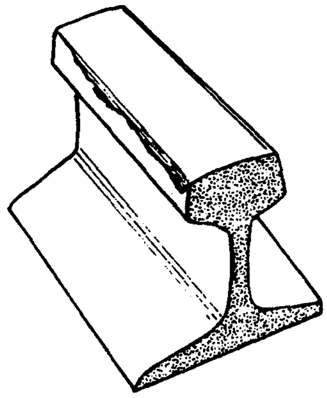


FIG. 6 - FLOWED RAIL.

The gauge measurement must be made at right angles to the rail and from the line surface of the rail not from the lip or overflow.

Poor Ties

Poor ties or tie defects, especially when several poor ties are side by side, are also a sign that the track may be out of gauge. The most common areas where poor ties are found is in the joint areas, where poor ties can cause line kinks, and poor surface. In curves, they cause poor superelevation as well as poor gauge.

Figures 7 to 15 show the kinds of tie defects which may indicate out of gauge track.

3. VISUAL SIGNS INDICATING THE TRACK IS OUT OF GAUGE (Cont'd)

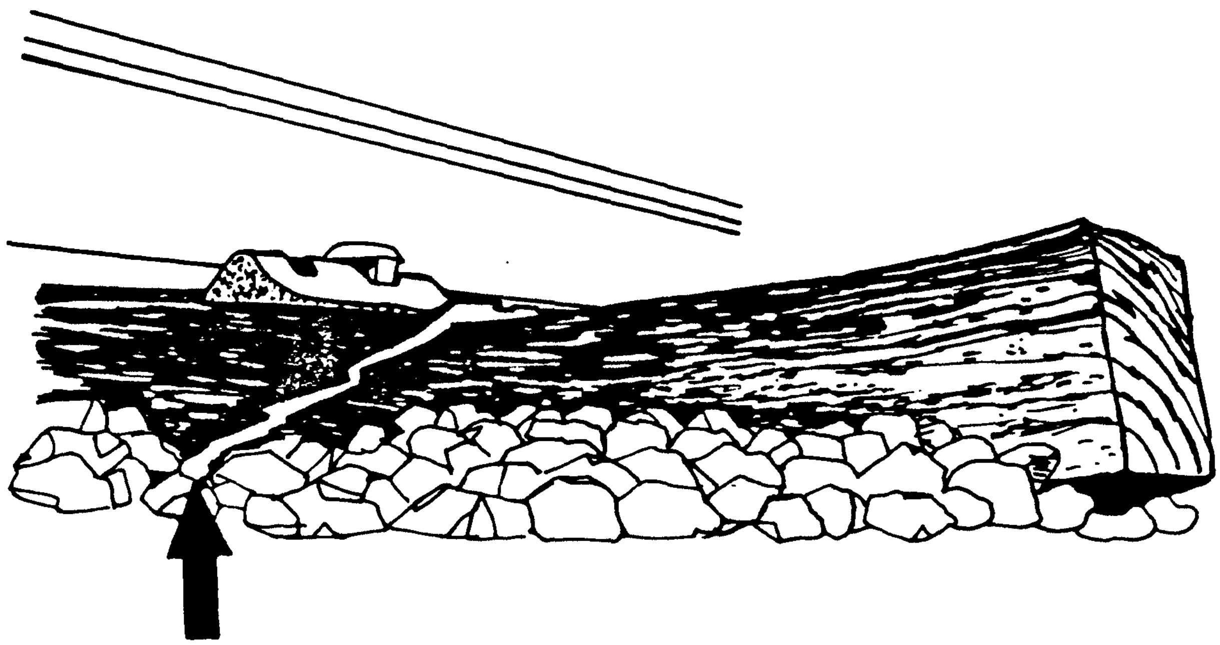


FIG. 7 - BROKEN TIE UNDER BASE OF RAIL.

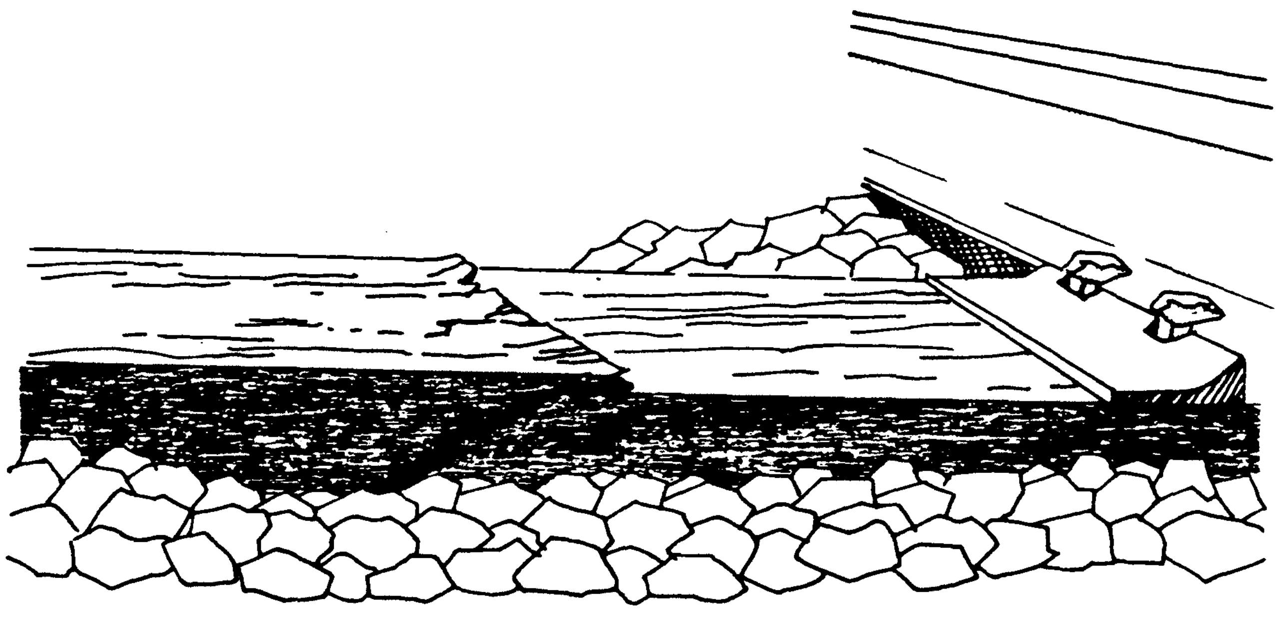


FIG. 8 - TIE BROKEN IN CENTRE OF TRACK.

VISUAL SIGNS INDICATING THE TRACK IS OUT OF GAUGE (Cont'd)

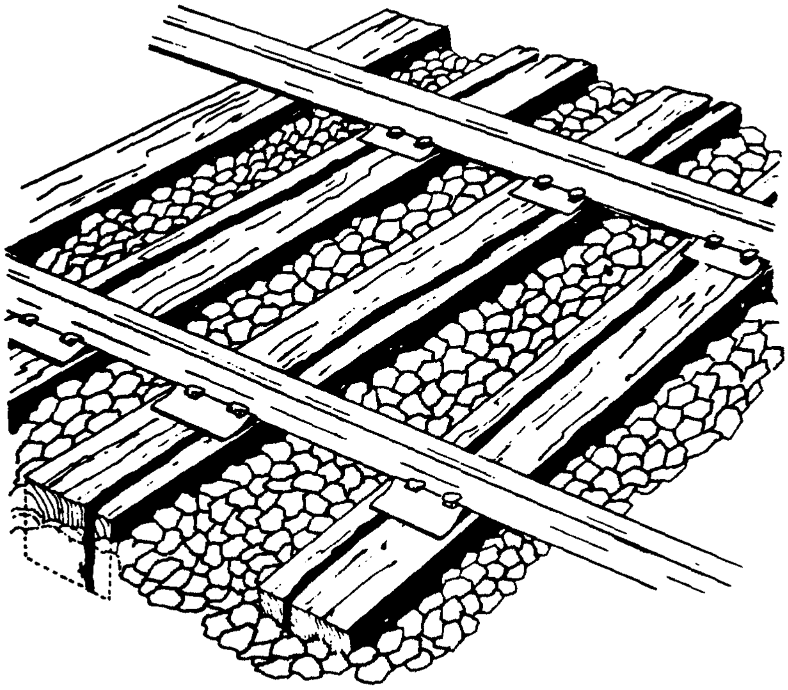


FIG. 9 - TIE SPLIT END TO END.

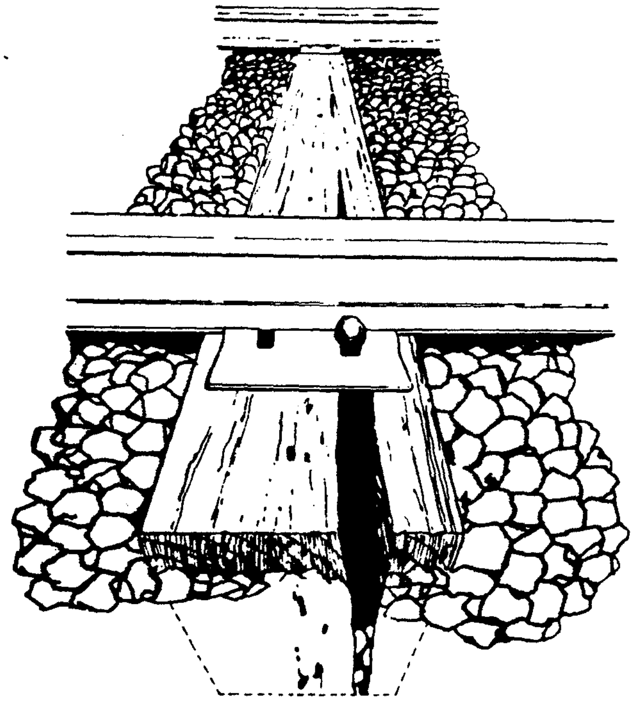
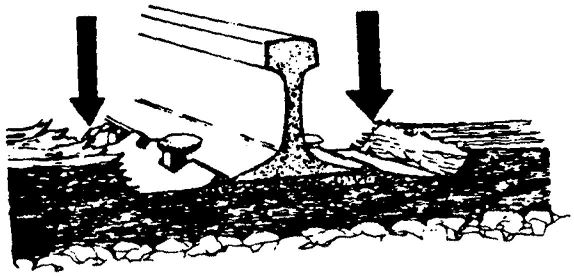


FIG. 10 - SPLIT TIE END.

3. VISUAL SIGNS INDICATING THE TRACK IS OUT OF GAUGE (Cont'd)



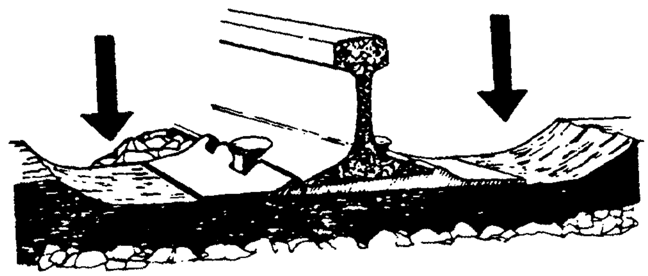


FIG. 11.

TIE CUT TO A DEPTH OF 2 INCHES

OTHERS ADZED TO A DEPTH OF 2 INCHES

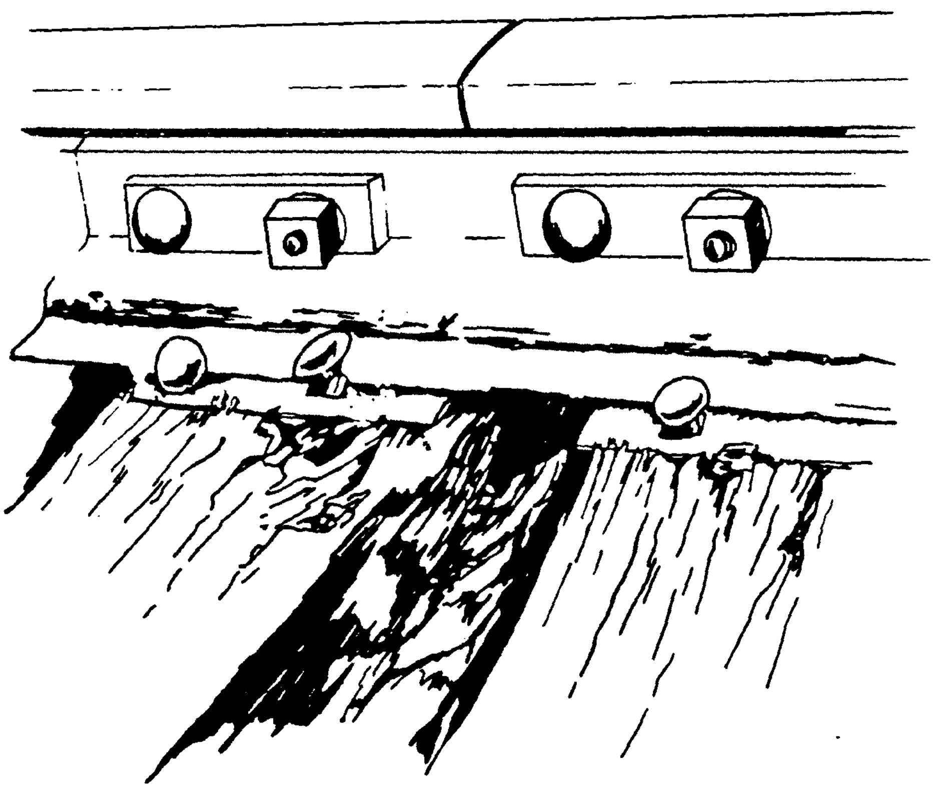


FIG. 12 - SPIKED-KILLED, CRUSHED AND DECAYED.

VISUAL SIGNS INDICATING THE TRACK IS OUT OF GAUGE (Cont'd)

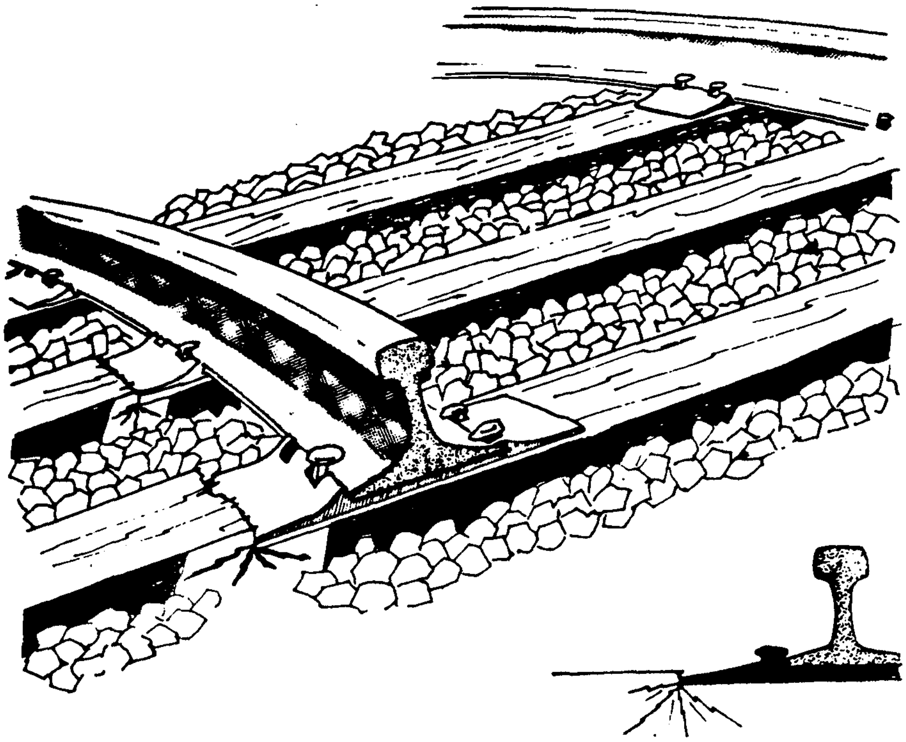


FIG. 13 - CUT TIE FIELD SIDE, CAUSING RAIL TO "CANT" OUTWARD.

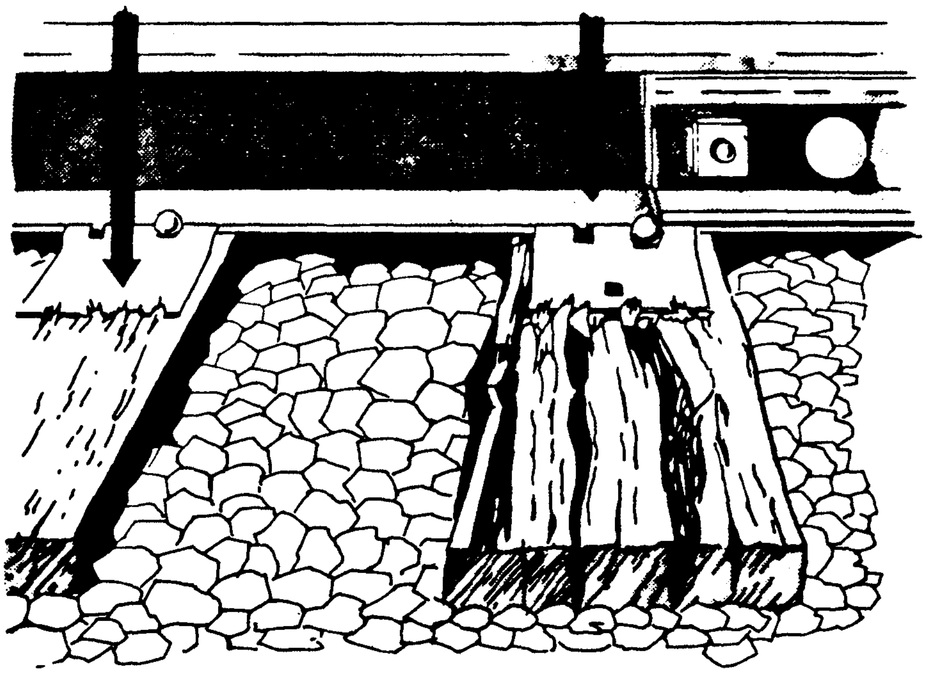


FIG. 14 - SPREADING TRACK AND SPIKE KILLED AND CRUSHED.

3. VISUAL SIGNS INDICATING THE TRACK IS OUT OF GAUGE (Cont'd)

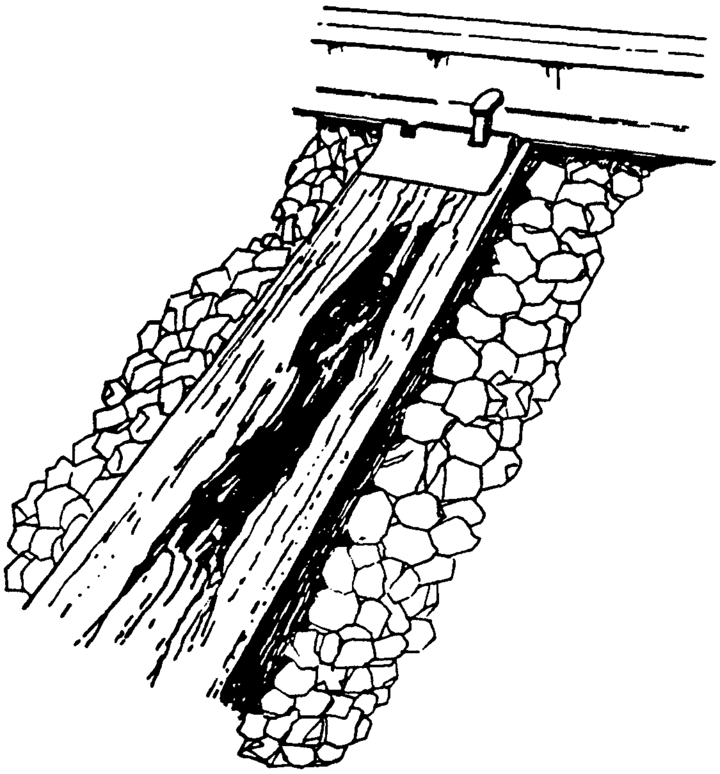


FIG. 15 - DECAYED TIE PROGRESSED UNDER THE TIE PLATE.

Poor Spikes

Two types of spike damage, throat cut and bent spikes, are also signs that the track may be out of gauge. Figure 16 shows these conditions.

VISUAL SIGNS INDICATING THE TRACK IS OUT OF GAUGE (Cont'd)

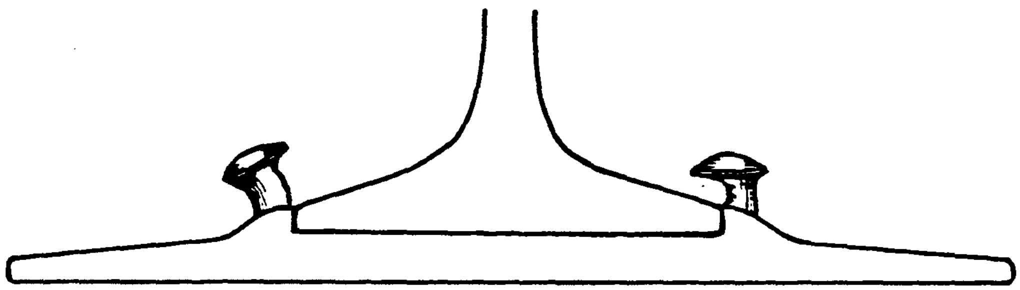


FIG. 16.

BENT SPIKE THROAT CUT SPIKE

Poor Surface

Figure 17 shows wide gauge at a rail joint.

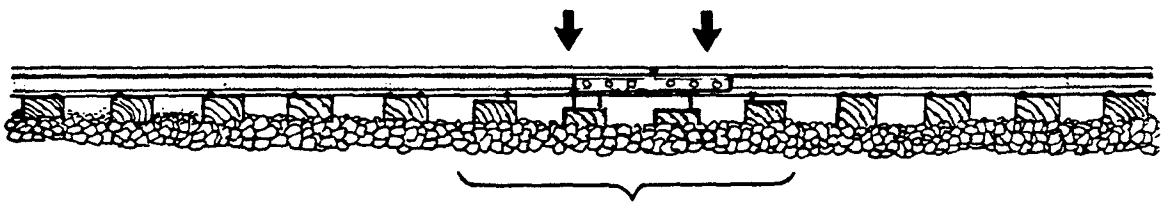


FIG. 17 - POOR SURFACE.

Line Kinks

Usually when track goes out of line, both rails move together, but sometimes this is not so, and gauge should be checked at the line kinks.

3. VISUAL SIGNS INDICATING THE TRACK IS OUT OF GAUGE (Cont'd)

Rail Canting

This is caused by the tie plate wearing into the tie at both rails but especially on the low side of the curve. The rail will then cant outward and cause wide gauge.

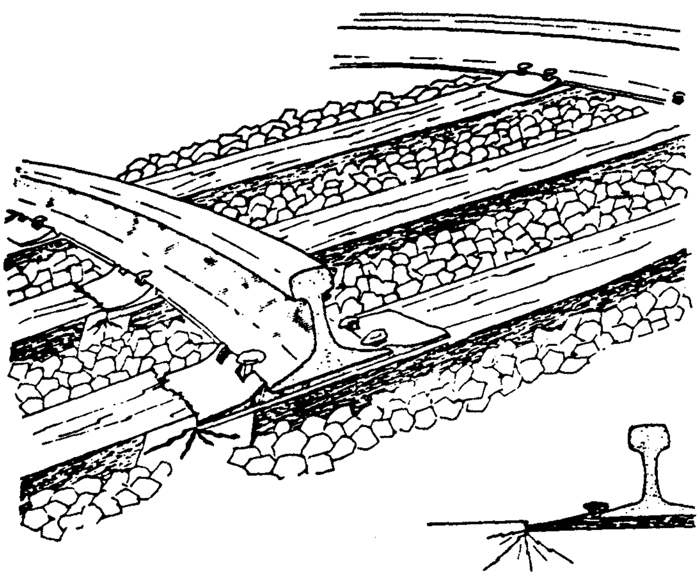


FIG. 18 - RAIL CANTING.

Grease Mark on Rail

This situation exists on curves and can easily be seen when inspecting the track. The signs are an oily or dark line on the surface of the low rail, made by the wheels of the equipment.

When these signs are found, the gauge of the track should be checked.

VISUAL SIGNS INDICATING THE TRACK IS OUT OF GAUGE (Cont'd)

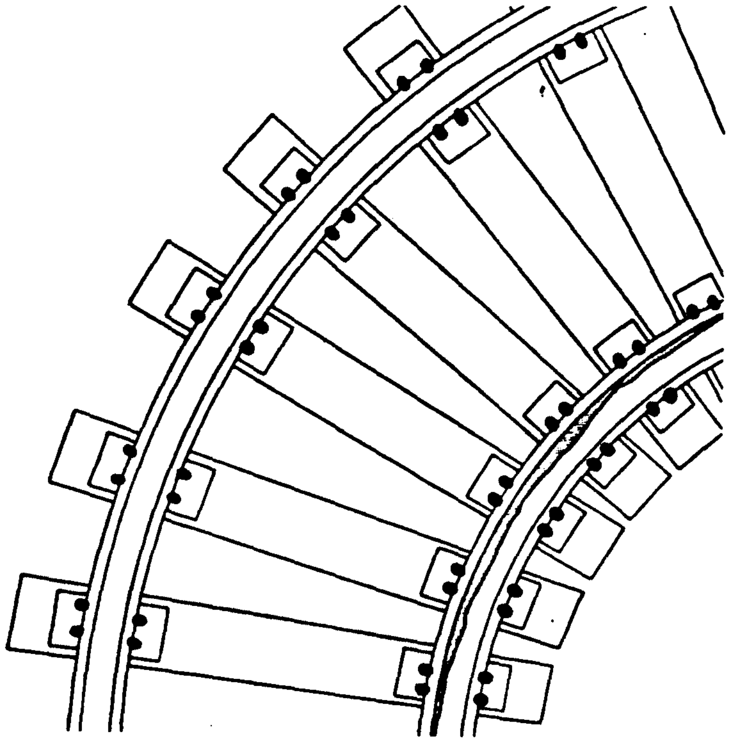


FIG. 19 - GREASE MARK ON RAIL.

Snow Cracking

Cracking of snow along the base of rail will show rail movement. This rail movement can, if not corrected periodically, cause a build-up of ice under the tie plates raising the rail above the tie plate shoulder, thus causing pulled or bent spikes which could lead to wide gauge.

3. VISUAL SIGNS INDICATING THE TRACK IS OUT OF GAUGE (Cont'd)

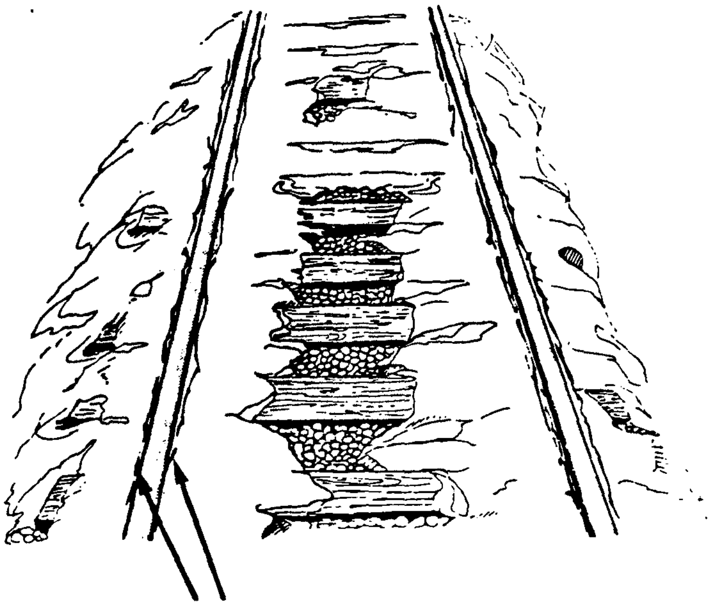


FIG. 20 - SNOW CRACKING.

4.0 VISUAL SIGNS INDICATING THE TRACK MAY GO OUT OF GAUGE UNDER LOAD

Sometimes, when signs of out of gauge track are found and the gauge is measured, the track is not out of gauge. You should then suspect that the track will go out of gauge under load. The main signs indicating this condition are:

- Worn rail
- Marks in the snow
- Marks on the rail surface
- Canted plates and worn plates
- Bent and throat cut spikes
- Poor line
- Spikes ripping into the ties
- Tie plates moving on ties

4. VISUAL SIGNS INDICATING THE TRACK MAY GO OUT OF GAUGE UNDER LOAD (cont'd)

Track Recording Car

While the above are good signs that the track may go out of gauge under load, the best way to check this condition is with the track recording car.

The printout from the car shows where and how much the track is out of gauge. The track recording car is heavy enough to show a wide gauge condition as if under a locomotive or a heavy freight car.

5. HOW TO CORRECT IMPROPER GAUGE

The gauge of the track should be checked often and whenever signs showing that the track may be out of gauge are found.

Protection

The type of protection will depend on how much track is to be gauged and how long it will take to finish the work. The flagging protection required will also depend on the subdivision and what rules may be used. (This information is found in current timetables)

Correcting Gauge with a 4-Man Gang

Gauging of track can be performed with 2, 3 or 4 men or with a gauging gang. The procedure outlined below requires a work force of one foreman and three men.

The foreman first makes sure that the line rail is in proper line. He then uses the track gauge to find and mark the beginning and end of the section of track to be gauged.

Once the starting point has been marked, the first man will pull the spikes from both sides of the rail to be gauged. When gauging for a long distance, spikes are left in every 3rd or 4th tie so that the rail can be kept in place.

5. HOW TO CORRECT IMPROPER GAUGE (Cont'd)

The second man will remove the tie plates, plug the holes with plugs and remove any anchors that will be in the way when re-gauging.

The third man taps the tie plugs, adze the ties if necessary and replaces the tie plates. These men continue in this manner until they have reached the end of the gauging area.

The spikes left in every 3rd or 4th tie are pulled and then the foreman sets the track gauge between the two rails and the first man pushes the rail to the proper gauge with a lining bar.

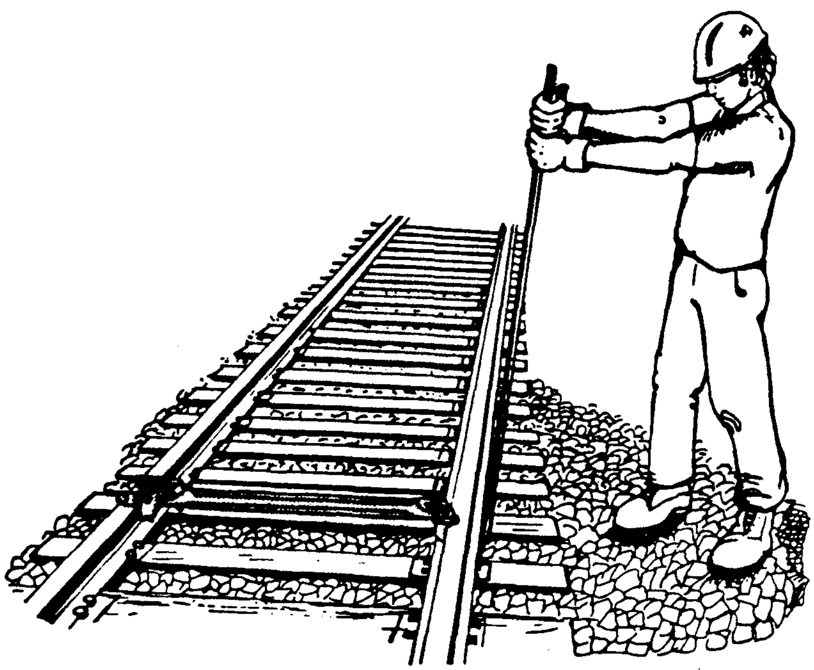


FIG. 21 - PUSHING RAIL TO GAUGE.

The second man uses a claw bar or shovel to hold the tie tight to the base of the rail, while the third man spikes the rail on the field side, if it is wide gauge and on the inside if it is tight gauge. The spike should always be driven straight into the tie.

5. HOW TO CORRECT IMPROPER GAUGE (Cont'd)

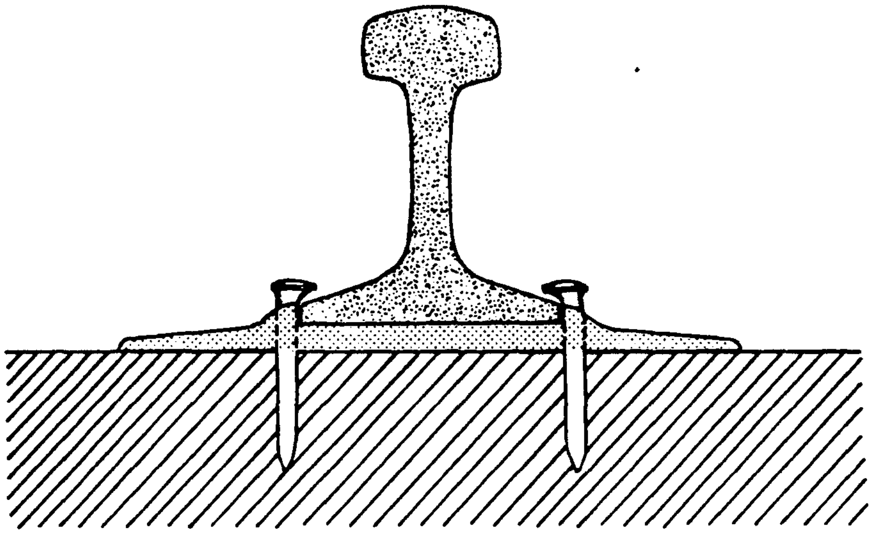


FIG. 22 - SPIKE DRIVEN INTO TIE.

On straight track, the gauge is set at every 4th tie, and on a curve it is set at every 3rd tie. Once you have reached the end, the remaining ties can be spiked with two men spiking and two men holding the ties in place.

If a larger gang is available, you may have more men pulling spikes ahead of the re-gauging and more men gauging every 3rd or 4th tie. Other men can spike the remaining ties, and re-install rail anchors where necessary.

Upon completion always make sure the protection is removed.

6. WHERE TO CHECK GAUGE THROUGH TURNOUTS

A - At toe of frog

B - At point of frog

C - At heel of frog

6. WHERE TO CHECK GAUGE THROUGH TURNOUTS (Cont'd)

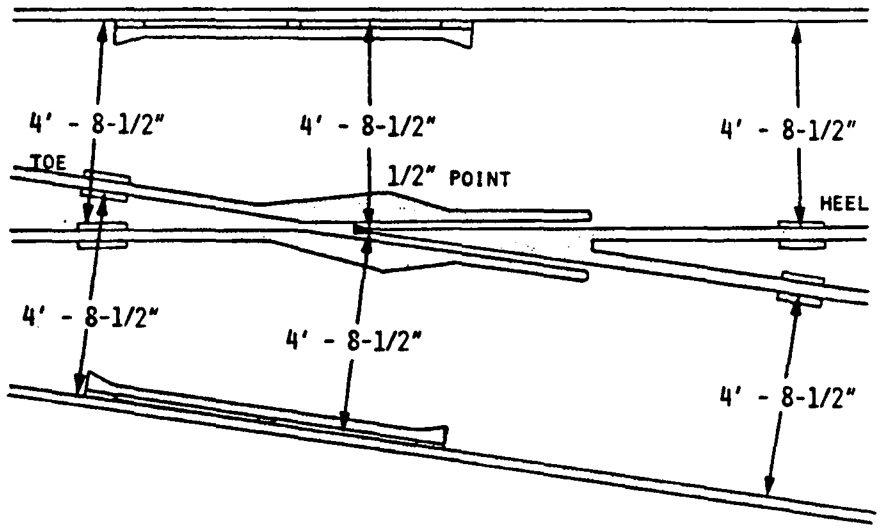


FIG. 23 - CHECK GAUGE AT FROG.

- Figure 24 shows where to check gauge in the switch point area.

A - At the first straight gauge plate

B - At the centre of the switch point

C - At the heel of the closed point of the switch

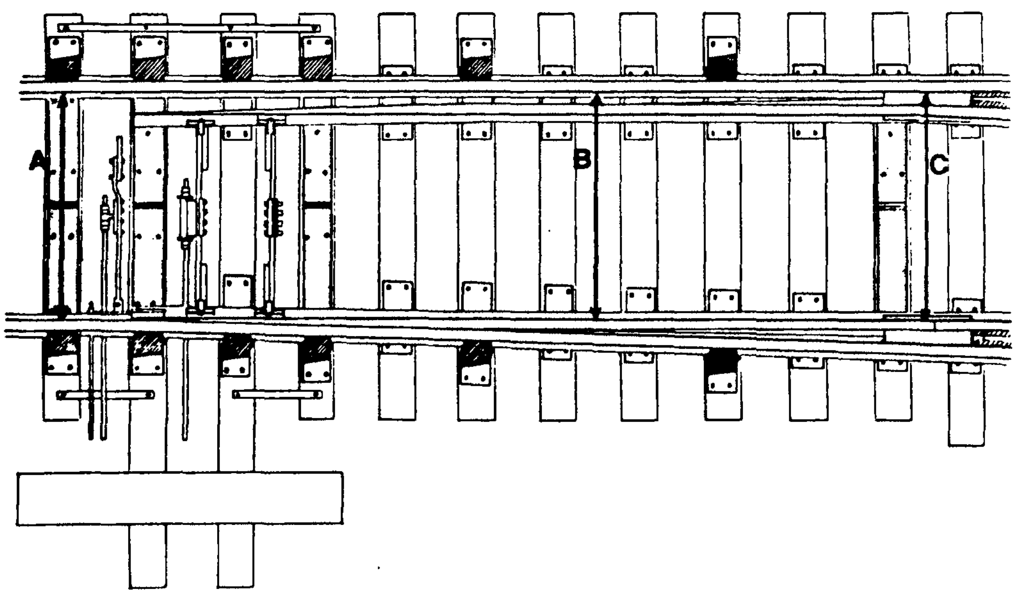


FIG. 24 - GAUGE THROUGH TURNOUTS.

6. WHERE TO CHECK GAUGE THROUGH TURNOUTS (Cont'd)

At intervals not exceeding 10 feet from the heel of the switch point to the toe of the frog.

7. EXCEPTIONS WHERE GAUGE OF TRACK MAY BE WIDER THAN STANDARD

In the days of steam engines, the gauge was widened in sharp curves to allow for the long wheel-base of multi-driver engines. The practice has carried over until now, even though the steam engines are gone and the diesel engine trucks are shorter and can adjust to the track alignment. Where concrete ties are used, track is now being laid to standard gauge on curves, and tests are being made on sharp curves where the gauge is put to the standard 4' 8-1/2". Therefore, we may expect some changes in our standards.

HOWEVER, for the time being, the following instructions are to be followed:

GAUGE IN CURVES

Curve	Gauge	Widening
up to 12°	4' 8-1/2"	0
over 12° up to 16°	4' 8-3/4"	2-(1/8") shims
over 16° up to 20°	4' 9"	2-(1/8") and 1(1/4") shims
over 20°	4' 9-1/4"	2-(1/4") and 2(1/8") shims

Except that when a frog is located on the inside of a curve the gauge of that curve through the frog must be 4'-8-1/2".

8. GAUGE IN TURNOUTS

Starting at a point 10' from the last turnout plate, (point "A" in Figure 25) and continuing to a point 10' from the toe of the frog (point "B" in Figure 25), the gauge of the track should be as follows:

8. GAUGE IN TURNOUTS (cont'd)

No. 5 turnout	4' 9-1/4"
No. 6 turnout	4' 9-1/4"
No. 7 turnout	4' 8-3/4"
No. 9 turnout	4' 8-1/2"
No. 11 - 100 lb. turnout	4' 8-5/8"
115	4' 8-1/2"
130	4' 8-5/8"
136	4' 8-1/2"
No. 13 turnouts	4' 8-1/2"

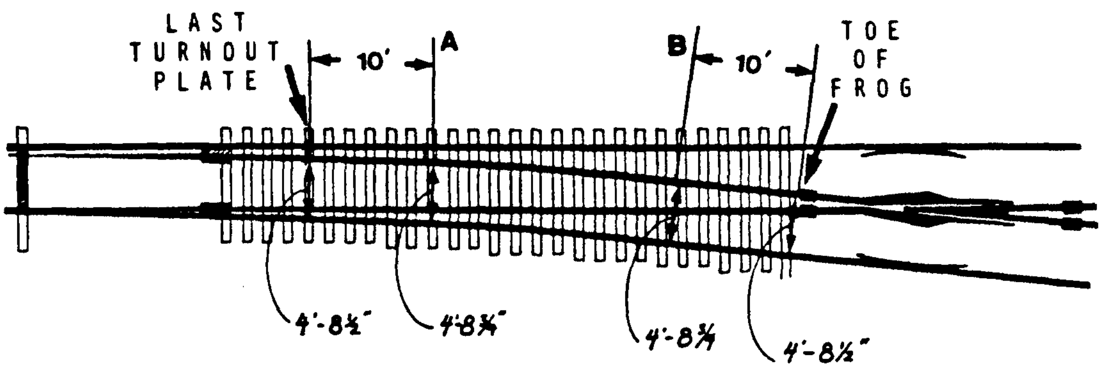


FIG. 25 - GAUGE IN TURNOUTS.

References

S.P.C.- 17

Standard Plans-T 14-8-14 Adjustable Track Gauge

CP Rail

MAINTENANCE OF WAY TRAINING

Lesson no.: 49

Subject: TURNOUT CONSTRUCTION

First issued: 79/03/12

Maintenance of way training

1. HOW TO READ STANDARD TURNOUT PLAN

Standard plans are available for the foreman who has to build a turnout and also to the man who has to maintain them. In the past, very few Section Foremen were shown how to read a standard plan and when they were handed a turnout plan it was a real mystery to them. As a result the foreman didn't ask for them.

Building a turnout becomes easier when the foreman can read the plans. The plan shows you exactly where every piece of material goes and many of the parts are numbered, both on the plan and on the part, for still easier recognition.

1.1 Reading the Plan

Figure 1 is a plan of a #9 - 100 lb. turnout with 16'-6" switch points and RE-HF Rail. Before using a standard plan look at the title block Figure 2, to see that you have the proper plan and check with the Roadmaster to see that you have the latest issue of the plan.

The first thing shown at the top of the plan, Figures 3 and 4 is the tie spacings and the tie numbers. The tie spacings are shown in two ways.

1) Measurements are shown from the actual point of switch to the centre of each tie.

   Note: That the centre of the first tie is 0'-3" from the actual point of switch (4" for a power switch). The second tie is at 1'-11" and so on to end of the turnout.

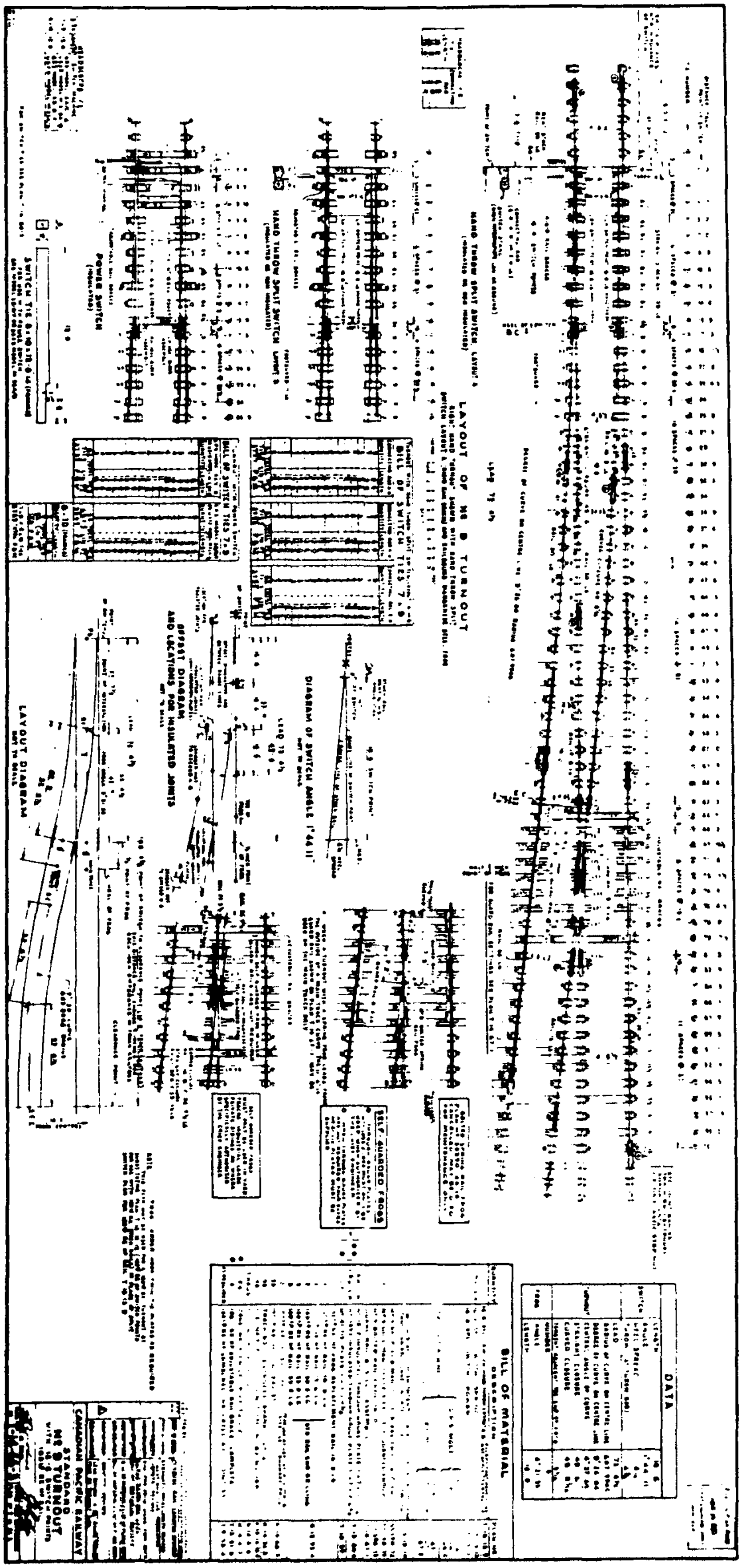


FIGURE 1.

BT E H.T.	FEB. 23, 1978	BILL OF MATERIAL & LIST OF PLANS REV'D THROUGH GAUGE PLATES & Nº41 PLATES ADDED
EHT MH	~~MAY 7 1976~~	CLOSURE RAIL LENGTHS REVISED
	~~MAR 31 1976~~	STRAIGHT CLOSURE LENGTH REVISED
	~~MAY 27, 1974~~	LOCATIONS FOR INSULATED JOINTS REVISED.
	~~NOV. 24, 1971~~	DIM. FOR SOLID MANG. FROG REV'D
	~~JAN 27, 1970~~	BOLTED GUARD RAIL USED. BILL OF MATERIAL REVISED
	~~AUG 24 1966~~	BILL OF MATERIAL & LIST OF PLANS REV'D
	~~OCT 25 1962~~	BILL OF MATERIAL & LIST OF PLANS REV'D
△1	~~JULY 4 1960~~	QUANTITY REVISED
	~~DEC 17 1959~~	LEAD REVISED. 4'-8½" GAUGE THROUGH FROG ON TURNOUT SIDE.

CANADIAN PACIFIC RAILWAY

STANDARD

Nº 9 TURNOUT

WITH 16'-6" SWITCH POINTS

100LB RE-HF RAIL

ENGINEER OF TRACK — CHIEF ENGINEER

PLAN Nº **T-14-66-3** — THIS PLAN SUPERSEDES PLAN Nº T-14-66-2

FIGURE 2.

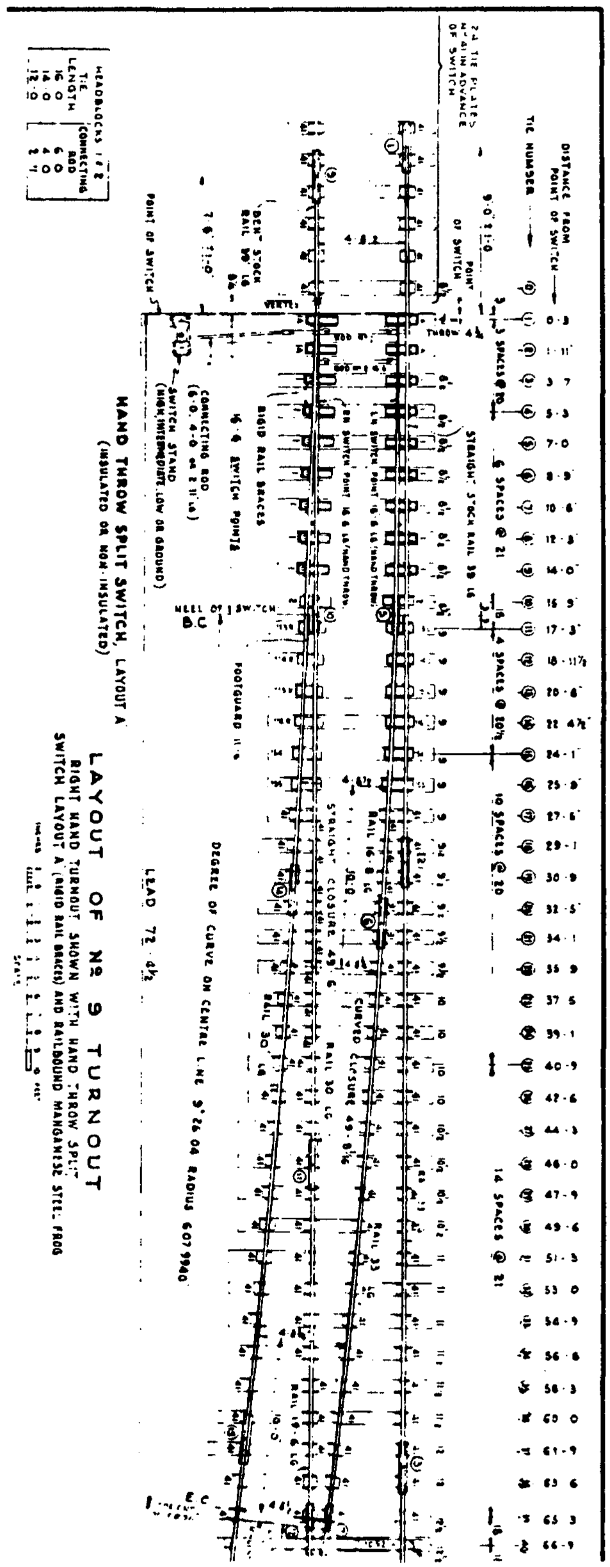
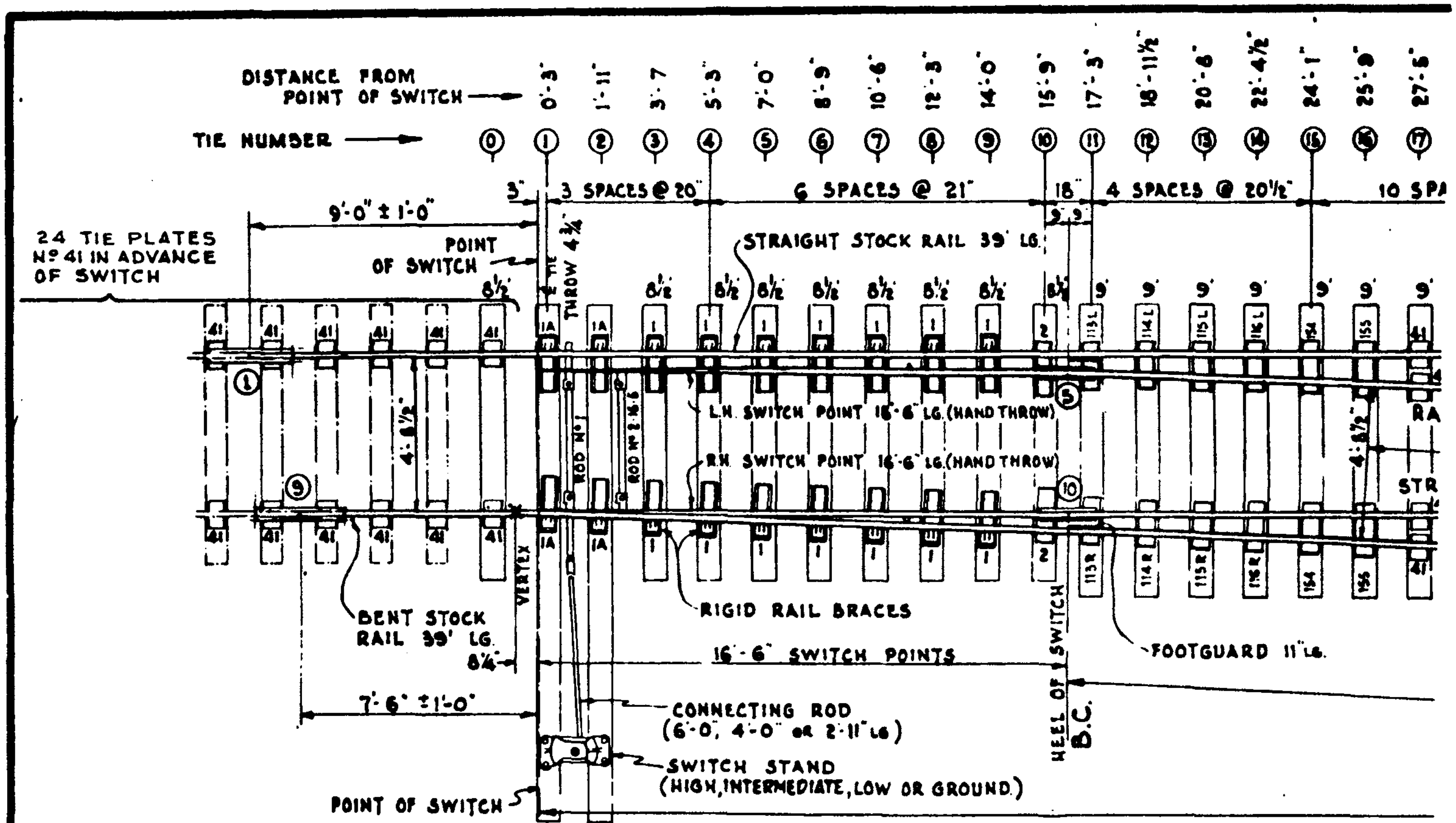

LAYOUT OF № 9 TURNOUT
RIGHT HAND TURNOUT SHOWN WITH HAND THROW SPLIT
SWITCH LAYOUT A (RIGID RAIL BRACES) AND RAILBOUND MANGANESE STEEL FROG
HAND THROW SPLIT SWITCH, LAYOUT A
(INSULATED OR NON-INSULATED)
DISTANCE FROM POINT OF SWITCH
TIE NUMBER
POINT OF SWITCH
HEEL OF SWITCH
FOOTGUARD
CONNECTING ROD
SWITCH STAND
RIGID RAIL BRACES
STRAIGHT CLOSURE
CURVED CLOSURE

FIGURE 3.



HAND THROW SPLIT SWITCH, LAYOUT "A"
(INSULATED OR NON-INSULATED)

HEADBLOCKS 1 & 2	
TIE LENGTH	CONNECTING ROD
16'-0"	6'-0"
14'-0"	4'-0"
12'-0"	2'-11"

FIGURE 4.

1. HOW TO READ STANDARD TURNOUT PLAN

Reading the Plan (Cont'd)

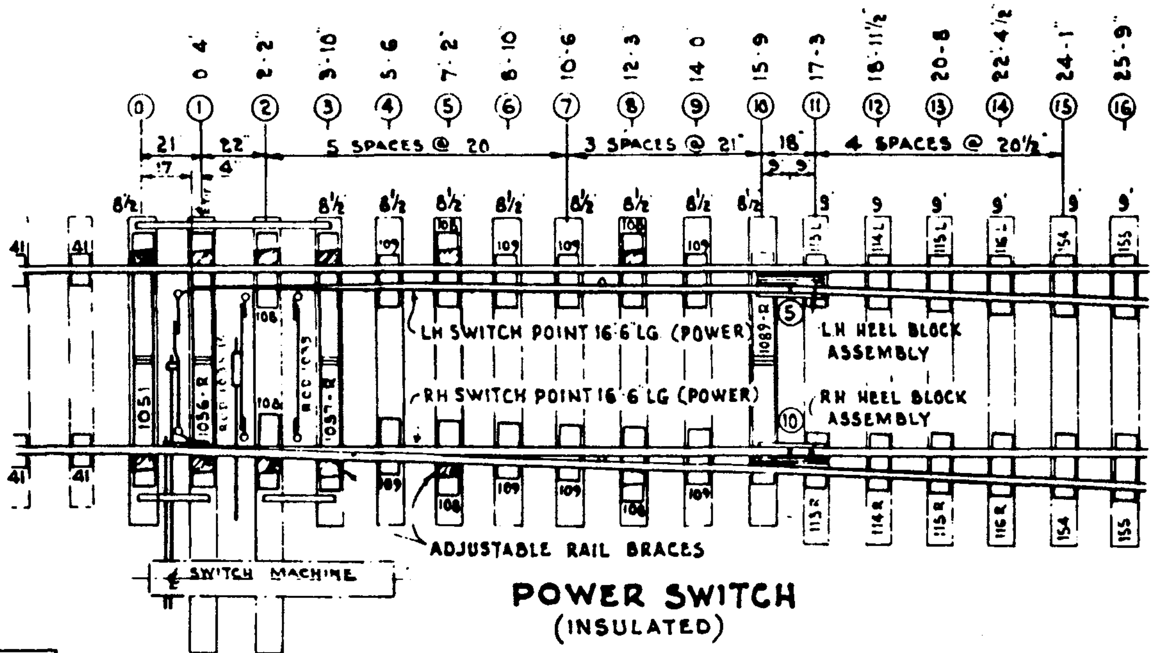
2) The tie locations are also shown by the spacing between tie centres. e.g. 3 spaces at 20".
   The length of the ties are shown at the top of each tie. On this plan the lengths are from 8 1/2' to 16' long.

Now let's look at the track layout starting at the top left of the plan, Figure 5. This portion of the plan shows the switch point area, starting at the top left of the plan we see:

1) The proper location of the joints just ahead of the point of switch. The joint on the bent stock rail is 7'-6" ± 1'-0" from the point of switch and the other joint is at 9'-0" ± 1'0".
2) The connecting rod and switch stand and the No. 1 and No. 2 rods.
3) The proper throw at the switch point is 4 3/4".
4) The point of switch is 3" from the centre line of the first head block tie.
5) The LH and RH points. 16'-6" long (hand throw).
6) The rigid rail braces.
7) The uniform riser plates 1, 1A, and 2.

To the right of the switch point area is the portion of the turnout from the heel of the switch point to the toe of the frog, Figure 6. The tie spacing in this area must be as shown on the plan especially where the turnout plates are, or else the turnout plates will not fit correctly on the rail. The turnout plates 113 to 116, are marked R or L. Some like No. 154 and 155 can be used on either side. This part of the plan also shows the length of the turnout rails, the gauge of the track at different locations is shown and the proper alignment of the turnout rails, which will be dealt with later on in this lesson.

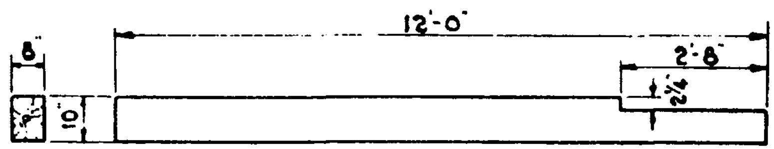
Maintenance of way



POWER SWITCH
(INSULATED)

HEADBLOCKS 1 & 2		
SIZE	LENGTH	SWITCH MACHINE
7"x9"	12'-0"	GRS MODEL 5A/C, 6 US&S MODEL M-3, DA-10
8"x10"	12'-0"	GRS MODEL 5B/D/F US&S MODEL M-23A/B

FOR SWITCH TIES SEE PLAN T-14-80-3



SWITCH TIE 8"x10"x12'-0" LG (FRAMED)
FOR USE WITH POWER SWITCH
GRS MODEL 5B/D/F OR US&S MODEL M-23A/B

FIGURE 5.

CP Rail

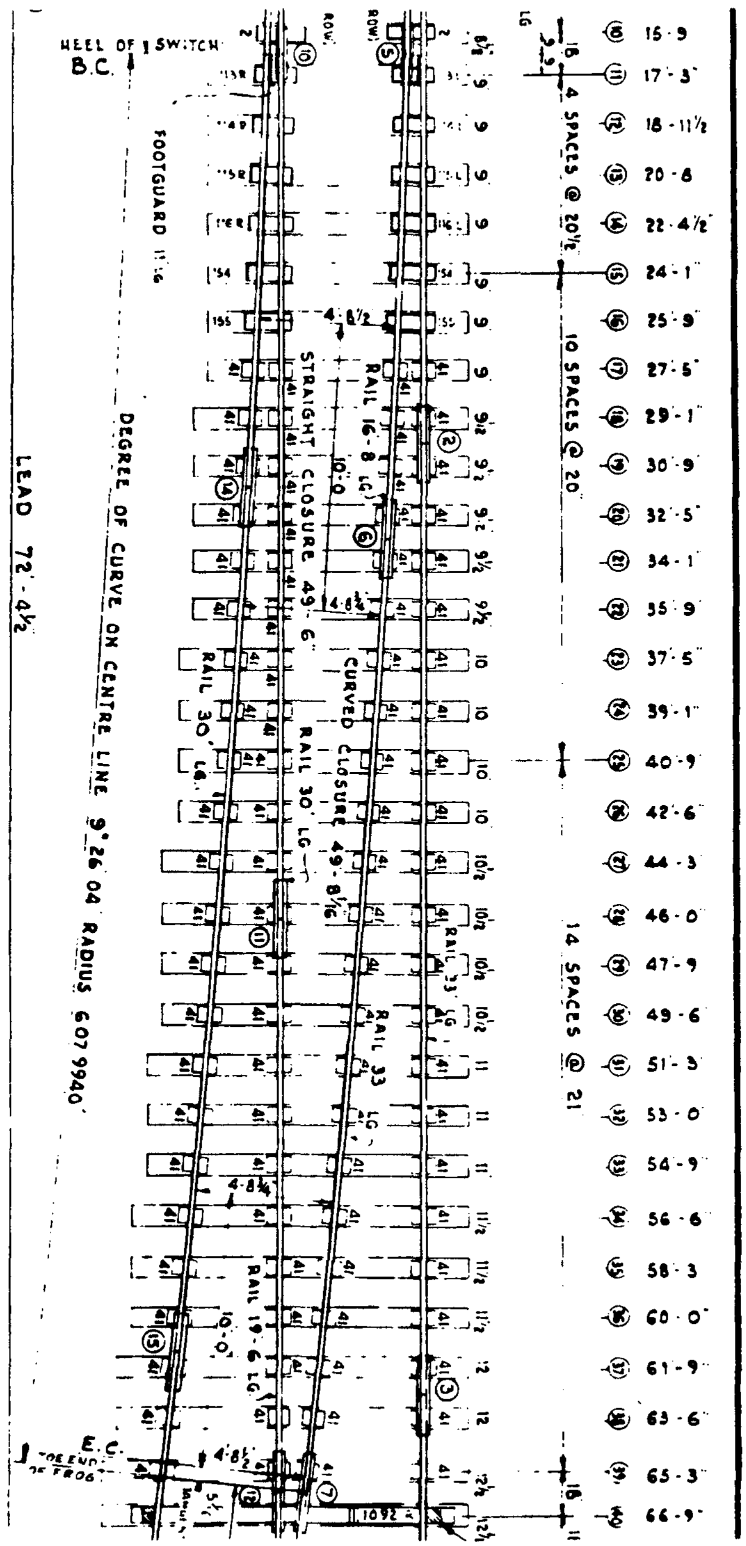


FIGURE 6.

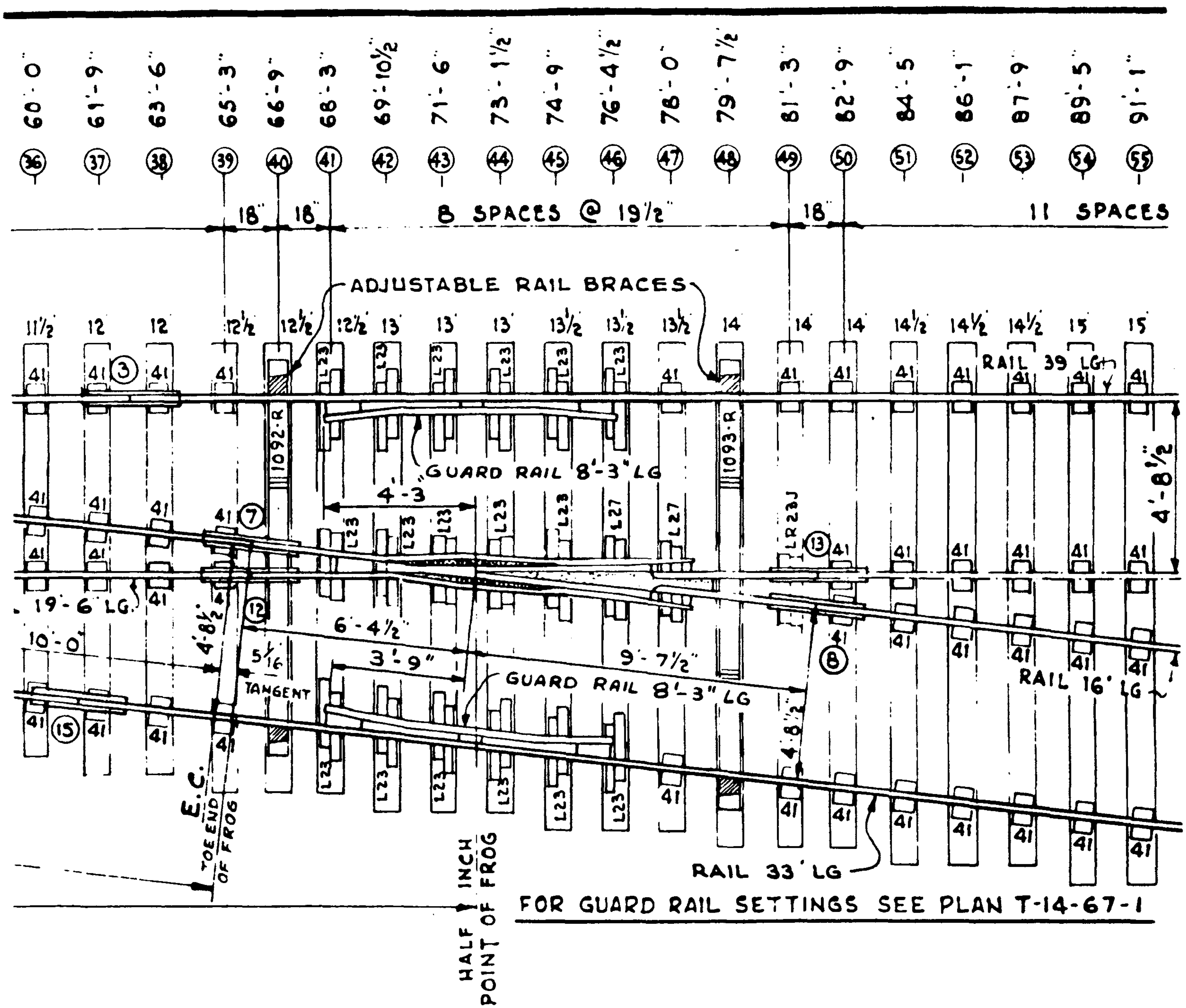
1. HOW TO READ STANDARD TURNOUT PLAN

Reading the Plan (Cont'd)

From the toe of the guard rail to the 1/2" point of the frog is 4'-3" for the straight track side and 3'-9" for the turnout side, Figure 7. Details for the proper lateral locations of the guard rail are shown on Plan T-14-67-1.

Now let us look at the complete turnout and note the length of the rails used. First locate the joints in front of the switch points properly, Figure 5. From here the proper rail lengths must be used, Figure 6, so that:

1) The joints will not be in the switch point or guard rail area.
2) The joints will be in their proper location for insulated joints for track circuits.
3) The rail next to the frog on the turnout side will be the proper length for replacement of the frog in case of failure of the frog.



36 60'-0"
37 61'-9"
38 63'-6"
39 65'-3"
40 66'-9"
41 68'-3"
42 69'-10½
43 71'-6
44 73'-1½
45 74'-9
46 76'-4½
47 78'-0
48 79'-7½
49 81'-3
50 82'-9
51 84'-5
52 86'-1
53 87'-9
54 89'-5
55 91'-1
18" 18" 8 SPACES @ 19½" 18" 11 SPACES
ADJUSTABLE RAIL BRACES
11½ 12 12 12½ 12½ 12½ 13 13 13 13½ 13½ 13½ 14 14 14 14½ 14½ 14½ 15 15
RAIL 39' LG
1092-R
1093-R
GUARD RAIL 8'-3" LG
4'-3
4'-8½"
LR23J
19'-6 LG.
10'-0"
4'-8½
6'-4½"
5 1/16
3'-9"
9'-7½"
TANGENT
GUARD RAIL 8'-3" LG
RAIL 16' LG
4'-8½
E.C.
TOE END OF FROG
HALF INCH POINT OF FROG
RAIL 33' LG
FOR GUARD RAIL SETTINGS SEE PLAN T-14-67-1

FIGURE 7.

HOW TO READ STANDARD TURNOUT PLAN

Reading the Plan (Cont'd)

Now let's look at the next section of the plan at the left end below the switch point area. This part shows other switch layouts.

(1) Hand Throw switch with adjustable rail braces (Layout "B"), Figure 8.

In this layout the tie spacing, the switch points, the turnout plates and the head blocks are all the same. The differences are:

1 - Adjustable rail braces are used.

2 - Riser plates numbers 108 and 109 are used and there are riser plates ahead of switch point.

3 - A gauge plate #1038 is used on the 1st headblock tie.

(2) Power Switch, Figure 9.

This layout is quite different than the others. Some of the differences are:

1 - The power switch points are offset 4" from the outside centre line of tie #1.

2 - Insulated gauge plates numbered, 1051, 1056R and 1057R are used.

3 - Heel block assemblies are used. These are now also used on new or rebuilt handthrow switches.

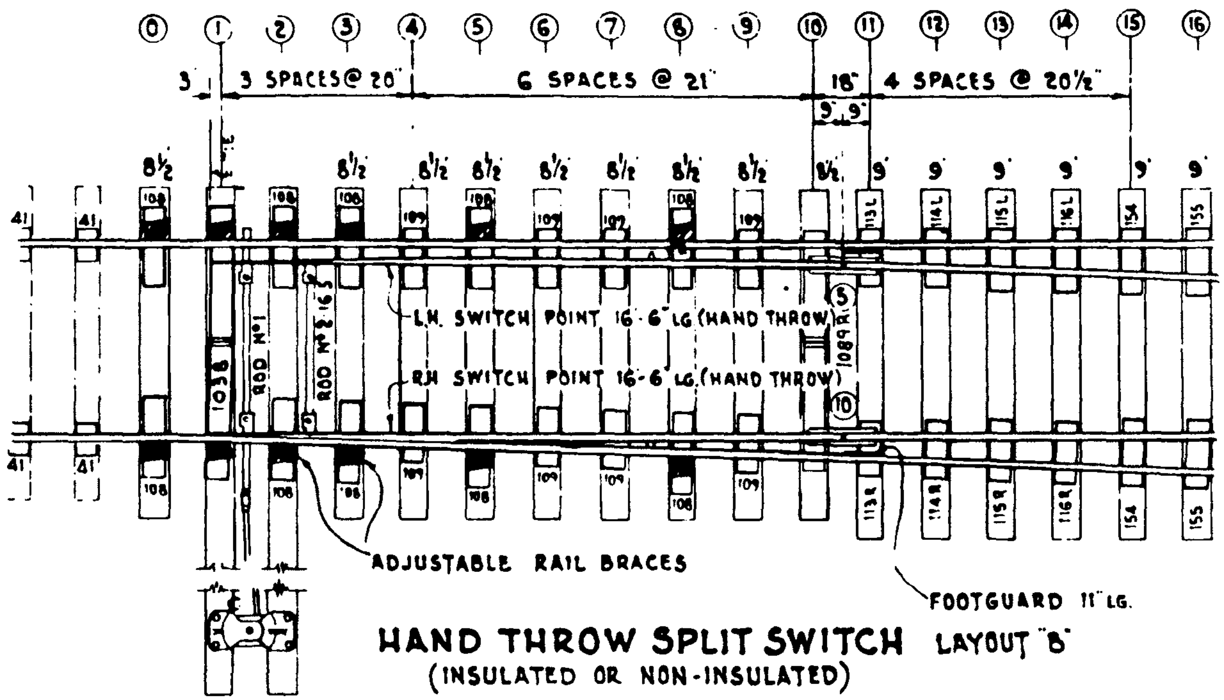
4 - Head blocks are 12' long and different sizes depending on the switch machine model.

5 - Vertical switch rods are used.

CP Rail

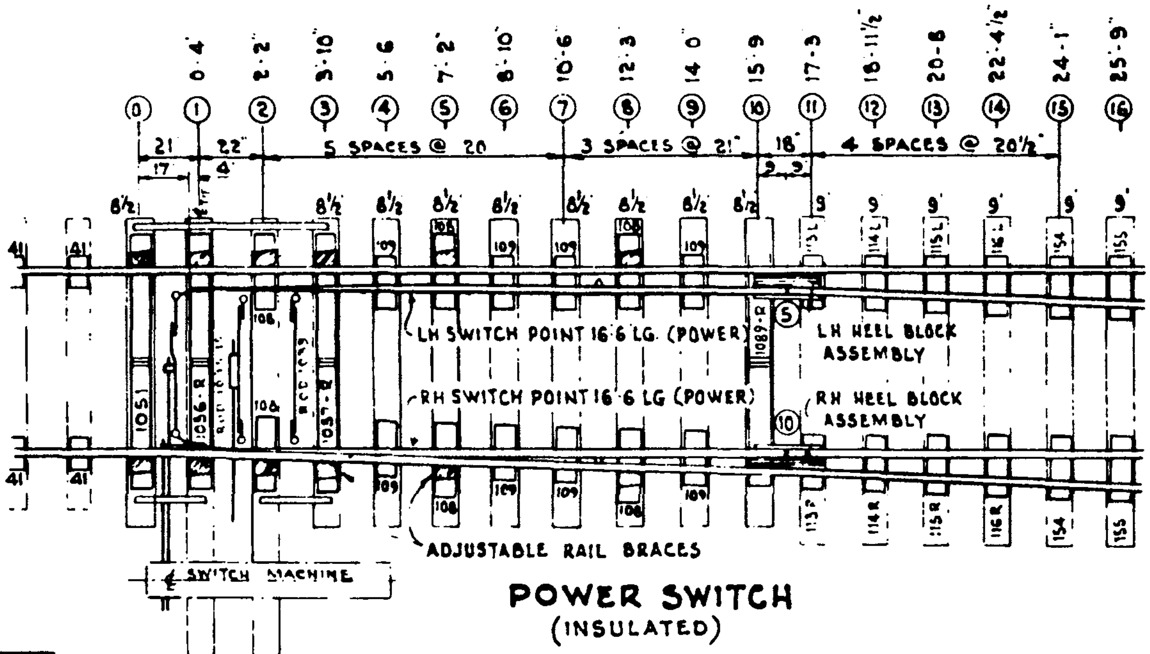
HAND THROW SPLIT SWITCH, LAYOUT "A"
(INSULATED OR NON-INSULATED)

HEADBLOCKS 1 & 2	
TIE LENGTH	CONNECTING ROD
16'-0"	6'-0"
14'-0"	4'-0"
12'-0"	2'-11"



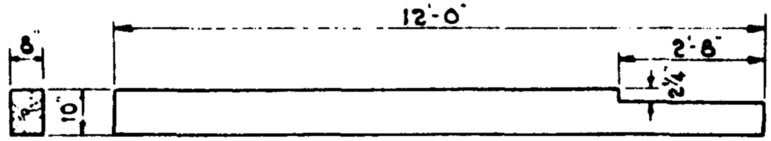
HAND THROW SPLIT SWITCH LAYOUT "B"
(INSULATED OR NON-INSULATED)

FIGURE 8.



POWER SWITCH
(INSULATED)

HEADBLOCKS 1 & 2		
SIZE	LENGTH	SWITCH MACHINE
7"x9"	12'-0"	GRS MODEL 5A/C, 6 US&S MODEL M-3, DA-10
8"x10"	12'-0"	GRS MODEL 5B/D/F US&S MODEL M-23A/B



SWITCH TIE 8"x10"x12'-0" LG. (FRAMED)
FOR USE WITH POWER SWITCH
GRS MODEL 5B/D/F OR US&S MODEL M-23A/B

FOR SWITCH TIES SEE PLAN T-14-80-3

FIGURE 9.

1. HOW TO READ STANDARD TURNOUT PLAN

Reading the Plan (Cont'd)

1.3 Power Switch (Cont'd)

6 - Tie spacing is different than for the hand throw switch.

7 - Tie straps are used at both ends of the block head ties.

1.4 Bill of Material of Ties, Figure 10

The tables to the right of these switch layouts give the bill of material for switch ties. It shows the ties required if you are using a 6', 4' or a 2'-11", connecting rod and the total lineal feet which you must show on your report M.W.S. 9.

1.5 Switch Angle & Offset Diagrams

The next portion of the plan to the right of the tables shows the switch angles, Figure 11, the offset diagram and the location of the insulated joints when required, Figure 12. The top portion (diagram of switch angle) shows the bend in the stock rail. The spread at the heel of the point is 6 1/4", (gauge to gauge). The "Offset Diagram and Locations for Insulated Joints" shows the offset distances which are very important in the construction of a turnout to give a smooth ride. Starting at the switch point you see that the spread at the heel of the point at 16'-6" is 6-1/4". At 33' the spread is gauge to gauge 14-15/16" and at 49'-6" the spread is 2'-5". The diagram also shows the locations for insulated joint when they are needed.

TURNOUT WITH HAND THROW SPLIT SWITCH (LAYOUT A OR B)

BILL OF SWITCH TIES 7" x 9"

CONNECTING ROD 6'-0"		CONNECTING ROD 4'-0"		CONNECTING ROD 2'-11"	
QUANTITY	LENGTH	QUANTITY	LENGTH	QUANTITY	LENGTH
9	8'-6"	9	8'-6"	9	8'-6
7	9'-0"	7	9'-0"	7	9'-0
5	9'-6"	5	9'-6"	5	9'-6
4	10'-0"	4	10'-0"	4	10'-0
4	10'-6"	4	10'-6"	4	10'-6
3	11'-0"	3	11'-0"	3	11'-0
3	11'-6"	3	11'-6"	3	11'-6
2	12'-0"	2	12'-0"	4	12'-0"
3	12'-6"	3	12'-6"	3	12'-6
3	13'-0"	3	13'-0	3	13'-0
3	13'-6	3	13'-6"	3	13'-6
3	14'-0"	5	14'-0	3	14'-0"
3	14'-6"	3	14'-6"	3	14'-6
2	15'-0"	2	15'-0"	2	15'-0"
3	15'-6"	3	15'-6"	3	15'-6
5	16'-0"	3	16'-0"	3	16'-0"
62 TOTAL PC'S		62 TOTAL PC'S		62 TOTAL PC'S	
719.5 LIN FT		715.5 LIN FT		711.5 LIN FT	
3777 F.B.M.		3756 F.B.M.		3735 F.B.M.	

TURNOUT WITH POWER SWITCH

BILL OF SWITCH TIES 7" x 9"

GRS MODEL 5A/C, 6 OR US&S MODEL M-3, DA 10		GRS MODEL 5B/D/F OR US&S MODEL M23A/B	
QUANTITY	LENGTH	QUANTITY	LENGTH
9	8'-6"	9	8'-6"
7	9'-0"	7	9'-0"
5	9'-6"	5	9'-6
4	10'-0"	4	10'-0
4	10'-6"	4	10'-6"
3	11'-0"	3	11'-0"
3	11'-6"	3	11'-6
4	12'-0"	2	12'-0"
3	12'-6"	3	12'-6"
3	13'-0"	3	13'-0"
3	13'-6"	3	13'-6
3	14'-0"	3	14'-0"
3	14'-6"	3	14'-6
2	15'-0"	2	15'-0"
3	15'-6"	3	15'-6"
3	16'-0"	3	16'-0"
62 TOTAL PC'S		60 TOTAL PC'S	
711.5 LIN FT		687.5 LIN FT	
3735 F.B.M.		3609 F.B.M.	

8" x 10" (FRAMED)

QUANTITY	LENGTH
2	12'-0"
2 TOTAL PC'S	
24 LIN FT	
160 F.B.M.	

7" x 9" & 8" x 10" TIES
3769 TOTAL F.B.M.

FIGURE 10.

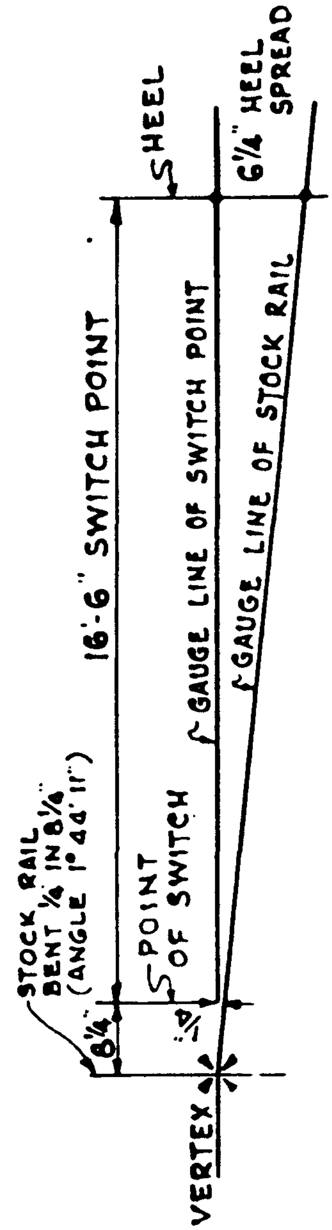


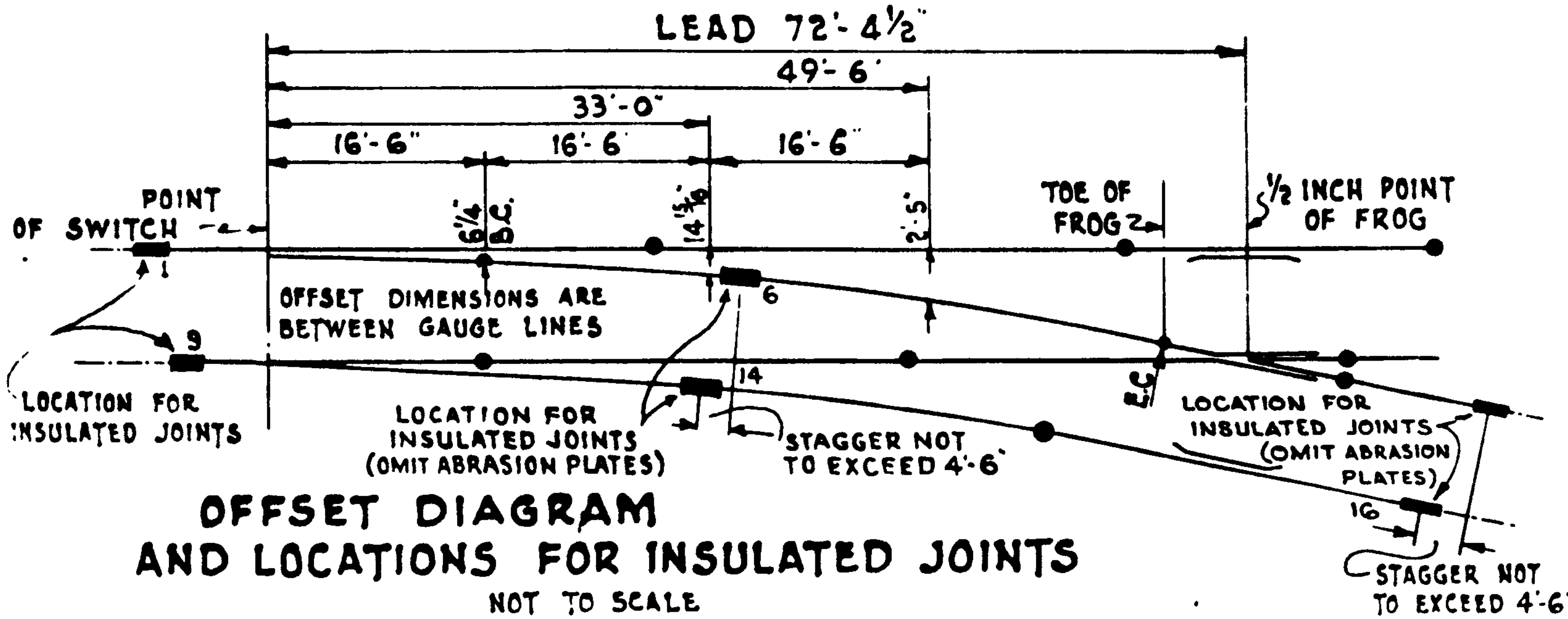
DIAGRAM OF SWITCH ANGLE 1°44'11"

NOT TO SCALE

FIGURE 11.

CP Rail

FIGURE 12.



OFFSET DIAGRAM AND LOCATIONS FOR INSULATED JOINTS

NOT TO SCALE

Maintenance of way

1. HOW TO READ STANDARD TURNOUT PLAN

Reading the Plan (Cont'd)

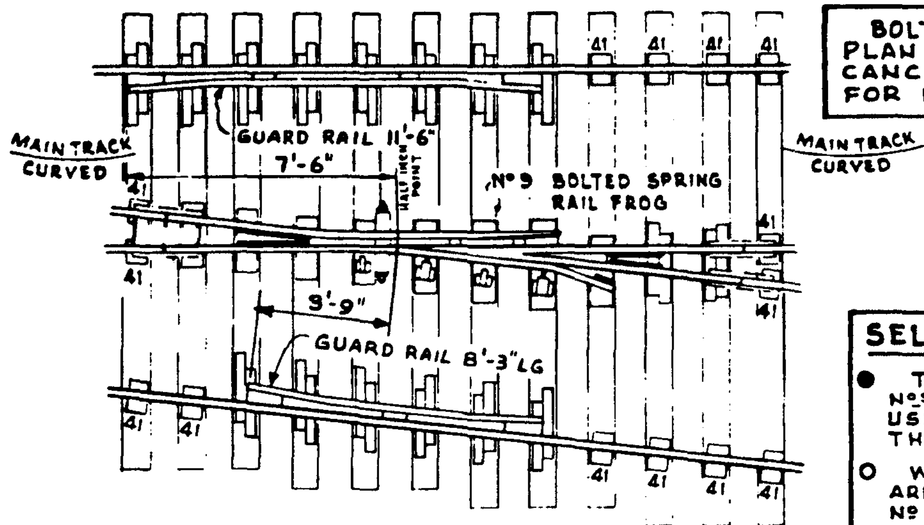
Note: In the turnout the abrasion plates are not used under the insulated joints because an abrasion plate under the joint would keep the tie too low and the other rails could not bear against the tie properly.

1.6 Frogs & Guard Rails

The next portion of the plan to the right of the offset diagram Figure 13 shows information on different types of frogs that may be used. The top part shows the installation of a #9 spring frog. When a turnout with a spring frog leads from the outside of a main track curve a 11'-6" long guard rail may be used on the main track only. On the turnout side a 8'-3" guard rail is used. It also shows the longitudinal locations of the guard rails measured from the 1/2 inch point of the frog.

The diagram below the spring frog shows the installation of a solid manganese self guarded frog. Self guarded frogs must only be used in yard tracks, industrial leads, private sidings or where specifically authorized by the Chief Engineer. You see that guard rails are not required in this case. The length of the closure rails, in solid manganese frogs are different than in bolted frogs. When using a solid manganese frog the curved closure is made up of 1 rail, 16'-8" long and one rail, 36'-9-1/2" long. The straight closure is made up of rails 30'0" and 23' 3-1/2" long.

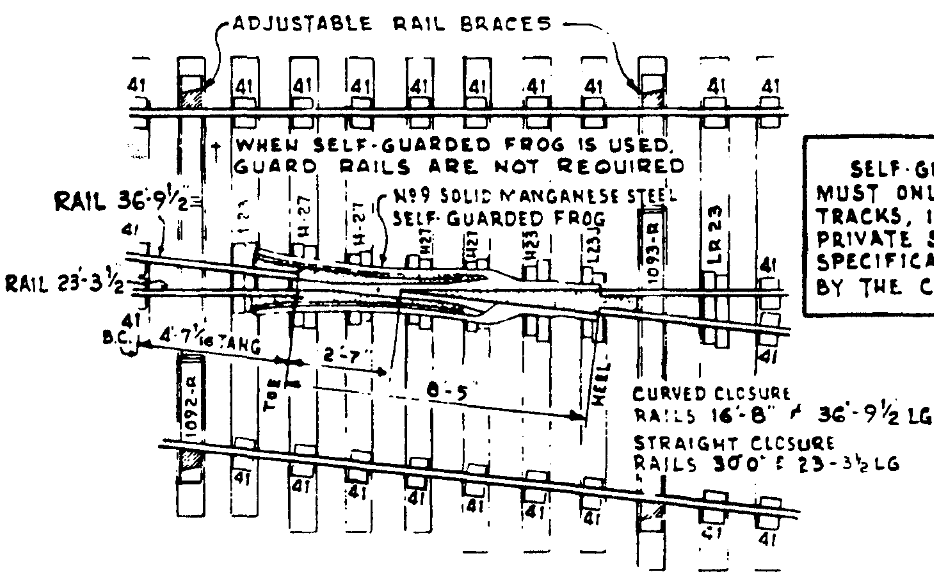
BOLTED SPRING RAIL FROG PLAN Nº 55390-44 IS CANCELLED. MAY BE USED FOR MAINTENANCE ONLY.



SELF-GUARDED FROGS

- ● THROUGH GAUGE PLATES Nºs 1092 & 1093 MUST ONLY BE USED WHEN AUTHORIZED BY THE CHIEF ENGINEER
- O WHEN THROUGH GAUGE PLATES ARE NOT REQUIRED FOUR EXTRA Nº 41 TIE PLATES MUST BE SUPPLIED

* WHEN A TURNOUT WITH A SPRING FROG LEADS FROM THE OUTSIDE OF A MAIN TRACK CURVE, THE 11'-6" LG GUARD RAIL SHOWN ON PLAN T-14-67-1 MAY BE USED ON THE MAIN TRACK ONLY.



SELF-GUARDED FROGS MUST ONLY BE USED IN YARD TRACKS, INDUSTRIAL LEADS, PRIVATE SIDINGS OR WHERE SPECIFICALLY AUTHORIZED BY THE CHIEF ENGINEER

FIGURE 13.

1. HOW TO READ STANDARD TURNOUT PLAN (Cont'd)

1.7 Layout Diagram, Figure 14

The clearance distance will be 188'-10" for 14' centres. If the track centres are over 14' you must add 9" of clearance for every inch over 14'. For example: if track centres are 14'-6" the new clearance distance is found by multiplying 6 x 9" = 54" or 4'-6" and adding this amount to 188'-10". The clearance distance for track centres of 14'-6" is therefore (188'-10") + (4'-6") or 193'-4".

1.8 Data and Bill of Material, Figure 15

The last portion of the plan gives additional information and also the bill of material. Most of the data table has already been covered. The remainder is Engineering data that is interesting but not necessary for a section foreman. The bill of material table shows quantities required, the part description and the number of the standard plans which shows more detail for the different parts. These plans will be sent to you if you need them. The standard plans for turnouts whether a #5, 7, 11 or 13 are all similar and all are just as easy to read as this one.

2. TURNOUT CONSTRUCTION PROCEDURES

You have already had lessons on:

- Bending, cutting and drilling of a stock rail.
- Preparation and changing of a stock rail.
- Replacement of switch points and stands.

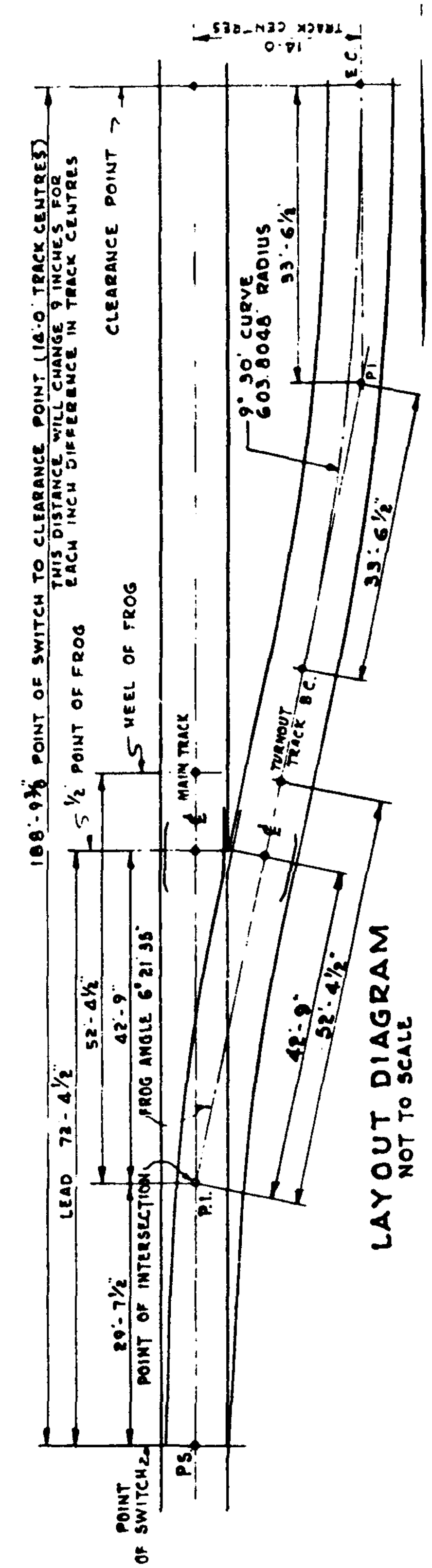

14'-0 TRACK CENTRES
E.C.
188'-9⅞" POINT OF SWITCH TO CLEARANCE POINT (14'-0 TRACK CENTRES)
THIS DISTANCE WILL CHANGE 9 INCHES FOR EACH INCH DIFFERENCE IN TRACK CENTRES
CLEARANCE POINT
9°30' CURVE
603.8048' RADIUS
33'-6½
P.I.
33'-6½"
5 ½" POINT OF FROG
HEEL OF FROG
MAIN TRACK
TURNOUT TRACK
B.C.
LEAD 72'-4½
52'-4½
42'-9"
FROG ANGLE 6°21'35"
42'-9"
52'-4½"
29'-7½
POINT OF INTERSECTION
P.I.
P.S.
POINT OF SWITCH
LAYOUT DIAGRAM
NOT TO SCALE

FIGURE 14.

DATA		
SWITCH	LENGTH	16'-6"
	ANGLE	1° 44' 11"
	HEEL SPREAD	6¼"
	THROW (AT THROW ROD)	4¾"
TURNOUT	LEAD	72'-4½"
	RADIUS OF CURVE ON CENTRE LINE	607.9940'
	DEGREE OF CURVE ON CENTRE LINE	9° 26' 04"
	CENTRAL ANGLE OF CURVE	4° 37' 24"
	STRAIGHT CLOSURE	49'-6"
	CURVED CLOSURE	49'-8 1/16"
	TANGENT ADJACENT TOE END OF FROG	5 1/16"
FROG	NUMBER	9
	ANGLE	6° 21' 35"
	LENGTH	16'-0"

BILL OF MATERIAL

QUANTITY	DESCRIPTION	PLAN Nº
	16'-6" SPLIT SWITCH - HAND THROW LAYOUT A/B (EXCEPT THAT HAND DOES NOT APPLY TO LAYOUT A)	T-15-13-9
1-RH/LH	16'-6" SPLIT SWITCH - SPRING	T-15-13-13
	16'-6" SPLIT SWITCH - POWER	T-15-13-11
1	SWITCH MACHINE — G R S MODEL: 5 A/C	T-15-66
	5 B/D/F	T-15-66-1
	[illegible]	T-15-66-2
	U S & S MODEL: [illegible]	T-15-67
	[illegible]	T-15-67-1
	[illegible]	T-15-67-2
	SWITCH STAND - HIGH INTERMEDIATE LOW [illegible] CONNECTING ROD (CONNECTING ROD [illegible] SWITCH)	T-15-18-10
	Nº 9 RAILBOUND MANGANESE STEEL FROG 16'-0" LG	55390-72
1	Nº 9 SOLID MANGANESE STEEL SELF GUARDED FROG [illegible]	55390-79
	Nº 9 BOLTED RAIL FROG 16'-0" LG	55390-12
+ 2	GUARD RAIL 8'-3" LG (ASSEMBLY)	T-14-67-1
1 RH/LH	Nº 1092 INSULATED THROUGH GAUGE PLATE 1"x7"x11'-1 [illegible]/16	T-15-44-6
1-RH/LH	Nº 1093 INSULATED THROUGH GAUGE PLATE 1"x7"x12'-6⅜"	
168	Nº 41 TIE PLATE 1"x7"x9⅜"	T-10-59
1	100 LB RE-HF FROG REPLACEMENT RAIL 16'-0" LG	
1	100 LB RE-HF RAIL 16'-8" LG. } STD RAIL END DRILLING	R-12-93-4
1	100 LB RE-HF RAIL 19'-6" LG } STD RAIL END DRILLING	
2	100 LB RE-HF RAIL 30'-0" LG } STD RAIL END DRILLING	
3	100 LB RE-HF RAIL 33'-0" LG } STD RAIL END DRILLING	
3	100 LB RE-HF RAIL 39'-0" LG } STD RAIL END DRILLING	
2	100 LB RE-HF JOINT BAR [illegible] (FOR USE AT HEEL OF SOLID MANG. STEEL SELF-GUARDED FROG.)	R-14-68-3
30	100 LB RE-HF JOINT BAR 33" LG	
90	TRACK BOLT - EXTRUDED SHANK 1"x5¼"	R-14-32-5
90	1" ESNA ELASTIC STOP NUT, PART Nº 47-NU-165	X-10-16-164
3 KEGS	STL TRACK SPIKE ⅝"x6½"	R-14-4-6
24	CONE-NECK DRIVE SPIKE ¾"x6"	R-14-4-7
4	100 LB RE-HF ADJUSTABLE RAIL BRACE, COMPLETE	T-15-31-5
AS REQUIRED	100 LB RE-HF ARMOURED INSULATED RAIL JOINT 33" LG	T-9-53-4

FIGURE 15.

2. TURNOUT CONSTRUCTION PROCEDURES

- Replacement of frogs and guard rails.
- You are now ready to use all these lessons in one lesson and build a turnout.

2.1 Preparatory Work

If you are not too familiar with turnout construction you should study the plan carefully. From the standard plan, make up a list of the material required and ensure that material is on hand when required. Then organize the men. The number of men required is 10 to 15 depending on the experience of the men, and the equipment on hand, such as a speed swing to handle the rail, spiking machines, rail bolters, saws, drills, etc. Plan the work each man is to do and see that he does his job.

Before starting to build the turnout distribute all material at the proper location (ties, rails, plates, O.T.M. frogs, guard rails, etc.), then collect the tools required:

- Rail bender, wrenches, spike mauls, claw bars, picks, shovels.
- Track gauge and level.
- Power tools.
- Brace and bit for head blocks.
- Alligator and other wrenches required for adjustment of points.
- A 100' and a 12' tape.

After you have done this start by marking off the tie centre of the first tie which is 3" from the point of switch. Then mark off the other centres, as shown on the plan, on the web of the rail opposite the frog side. When this is done mark the length of the ties that go in at each centre mark, on the web or base of the rail and mark the length of the switch tie on each tie. This will save much time when placing ties. Finally arrange for track time.

2. TURNOUT CONSTRUCTION PROCEDURES (Cont'd)

2.2 Preparing the Turnout Area

- Set-up the track protection.
- Remember that the track must be left safe for passage of trains.
- The next step then is to install the rail on the straight side. That is the side of the main line opposite the frog.
- Locate the first joint ahead of the switch point at 9' ± 1'.
- Then install a 39' rail, a 36' rail, then a 39' rail, except on some turnouts use 39', 33', 39' rails if needed to keep the joint away from the guard rail area.
- Skeletonize the track. (Not in CWR territory)
- This saves respiking on the switch ties.
- Assign men to pull out track ties.
- Assign men to install switch ties.
- Check to ensure the ties are at the proper spacing.
- The switch ties must be properly lined, surfaced and the straight side ends lined.
- While putting in the switch ties assign a couple of men to cut and drill the closure rails and to bend the stock rail.

2.3 Building the Turnout

- When the turnout area is prepared and all men and material are in place you can start the rail work for the turnout.
- Set up track protection.
- Make sure that you have sufficient track time before starting each step.
- Do not forget that the rail temperature could cause you trouble, so make sure that the rail is well anchored on each side of the turnout.
- If it is not, when you remove rail and try to put in the closure rails you may find that they do not fit.
- It is not necessary to install the guard rail yet since the frog has not been installed but it is good policy to do so.
- Install the riser plates and turnout plates.
- Spike the rail solidly for safe passage of trains.

2. TURNOUT CONSTRUCTION PROCEDURES

Building the Turnout (Cont'd)

- The next step is to install the rail on the frog side.
- Locate the end of the bent stock rail as shown on Plan (7'-6" ± 1'0").
- Install the bent stock rail and the switch points on the riser plates.
- Connect the switch rods to the switch points and securely spike the switch point against the bent stock rail.
- Install the straight closure.
- Put in the frog.
- Install the guard rail.
- Spike to proper gauge.
- Complete spiking and make track safe for train operation.
- Next install the curved closure. Make sure that this turnout rail is at the proper offsets which are measured from the gauge side of the main track rail. The curved closure rail is then spiked and the opposite rail installed to the proper gauge as shown on the turnout plan.
- Install the guard rail.
- Spike this rail securely.
- Now install the switch stand and adjust the switch points.
- Surface and line the turnout.
- Rule 92 in the M/Way rules states that the Roadmaster must inspect each new main line turnout before it is put into service if possible or as soon thereafter as practical.
- When installing a switch in signal territory the signal maintainer must be present.
- Make a final inspection before putting the turnout into service.

3. RE-BUILDING A TURNOUT WHEN WEIGHT OF RAIL IS CHANGED

- For example: the weight of the rail in your territory may be changed from 100 lb. to 115 lb. rail and it has been decided that the #11 turnouts will be replaced by #13 turnouts.
- Some Roadmasters prefer to install the new turnouts prior to the new rail program, others only after the new rail has been installed. (Either way do not forget before starting to install the new turnout to have enough compromise joints on hand to make the proper connections to the existing rail at each end of the turnout.

  The following is a good way to change such a turnout.
- Obtain and study the latest standard plan for a #13-115 lb. rail.
- Prepare all necessary material, cut and drill the rail to the proper lengths.
- Remember that:
  - The rails ahead of the switch point and beyond the frog must be the same rail section as the switch. On the point end they have to be, as the first joints are usually insulated. So the compromise joints are one rail away from the switch.
  - If CWR is to be laid, then the adjacent rails should be 36 foot buffer rails.
- Order the swith out of service.
- Set up protection.
- Install and line the rail on the straight side of the turnout and connect each end with compromise joints.
- Install the ties as shown on the standard plan whenever possible.
- You may have to cheat a bit on the tie spacing for the time being to fit the existing layout but it will be necessary to move these ties to their proper position when you build the new turnout.
- Any good ties removed can be re-used if necessary.
- When all ties are installed you are now ready to start building the turnout.

3. <u>BUILDING A TURNOUT WHEN WEIGHT OF RAIL IS CHANGED</u> (Cont'd)

- Make sure that you have enough time to work and be sure that you are properly protected.
- Dismantle the old turnout and re-space any ties that are not correct.
- Build the turnout the same way as previously shown.
- The clearance point for this turnout is not the same as in the old turnout so make sure you connect up properly to the siding.
- On a 115 lb., #13 turnout with track centres at 14'0", the clearance point is 279'-5" and on a -115 lb., #11, the clearance point is 239'-3".

4. <u>TURNOUTS ON CURVES</u>

Turnouts should not be located on curves on main track when it can be avoided. Turnouts to the inside of a curve will have a very sharp turnout curve. Turnouts on the outside of a curve will have a very poor elevation for the turnout curve as its rails are on the same ties as the main track.

Sometimes turnouts on curves will be built to a special plan. Usually, though, they are built to the standard plan as much as possible, in which case:

- The lead and the tie spacing are the same;
- Use the same standard length rails, i.e. 30', 36', 39'.
- Lay the standard length rails using the standard offsets and measure the gap and cut the odd-length rails to fit.
- In track circuited territory and if the curve is very sharp all rails should be measured out and the locations of the joints marked on the ground. Then check to see that the insulated joint stagger does not exceed 4'-6" as shown in the standard plan.

4. TURNOUTS ON CURVES (Cont'd)

Gauge must be as on the standard plans at the switch, frog and guard rails. Gauge widening on the main and turnout tracks between the switch and the frog should be the same as for any curved track according to SPC 17.5.

Gauge reduction on the main track curve might also be needed beyond the turnout at both ends.

5. TIME SAVING METHODS

5.1 If you think you may have to install a turnout when the ground is frozen, get permission to install the switch ties before freeze-up.

- Power tools and lifting equipment will speed up the work if available.

5.2 Another good method to install a turnout when track time is short or if your crew is inexperienced is to build the complete turnout beside the proposed location.

- First build a good solid base.
- Lay three rails parallel to the track to support the turnout ties.
- Make sure that the bottom of the switch ties are at the same height as the bottom of the track ties.
- Lay the switch ties on the support rails and build the complete turnout on the prepared stand.
- When completed and you have been given sufficient track time, set up the proper protection, dismantle the main track and remove all track material.
- It is a good thing to lower the roadbed a couple of inches.
- Lay down a couple of inches of good ballast.
- Keep the new road bed a little lower than the existing road bed so that the new turnout will be almost at the same elevation as the existing track.

5. TIME SAVING METHODS (Cont'd)

- Make sure that you have rail on hand to hook up.
- Moving the new turnout sideways will be much easier using a loader or other heavy equipment than by using lining bars.
- Make sure that you have sufficient ballast on hand to surface and line the new turnout.
- Give final inspection.

REFERENCES

Regulations

U.C.O.R.	Nil
R.T.C.	Nil
Railway Act	Nil
Provincial	Nil

Technical References:

M/Way Rules	92
S.P.C.'s	No. 20
Standard Plans	T-14-66-3, (May 7-1976)
	T-15-40-6

CP Rail

MAINTENANCE OF WAY TRAINING

Lesson no. 50

Subject DIAMOND CROSSINGS

First issued 79/02/21

Maintenance of way training

Introduction

A standard turnout which has one frog and two switch points is hard enough to maintain, but when you consider that a diamond crossing has four frogs close together and a movable point diamond may have several switch points, the maintenance practices although basically the same require much more care and work. This lesson will show you what to look for and help you better supervise your men. The main points covered in the lesson are:

1 - Description of Diamond Crossings.

2 - Installation Procedures.

3 - Maintenance Procedures.

1. DESCRIPTION OF DIAMOND CROSSINGS

In rail terms a diamond is a railway crossing at grade; that is where one track crosses another track. A diamond can be a single track, a double track, or a multiple track diamond.

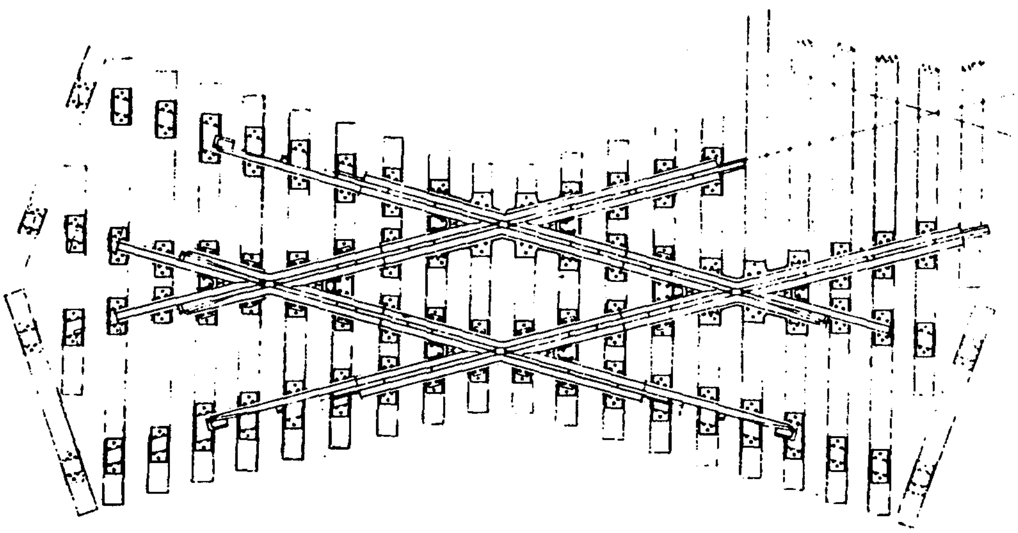


FIG. 1 - SINGLE TRACK DIAMOND.

The angle at which one track crosses over the other track determines the angle of the diamond and this angle could be from 90° down to 10°.

1. DESCRIPTION OF DIAMOND CROSSINGS (Cont'd)

Under 10° instead of using a rigid diamond, a movable point diamond is used. It is made of a combination of frogs and switch points. As in the case of the rigid diamonds, these diamonds can be simple as for double track or they might be complicated as for multiple tracks.

Any diamond has four frogs. Where the crossing is not at right angles we call the frogs at the sharp points of the diamond the "end frogs" and the other two the "middle frogs".

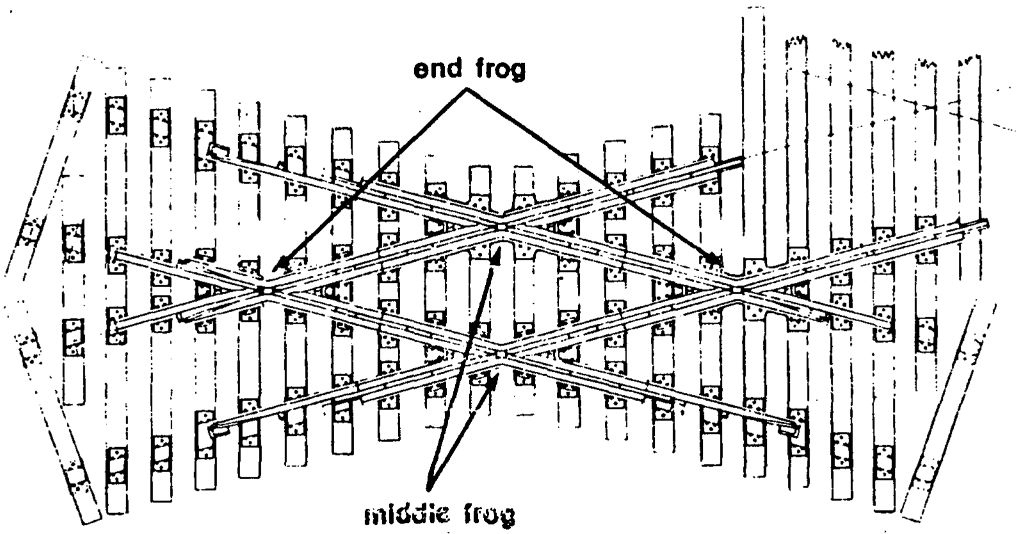


FIG. 2 - END AND MIDDLE FROGS

The two end frogs are the same and the two middle frogs are the same. All of these frogs are now usually railbound manganese, except some in light traffic crossings such as on industrial tracks where they may be build-up-rail.

The types of diamonds are:

1) Solid manganese diamonds
2) Manganese insert or rail bound manganese diamonds.
3) Bolted rigid diamonds
4) Movable point diamonds

DESCRIPTION OF DIAMOND CROSSINGS (Cont'd)

Solid Manganese Diamond

In solid manganese diamonds each frog is cast in one piece the same as the solid manganese turnout frogs now being issued. They are very expensive and seldom used.

Rail Bound Manganese Diamond

The manganese insert or railbound diamonds are frogs that have the heart of the diamond made of manganese alloy steel.

The manganese inserts in these diamonds are interchangeable. That is, as one part of the insert becomes worn it is only necessary to interchange the worn part with the part that has not been run on as much. Section "A" can be changed with section "B", and section "C" can be changed with section "D". The rest of the frog is bolted together with rail. These are used in heavy traffic territory.

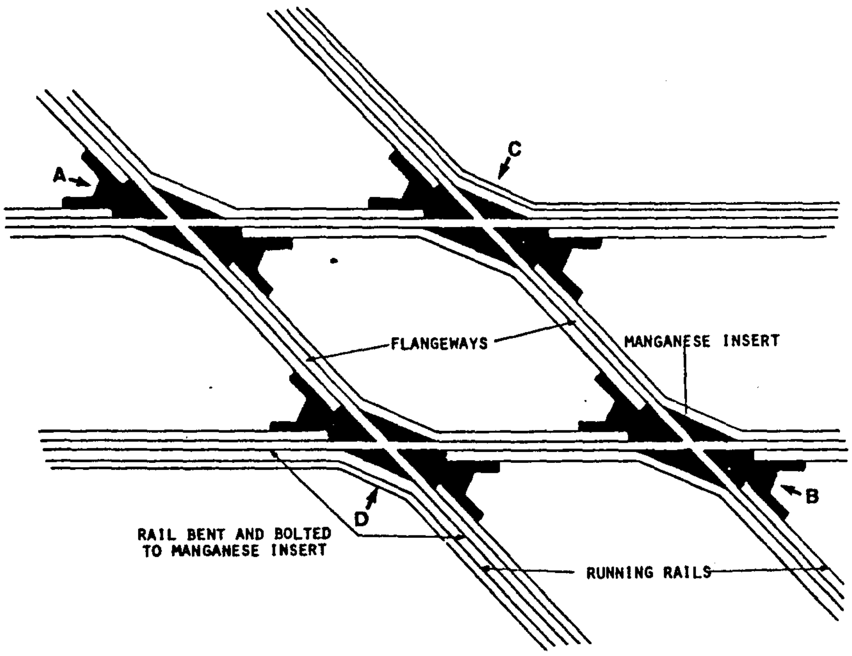


FIG. 3 - RAIL BOUND MANGANESE DIAMOND.

1. DESCRIPTION OF DIAMOND CROSSINGS (Cont'd)

Bolted Rigid Diamonds (On Bolted Rail)

Bolted rigid diamonds are made of rails that are bent to the proper angle and are bolted to other rails. The rails are separated by filler blocks. These diamonds are used in light traffic territory.

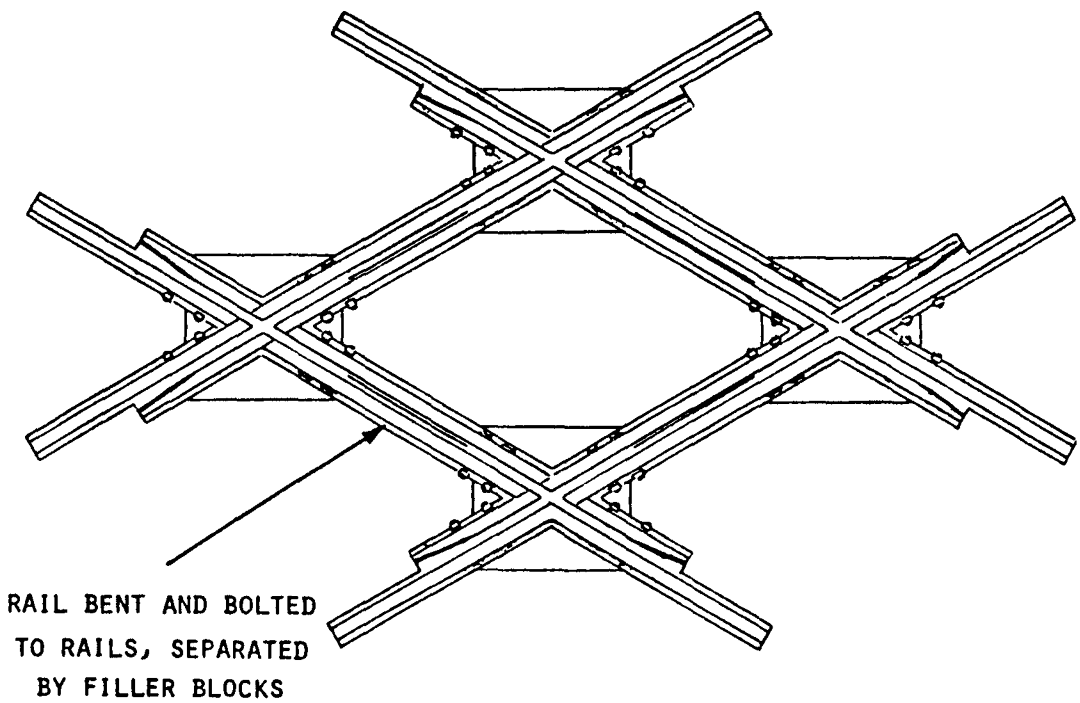


FIG. 4 - BOLTED RIGID DIAMOND (ON BOLTED RAIL).

Movable Point Diamonds

When the diamond angle is 10 degrees or less a standard middle frog could not guide the wheel flanges reliably and a movable point diamond is used. In this diamond the centre frogs are replaced by a knuckle rail and two movable points on each side of the knuckle. On account of the bend in the knuckle rail, the movable points have a more blunt angle than switch points.

DESCRIPTION OF DIAMOND CROSSINGS (Cont'd)

Movable Point Diamonds

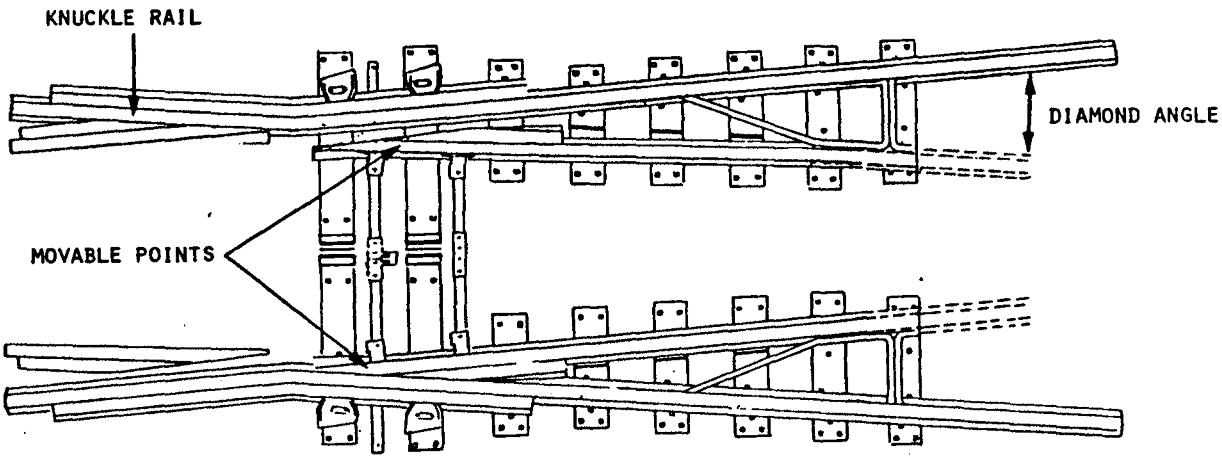


FIG. 5 - MOVABLE POINT DIAMOND.

2. INSTALLATION PROCEDURES

- The installation of a diamond is not too common and if one is installed the Roadmaster is more than likely to be on hand to assist in the proper installation.
- As in turnouts, when installing a diamond crossing you will be given a standard plan showing the track layout for that particular diamond.
- The exact location of the diamond is given by the Engineering Department.
- The roadbed must be properly prepared and drained.
- A bed of good ballast should be placed under the diamond.
- It is very important that the tie layout as shown on the standard plan be closely followed, otherwise the plates under the diamond will not be able to be spiked properly.
- In some cases it may be possible, and it is often preferable, to assemble the diamond off to one side and then place it in its proper position.
- Rail anchors must be placed for a sufficient distance on each side of the diamond to prevent any movement.

3. MAINTENANCE PROCEDURES

Most phases of Diamond maintenance are similar to turnout maintenance but they are harder to maintain and they must be inspected often. They are hard to maintain because:

1) The pounding, (impact) and vibration of the wheels passing over the frogs is much worse than on a turnout;
2) The spacing of the frogs, the equipment wheels and the stiffness between the frogs causes a rocking motion of the diamond;
3) Rail creep on both tracks tends to push the diamond out of line.

Most diamonds are protected with a permanent slow order of some kind. If you notice that these slow orders are not being observed it should be reported to the Roadmaster.

Sound ties are a must and they must be properly tamped. At times, tight clearances make tie renewal more difficult and may require removal of portions of the rail in order to renew the ties. Such situations, usually result in a need for greater periods of time to do the job than to change a turnout tie. Other things that need attention are:

1) All bolts in a diamond must be kept tight and properly torqued.
2) Rail anchors on each side of the diamond must be in their proper position and a sufficient number installed to prevent movement.
3) Gauge, line and surface must be maintained.
4) Parts such as frogs, switch points and stock rails may flow and require grinding or become battered or worn and require welding.
5) Watch especially for cracks in any of the parts.

INSPECTION

Points to watch:

- Loose bolts (not up to torque)
- Cracked flangeways
- Broken or chipped points
- Cocked or crowned surface
- Crushed rail or supports
- Metal overflow
- Flangeway 1-3/4" to 2" wide
  at least 1-1/2" deep
- Height of points and guards
- Loose guards or straps
- Defective ties and tie pads
- Defective welds
- Poor drainage

REFERENCES

Regulations

U.C.O.R.	Nil
R.T.C.	Nil
Railway Act	Nil
Provincial	Nil

Technical References:

M/W Rules	-	Nil
S.P.C.'s	-	21
Standard Plans	-	Diamond Crossing Plans, X-10-16-164
Other's	-	A.R.E.A. Track Plans drawings 700-68 to 836-55
	-	Racor Track works Products catalogue G-6

CP Rail

MAINTENANCE OF WAY TRAINING

Lesson no.: 39

Subject: MECHANICAL LINING METHODS - 2

First issued: 79/03/12

Maintenance of way training

INTRODUCTION

The speed of trains to-day has increased to a point where lining track by eye is often not good enough. To keep the track in good line, mechanized lining methods must be used as they can line track much faster and better than the old lining gangs.

Summary of Main Points

1) Description of track liners and lining devices
2) Duties of a foreman
3) Duties of a liner operator
4) A liner helper's duties
5) Set-offs for removal of the lining machine
6) Setting off the liners
7) Lining track with the Nordberg and Fairmont liners
8) Lining to a fixed point on tangents
9) Lining curves with graphs
10) Standard curves
11) Compound curves
12) Reverse curves
13) Fixed points in curves
14) Removing swings
15) Problems in curve lining
16) Safety precautions
17) More about curve graphs

1. DESCRIPTION OF TRACK LINERS AND LINING DEVICES

A track liner is a powered unit that moves the track into line. The wire device and the line indicator are used to tell exactly how far the track is out of line and to show the throw needed at each station or lining point.

1. DESCRIPTION OF TRACK LINERS AND LINING DEVICES (Cont'd)

The most common types of track liners used to-day are:

The Nordberg liner

The Fairmont liner

The Kershaw liner

All three liners use the Nordberg wire line indicator. The Fairmont liner also has a light beam device that can be used to line the track. This device however is not used very often. It's main use is to line out long swings in the track.

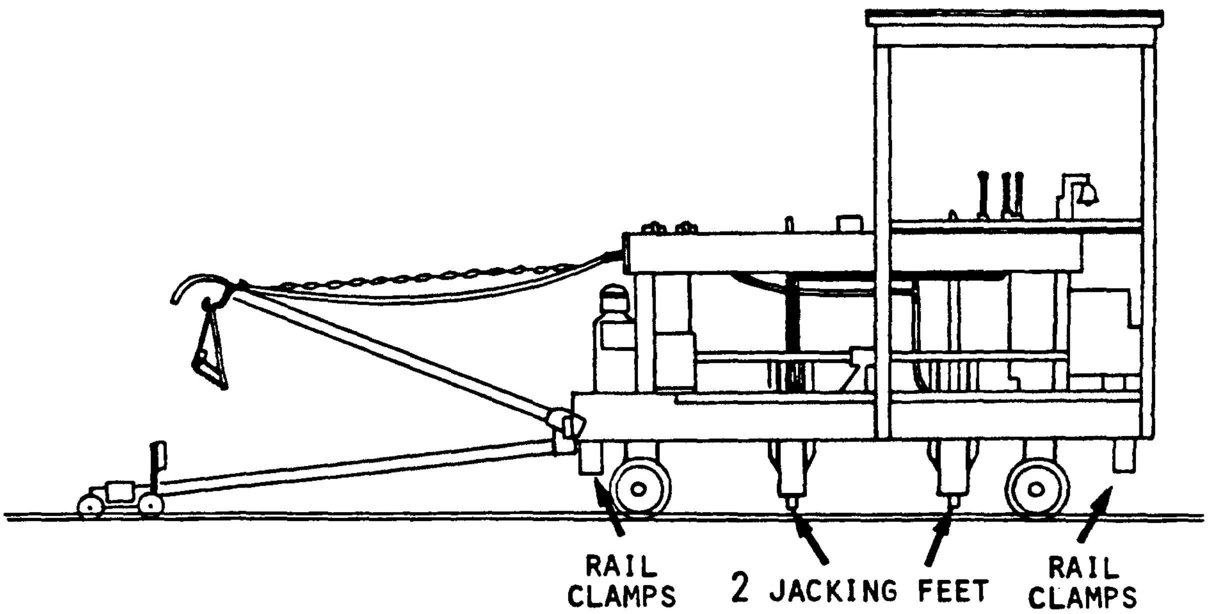


FIG. 1 - THE NORDBERG LINER.

This is a hydraulically operated machine that uses two jacking feet and two rail clamps to line the track.

1. DESCRIPTION OF TRACK LINERS AND LINING DEVICES

The Nordberg Liner (Cont'd)

The jacking feet are dropped in the cribs and anchor themselves in the ballast. To speed up the work by cutting out unnecessary movement of the jacks, shoes stops are placed on the jacking feet. This stops the jacking feet from lifting too high when the machine is moved from one lining point to another. However, these shoe stops must be removed when going over turnouts or crossings, to make sure the lining jacks clear any obstructions.

When lining skeleton track extensions must be added to the lining jacks to allow them to drop far enough to anchor themselves properly in the ballast.

The operator must watch the jack pressure to keep the track from humping. This liner is light enough so that it can be loaded in a three ton truck and can be easily set off along the track using a portable set-off.

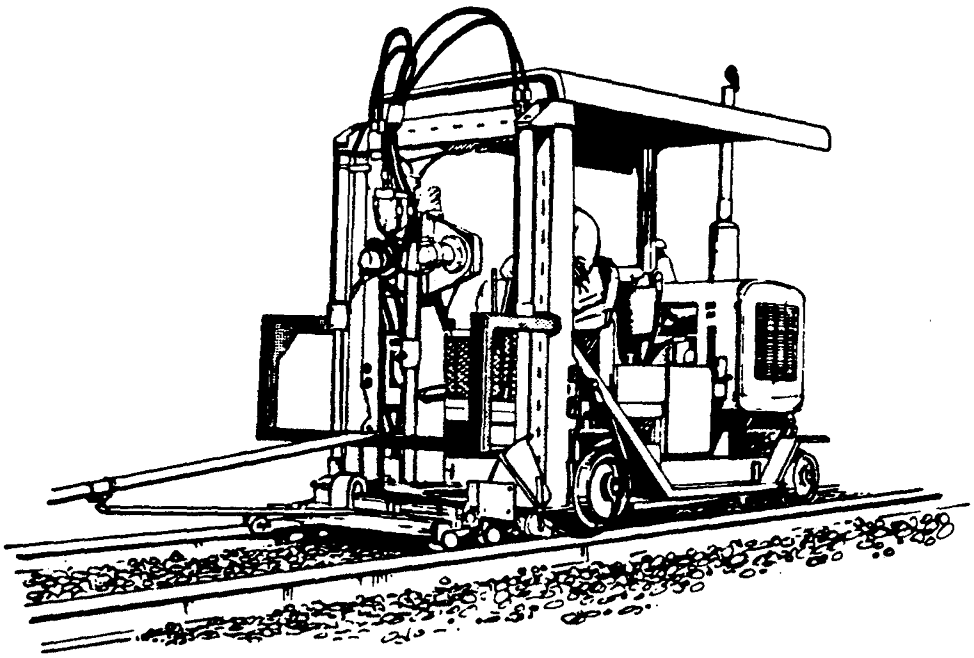
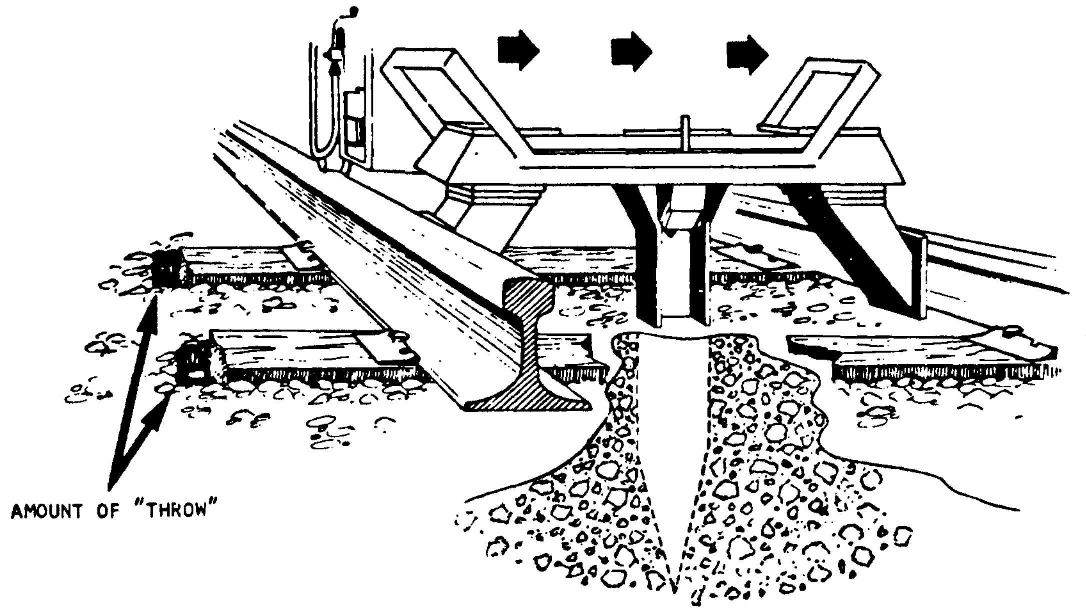


FIG. 2 - THE FAIRMONT LINER.

1. DESCRIPTION OF TRACK LINERS AND LINING DEVICES

The Fairmont Liner (Cont'd)

This is a hydraulically operated liner that uses a spud driven into the ballast to line the track.



- SPUD DRIVEN IN BALLAST TO ANCHOR LINING MACHINE.
- FORCE APPLIED TO RAIL TO "THROW" TRACK IN DIRECTION INDICATED BY LINE INDICATOR.

FIG. 3.

This liner is excellent for lining skeleton track. It is often used to rough line the track in a ballast operation as it moves the track quickly, even if it is out of line by two to three feet, by making several passes. In a case such as this it is used without the wire lining device. The track is eye lined by a lining foreman from preset offset stakes. This type of liner comes equipped with its own turntable and can be set off the track on a set-off. This liner does not hump the track.

1. DESCRIPTION OF TRACK LINERS AND LINING DEVICES (Cont'd)

FIG. 4 - THE KERSHAW LINER.

This liner is quite different from the Nordberg and Fairmont liners in that it uses inertia forces to line the track. A 2800 lb. weight is mounted underneath the liner in a box like frame. The weight is moved laterally by a pair of hydraulic cylinders and the force of this weight, somewhat like a hammer hitting a nail, moves the track into line. In operation the weight box is lowered to rest on the ties and the wheels of the liner are lifted clear of the rails. Then four inch wide wedge blocks are spread out and locked against the base of the rail in two adjacent cribs on each side of the liner. This is done with enough force to take out all the slack but the pressure in the circuit is limited to avoid spreading the gauge. When lining track the wedges butt up against the base of the rail and in lining turnouts the wedges are placed on the head of the rail.

1. DESCRIPTION OF TRACK LINERS AND LINING DEVICES (Cont'd)

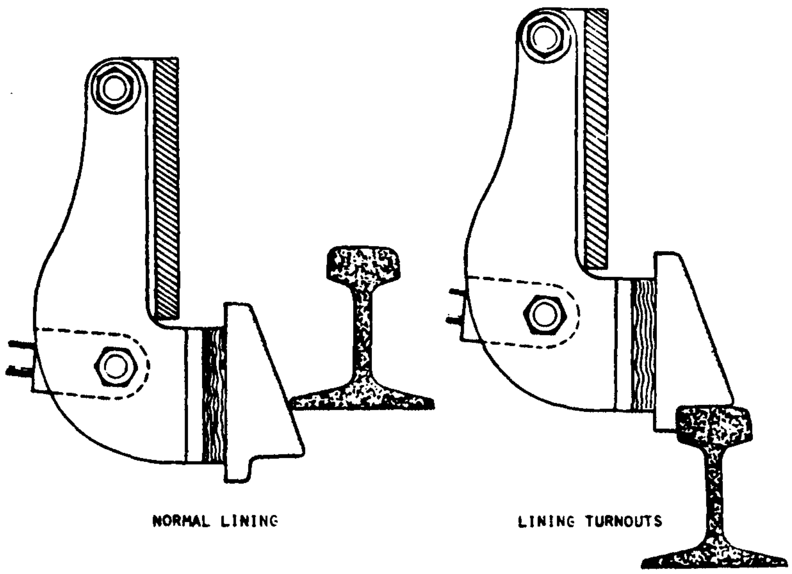


FIG. 5 - WEDGE BLOCKS.

The Kershaw liner should not be used to line track with concrete ties, as it may crack the ties.

The Line Indicator

The line indicator assembly is made up of a front buggy, an indicator buggy, a 120' wire, spacer buggies and a rear buggy.

1. DESCRIPTION OF TRACK LINERS AND LINING DEVICES (Cont'd)

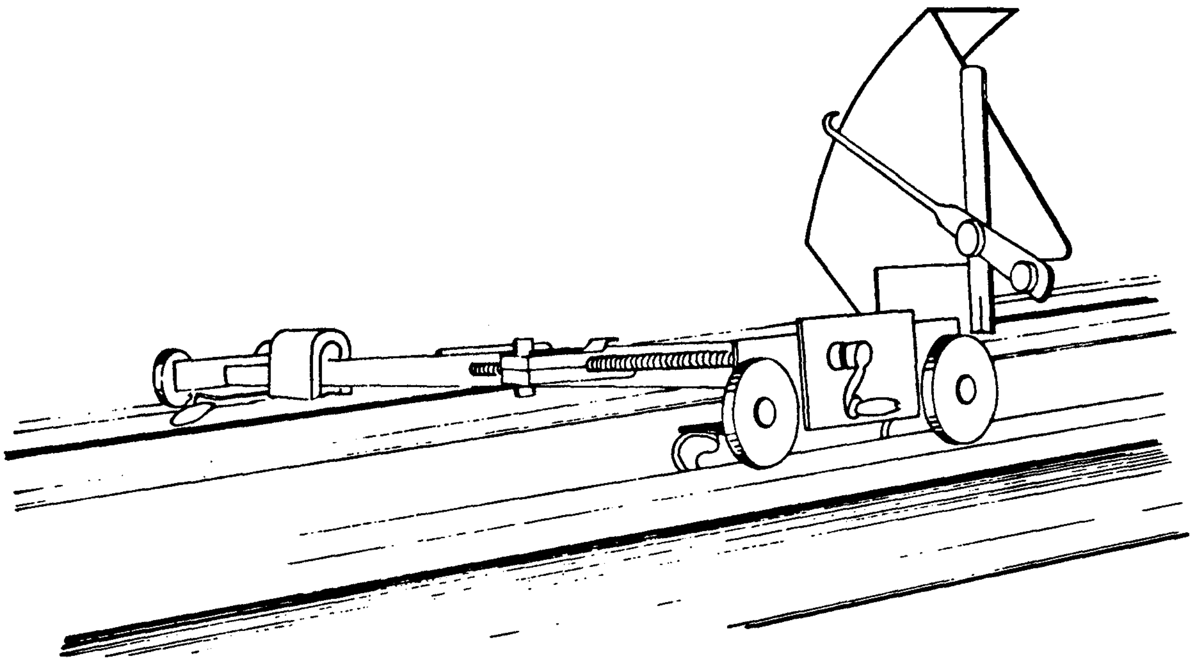


FIG. 6 - INDICATOR BUGGY.

When lining tangent track five spacer buggies are used and the indicator is put 20' from the rear of the machine. The front buggy is 100' from the indicator buggy and is the first buggy in the direction of lining.

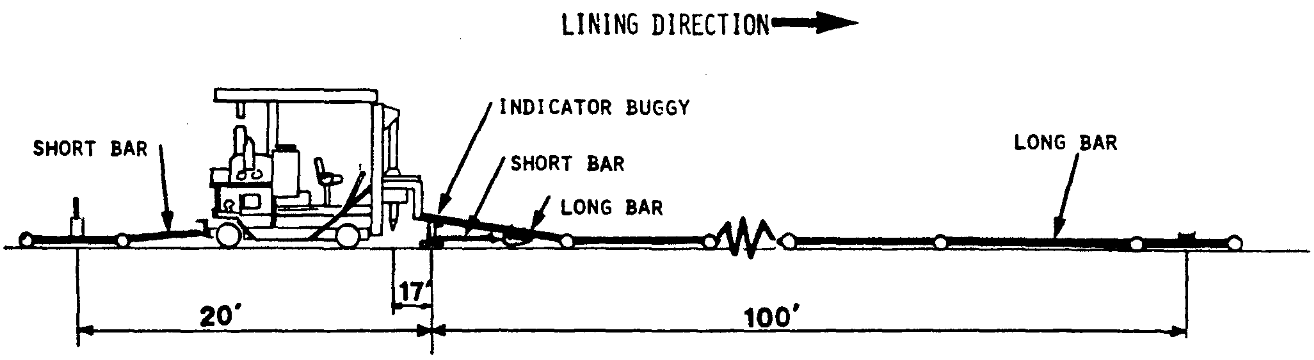


FIG. 7.

1. DESCRIPTION OF TRACK LINERS AND LINING DEVICES

The Line Indicator (Cont'd)

The spacer buggies are used to separate the front and rear buggies.

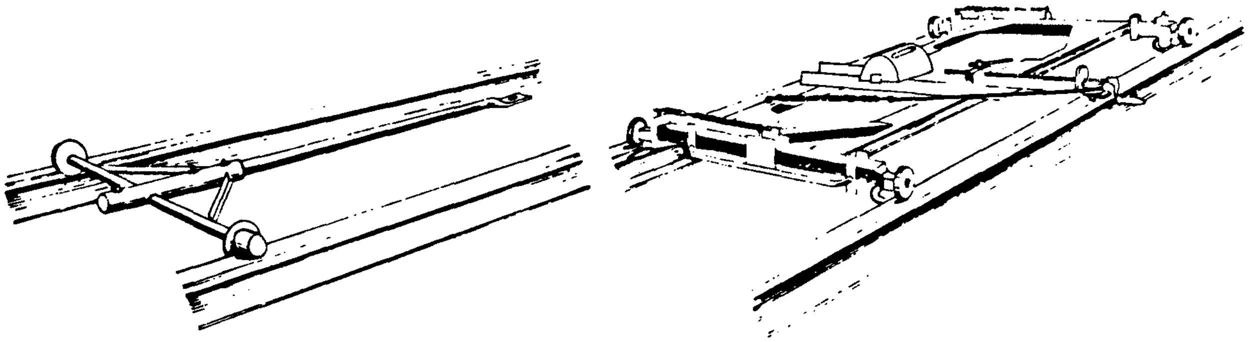


FIG. 8.

The rear buggy is the last buggy and this buggy has the reel of wire on which the proper tension for the line wire can be set.

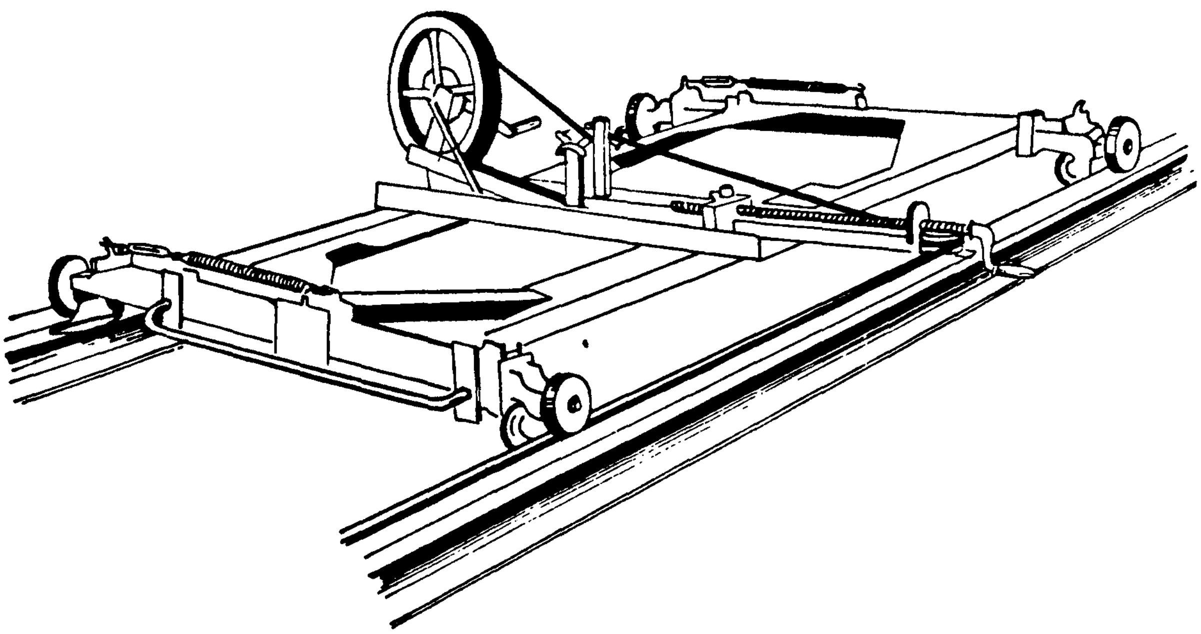


FIG. 9 - REAR BUGGY.

1. DESCRIPTION OF TRACK LINERS AND LINING DEVICES

The Line Indicator (Cont'd)

The indicator buggy is put on the line wire and tells you how much the track is out of line.

Switch Lining

Both the Fairmont and the Kershaw track liners use the same set up when lining turnouts as when lining track.

Using the Fairmont liner the operator faces forward and the buggy set up is as shown in Figure 10.

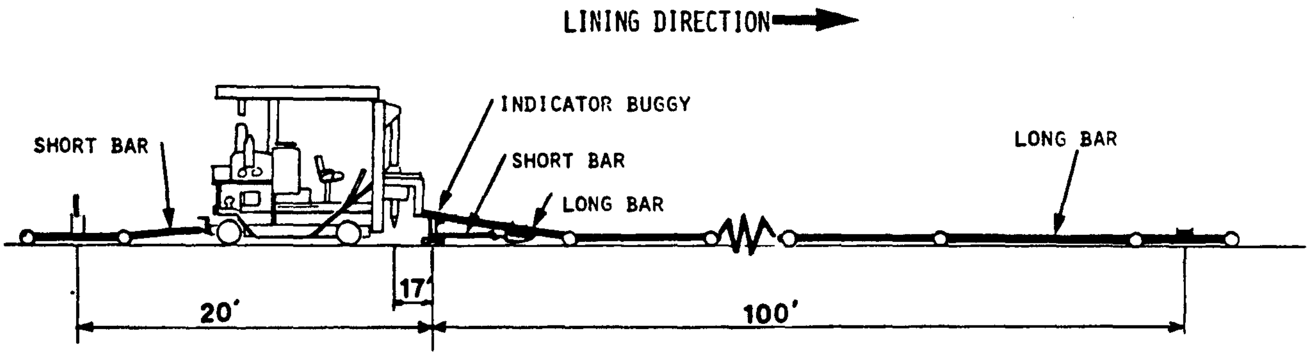


FIG. 10 - BUGGY SET UP ON FAIRMONT LINER

Using the Nordberg liner you must use a switch liner assembly to line turnouts. The wire line indicator is put behind the liner.

1. DESCRIPTION OF TRACK LINERS AND LINING DEVICES

The Switch Lining (Cont'd)

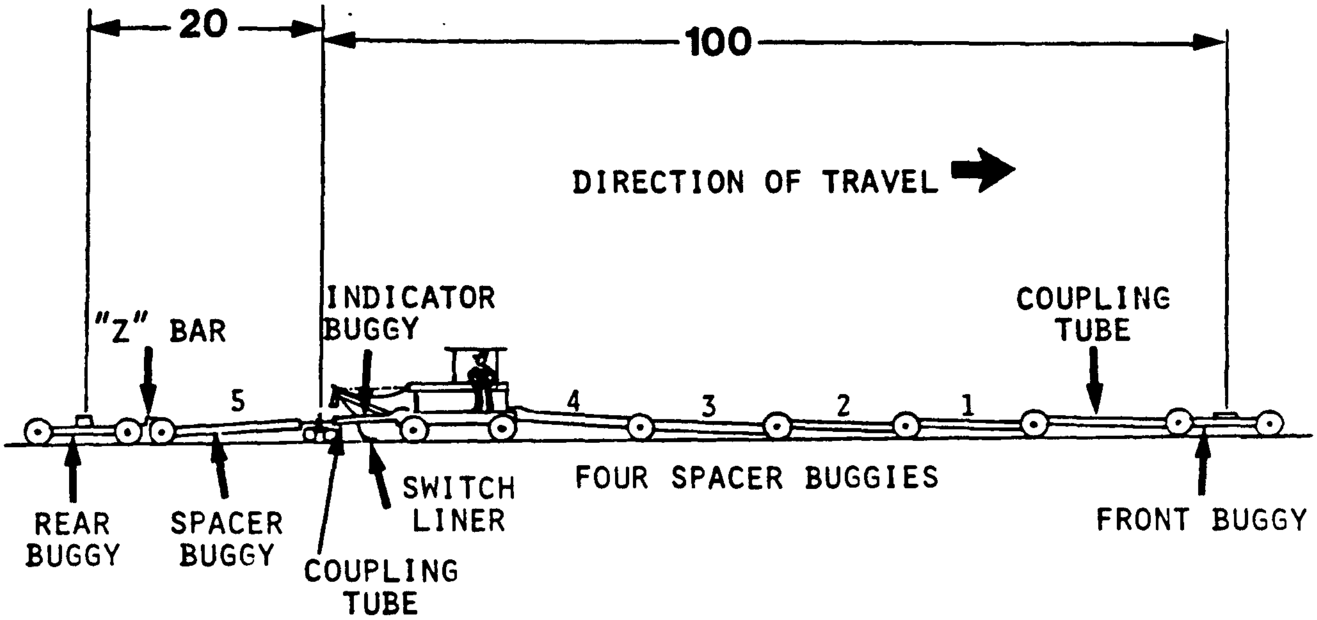


FIG. 11 - SET UP FOR LINING TURNOUT.

2. DUTIES OF A FOREMAN

A foreman is responsible for the safe operation of the liner when it is working on his territory. He supervises the machine operator and sees that the helper knows his duties. In addition he is responsible for:

1) Arranging and setting up flag protection
2) The quality of the work performed
3) Organizing the work program to use the available track time to the best advantage.
4) Preparing set-offs where needed.
5) Supplying fuel and supplies.
6) Providing curve lists.
7) Pre-marking curves and spirals.

3. DUTIES OF A LINER OPERATOR

The machine operator should ensure that the proper flag protection is arranged. He is responsible for operation and maintenance of the liner. He must also be able to line track and turnouts, to plot the graph for curves and spirals and to instruct his helper.

4. A Liner Helper's Duties

The helper assists the operator with the maintenance and setting up of the liner. He protects the machine when it is working by warning the operator when the buggies are about to derail when going over crossings and switches. He protects the wire line which is almost invisable and sees that there are no obstructions on the rails ahead of the buggies. In addition he:

1) Places ballast under the Nordberg liner if needed.
2) Places and removes the shoe stops.
3) Operates the lining unit around curves and spirals while the operator takes readings.
4) When using the Nordberg liner to line turnouts he places the lining jacks in their proper position.
5) On instruction from the operator he places the proper reading on the ordinate scale when lining curves.
6) He should watch the operator carefully to learn as much as possible about the operation of the liner so he can become a liner operator.

5. Set-Offs for Removal of the Lining Machine

Track time must be used to the best advantage and it is sometimes necessary to build set-offs for the liner if the sidings are too far apart. Set-offs must be built strong enough to carry the machine and long enough to provide proper clearances.

5. Set-Offs for Removal of the Lining Machine (Cont'd)

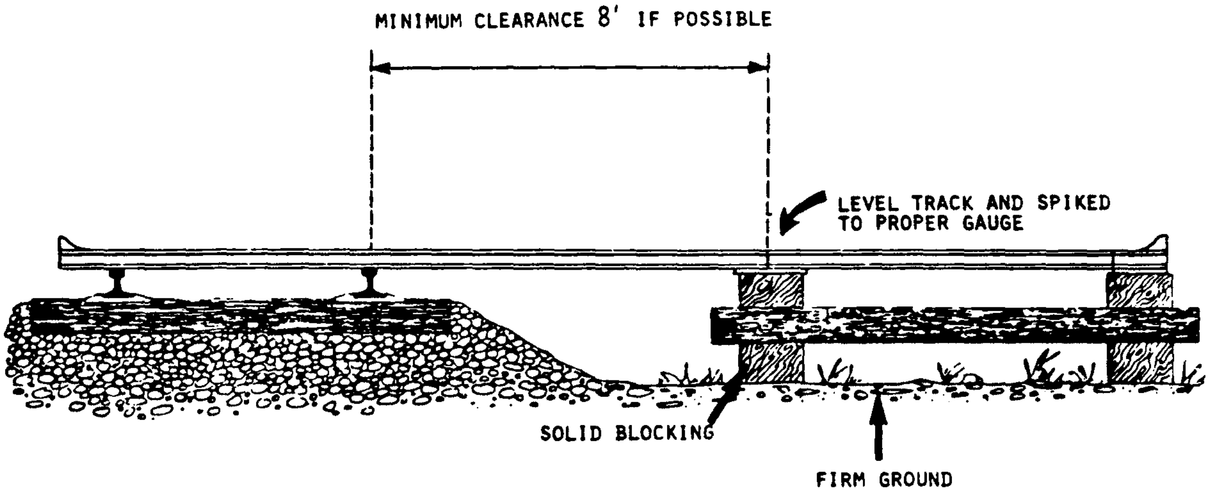


FIG. 12 - SET OFF FOR TRACK MACHINES.

6. SETTING OFF THE LINERS

Setting off the Nordberg Liner

This liner is set off sideways. The procedure to set off the machine is as follows:

- Spot the liner with the set-off wheels opposite the set-off.
- Remove the shoe stops.
- Raise the jacking feet.
- Close the valve in the hydraulic line near the end where the operator stands.
- Raise the engine end of liner with the jacking feet.
- Slide the set-off rails under the set-off wheels.
- Lower the liner onto the set-off rails.
- Open the valve on the end where the operators stands and then close the valve on the engine end.
- Raise the operator's end of the liner.
- Slide the set-off rails in place.
- Lower the liner onto the rail.
- Raise and lock the shoes in the proper position.

6. SETTING OFF THE LINERS

Setting off the Nordberg Liner (Cont'd)

- Push the liner along the set-off rails to the wheel stops.
- Block the liner securely.
- Remove the inner set-off rails.
- Shut off the engine.

To set the liner back on the track reverse the above procedure.

Setting Off the Fairmont or Kershaw Liners

These track liners are equipped with turntables and are removed as follows:

- Place the turntable base in position with the centre line of the track and the centre line of the set-off. The height of the turntable should be adjusted so the machine frame and wheels will clear the rail when it is fully supported by the turntable.
- Position the liner over the turntable base.
- Raise the liner and manually turn it 90° to the track.
- Place the set-off rails under the liner.
- Lower the liner onto the set-off rails.
- Raise the turntable.
- Move the liner onto the set-off.
- Remove the set-off rails to clear the track.
- Then block the liner securely and shut off the engine.

Setting off the Buggies

It is the usual practice to set off the buggies along the track and not run the buggies into clear with the liner, since you can move faster without the buggies.

7. LINING TRACK WITH THE NORDBERG AND FAIRMONT LINERS

Setting up the Nordberg Liner for Tangent Track

When using the Nordberg liner the wire line indicator is located under the liner. The line rail is the rail that is to be lined as accurately as possible and after lining it is used as the reference rail to maintain gauge. The line rail is the south or east rail on single track tangents and on curves it is the high rail, on double track it is the outer rails. The wire may be on either side of the track liner but it is best to set the line indicator so that the wire is on the side of the track liner opposite the operator. Place a straddle bracket on each end of the liner on the Nordberg lining unit.

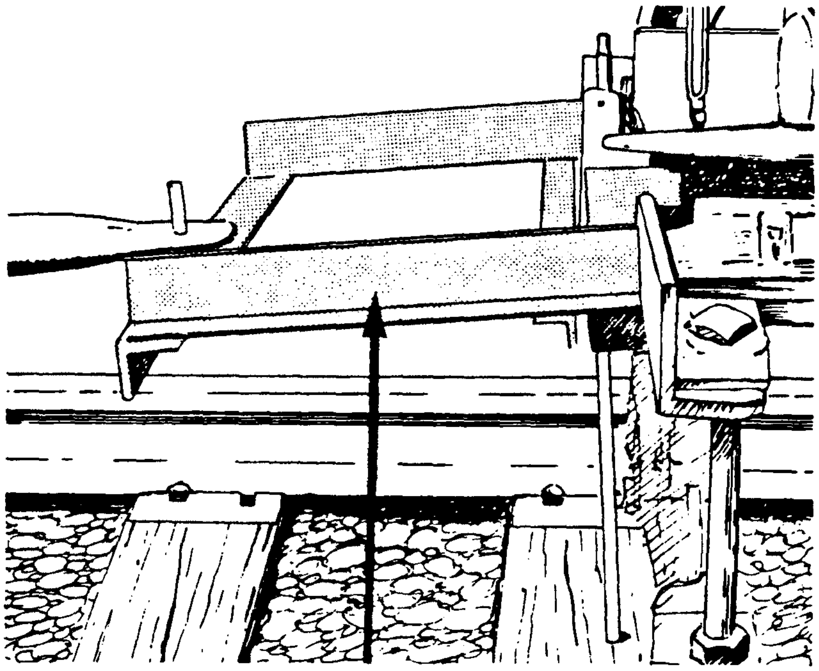


FIG. 13 - STRADDLE BRACKET.

- Set the front buggy on the track so that the wire support pully is over the desired rail.
- Pull on the counter weight.
- Place the rear buggy on the track so that the wire support pulley is over the same rail as the wire support pulley for the front buggy.

7. LINING TRACK WITH THE NORDBERG AND FAIRMONT LINERS

Setting up the Nordberg Liner for Tangent Track (Cont'd)

- Place the rear (long) tie bar between the rear buggy and the rear track liner straddle bracket.
- Place the spacer buggies on the track between the track liner and the front buggy with the tongue facing the track liner.
- Spacer buggies are joined by placing the hole at the end of each tongue over the pin on the axle unit of the adjoining spacer buggy. The tongue of the spacer buggy nearest the liner is placed over the pin on the liner straddle bracket.
- Place the front (short) tie bar between the front buggy and the front spacer buggy.
- Place the indicator buggy under the liner near the run off wheels on the end of the liner nearest the rear buggy.
- Place the indicator buggy connector over the rear track liner axle and on the indicator buggy.

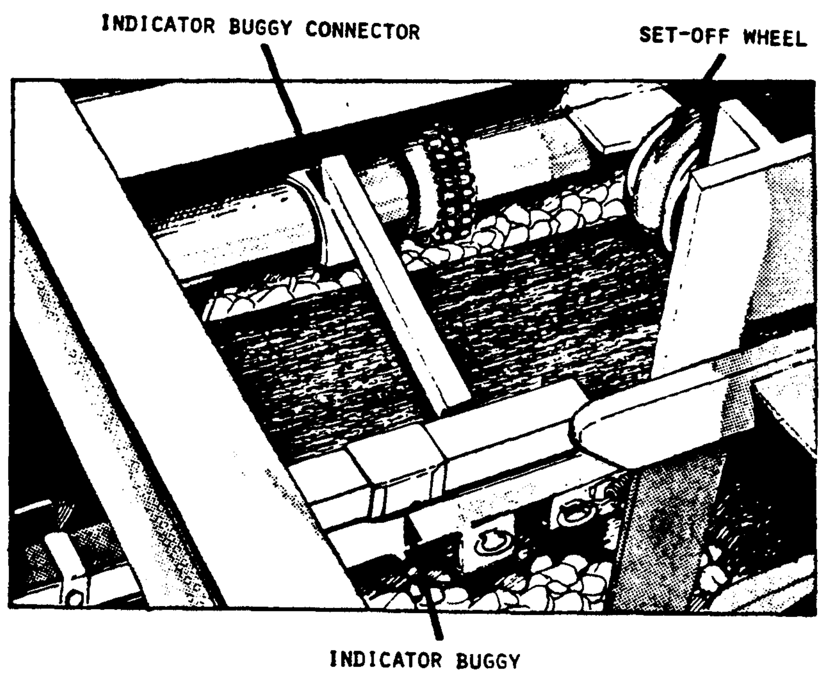


FIG. 14.

7. LINING TRACK WITH THE NORDBERG AND FAIRMONT LINERS

Setting up the Nordberg Liner for Tangent Track (Cont'd)

- The wheel springs on all three buggies must be towards the line rail. Make sure the slide and the spring move freely and the guide wheels stay tight against the gauge line of the rail.

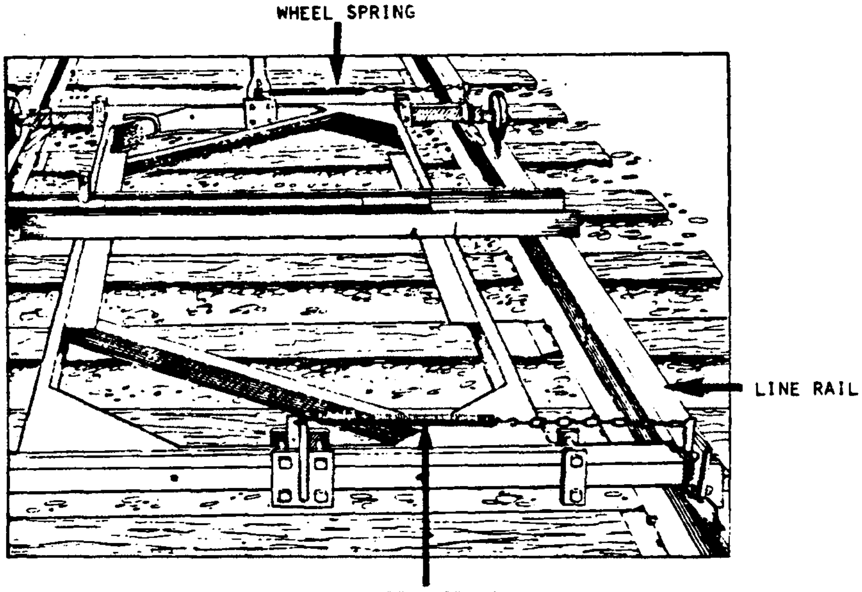


FIG. 15.

Placing on Track for Lining Curves

- Place the front and rear buggies on the track so that the wire support pulley is over the low rail.
- Place the indicator buggy under the liner so that the pointer is on the low rail side and is at the end of the liner nearest the rear buggy.
- Place the wheel springs on each of the three buggies towards the high rail.
- The spacer buggies are placed the same as for tangent track.
- Release the wire reel and pull the wire from the rear buggy to the front buggy and place the end chain link over the pin provided on the front buggy.

7. LINING TRACK WITH THE NORDBERG AND FAIRMONT LINERS

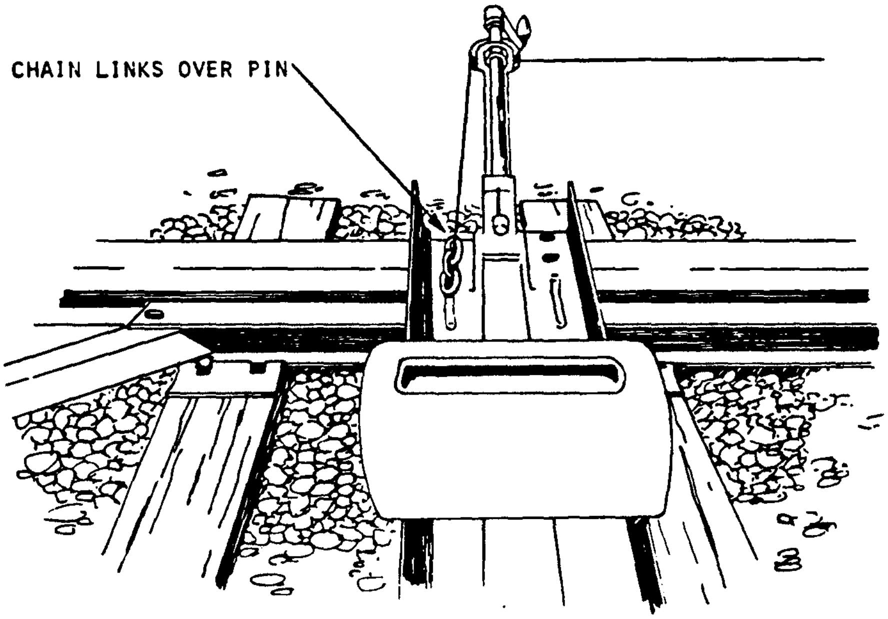


FIG. 16.

Pull the wire tight with the reel, and lock it in place with the reel stop. The reel gives the proper tension when it is set at an angle of approximately 30°.

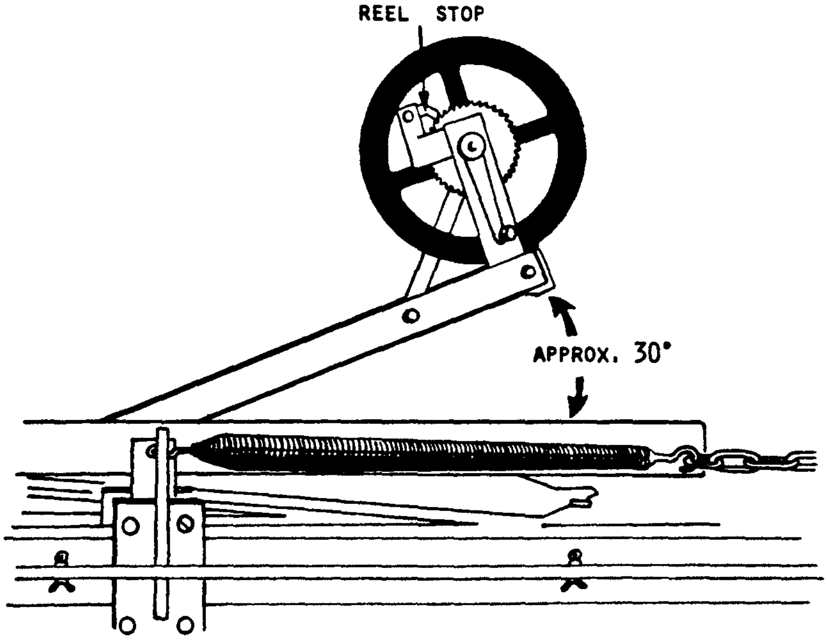


FIG. 17.

7. LINING TRACK WITH THE NORDBERG AND FAIRMONT LINERS (Cont'd)

Make sure that the wire is in the slot of the pointer.

Checking the Wire Positions

When checking the wire position the liner and buggies should be on tangent track. The wire position must be checked at 3 points

1) The front buggy
2) The indicator buggy
3) The rear buggy

To ensure accurate readings when checking the wire all three of these buggies must be on a rail which is not lipped and they must not be at a joint. When the check is made all three check points should read zero. To check these points you use the gauge provided sometimes called the template. Place the gauge so that the appropriate stop is tight against the gauge side of the line rail.

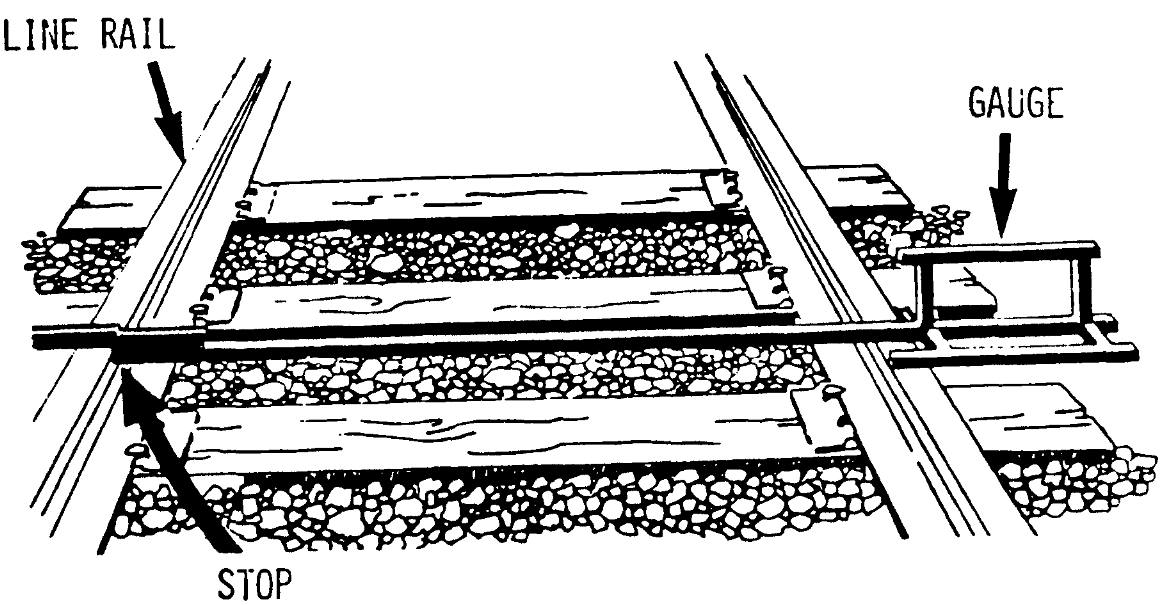


FIG. 18.

Loosen the locking screw for the wire support adjusting screw. Turn the adjusting screw until the wire passes over the zero on the wire position template.

7. LINING TRACK WITH THE NORDBERG AND FAIRMONT LINERS

Checking the Wire Positions (Cont'd)

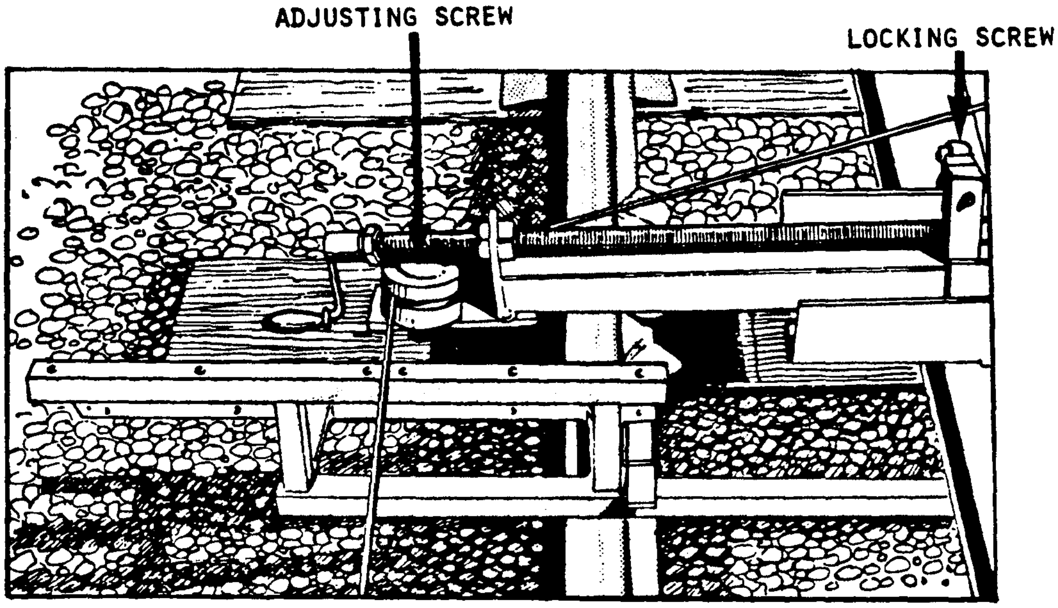


FIG. 19.

- Tighten the locking screw.
- Repeat this procedure at the front buggy.
- Place the gauge near the indicator buggy making sure that the stop is tight against the gauge side of the line rail.
- Loosen the locking screw and hold the indicating pointer in the zero position on the throw scale.

7. LINING TRACK WITH THE NORDBERG AND FAIRMONT LINERS

Checking the Wire Positions (Cont'd)

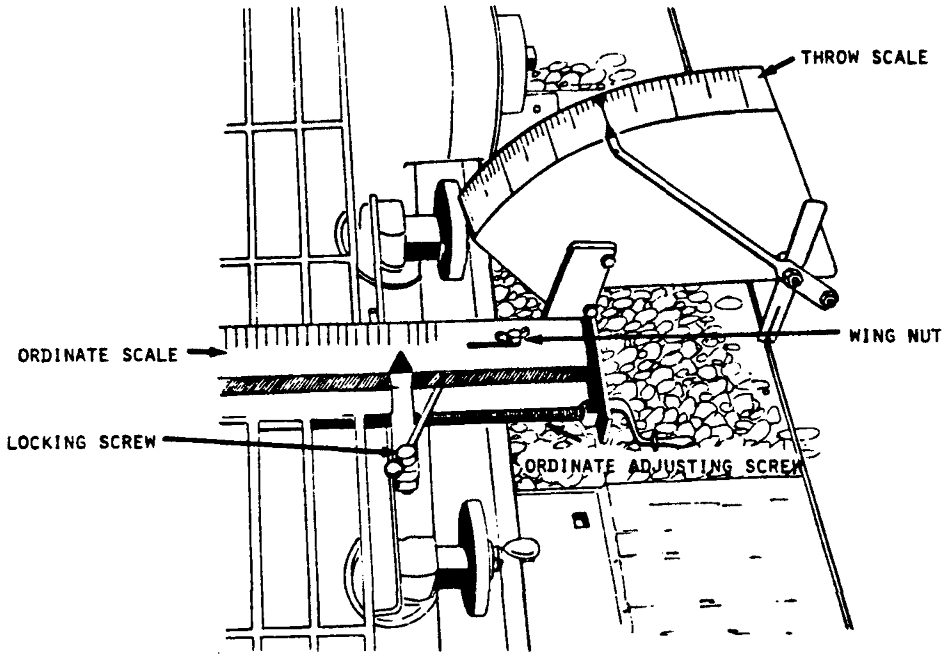


FIG. 20.

- Turn the adjusting screw until the wire passes over the zero on the gauge.
- Tighten the locking screw.
- If the ordinate scale does not read "Zero", loosen the wing nut that holds it in place and adjust to zero then tighten the wing nut.
- The ordinate scale should always be locked at zero for tangent track.
- Move along the track and stop at each quarter rail length and check the indicator throw scale reading. If the reading is not at zero, the track must be lined until the reading is zero.

7. LINING TRACK WITH THE NORDBERG AND FAIRMONT LINERS

During Operation

If the throws are always in the same direction and are increasing one of the following mechanical items may be the cause. Check that the wheel springs on all three buggies are towards the line rail.

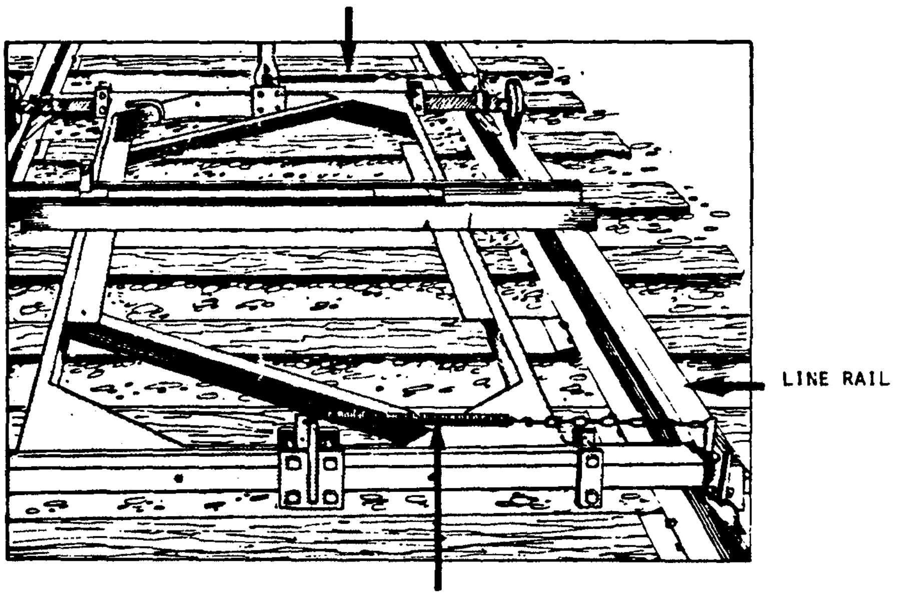


FIG. 21.

- Check the wire position on all three buggies.
- Check the telescoping axles on all three buggies to be sure that they are locked.

7. LINING TRACK WITH THE NORDBERG AND FAIRMONT LINERS

During Operation (Cont'd)

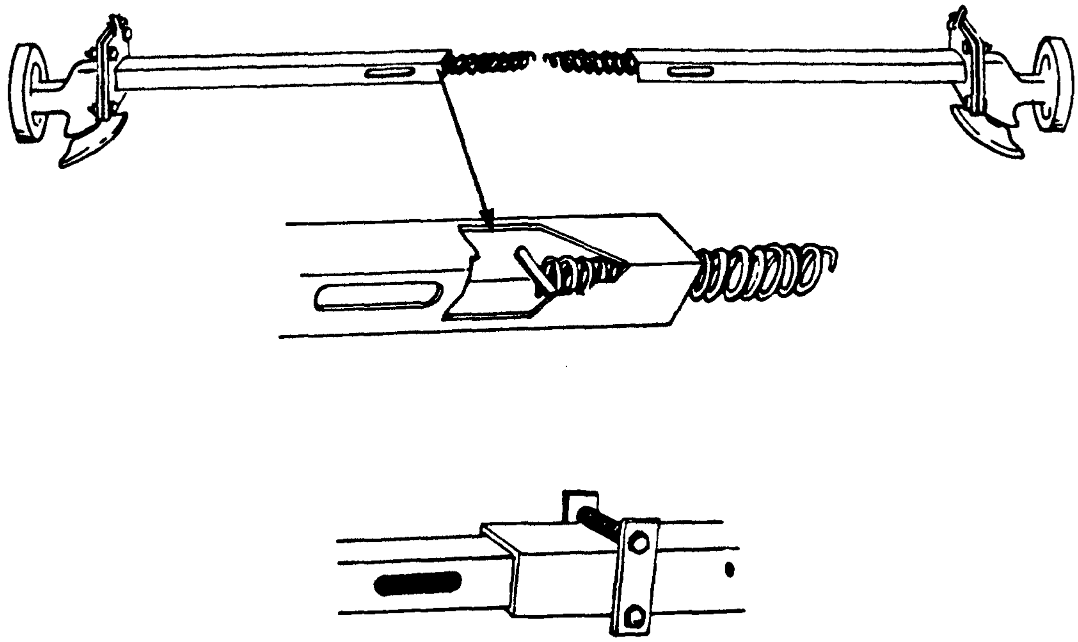


FIG. 22 - AXLE ASSEMBLY ILLUSTRATING SPRINGLOAD TELESCOPIC CONSTRUCTION.

In Windy Conditions

If strong winds are moving the wire too much set the wire reel at an angle of approximatley 10° instead of 30°.

Caution Do not pull the wire so tight that any of the guide rollers on the front buggies lose contact with the rail. In some cases it may be necessary to remove one or two spacer buggies.

Lining Track using the Fairmont Track Liner

The Buggy set-up is the same as when using the Norberg lining unit except that the wire line indicator is fastened to the long draw bar and is placed in front of the track liner. The operator is facing to the front.

7. LINING TRACK WITH THE NORDBERG AND FAIRMONT LINERS

Lining Track using the Fairmont Track Liner (Cont'd)

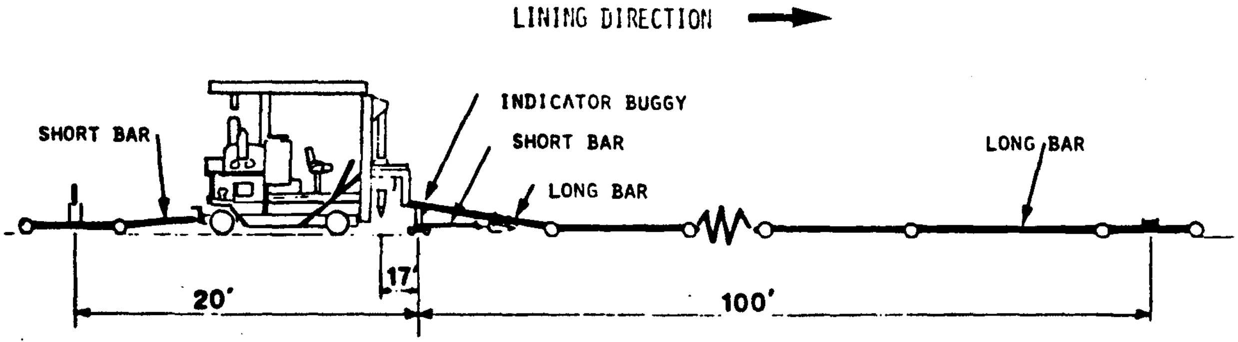


FIG. 23 - BUGGY SET UP ON FAIRMONT LINER

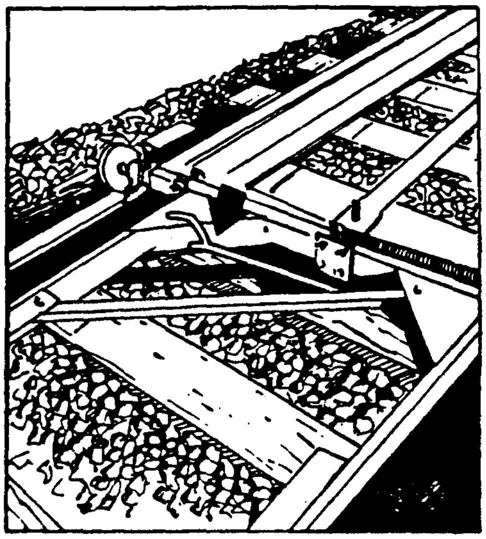
Lining Track Using the Kershaw Track Liner

The Buggy set up is like the Fairmont set-up. However the wire line must be offset 12" from the gauge side of the rail to clear the outside rail clamps and it is necessary to use an ordinate scale extension so that the pointer will read zero. It is also necessary to use a longer gauge bar.

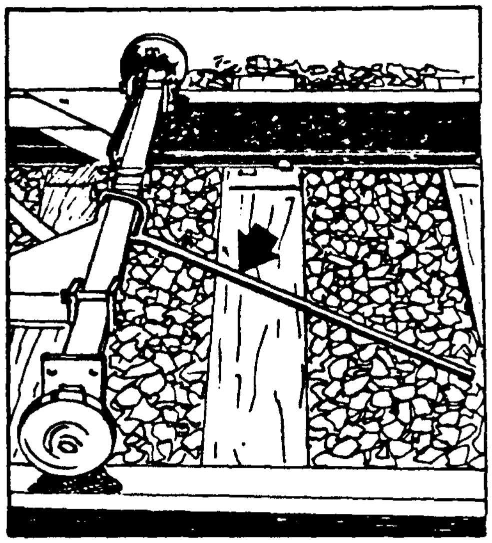
8. LINING TO A FIXED POINT ON TANGENTS

To line into a fixed point such as a railway crossing, a bridge, or other point that cannot be moved, first move the liner until the front buggy is just past the last point that can be lined. At this point the front and rear buggies are anchored in place with spears which are placed on the cross member of the buggy and butted against a tie.

8. LINING TO A FIXED POINT ON TANGENTS (Cont'd)



SPEAR IN CARRYING POSITION



BUGGY SPEAR

FIG. 24.

Remove all spacer buggies and the two tie bars then proceed to line along the wire at each quarter rail up to the front buggy.

9. LINING CURVES USING A GRAPH

To line curves the curve and the spirals must be plotted on a graph. Figure 25 shows how to plot a simple curve of two degrees.

9. LINING CURVES USING A GRAPH (Cont'd)

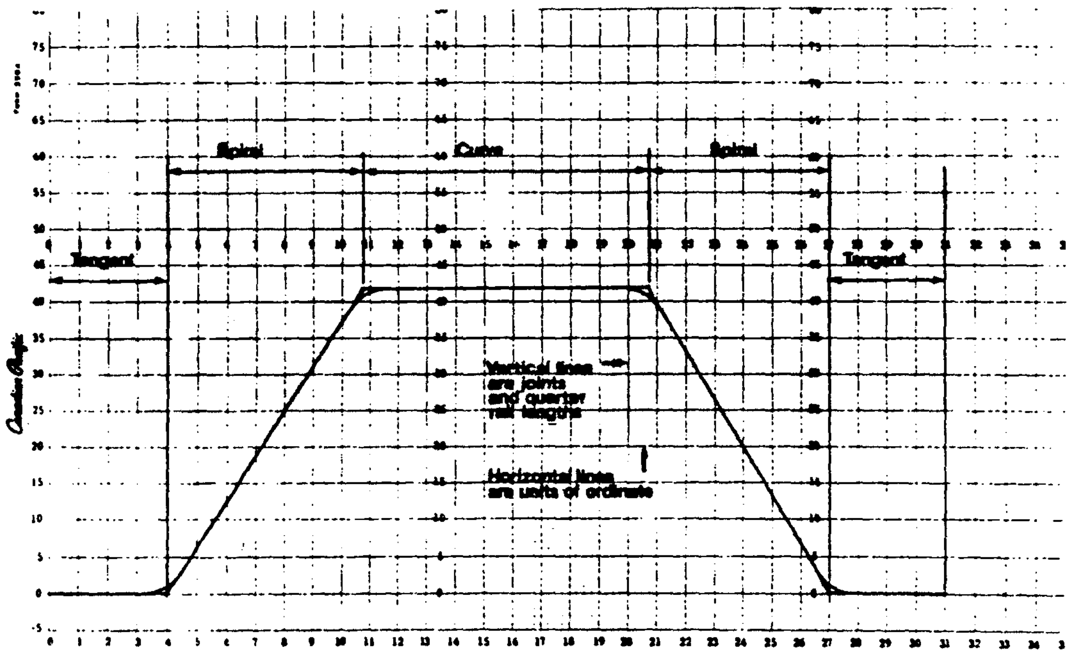


FIG. 25.

The vertical lines on the graph represent joints and quarter rail lengths (stations) while the horizontal lines are called units. The numbers are the readings from the ordinate scale on the indicator. A sheet of graph paper used in the field has room for 40 joints or stations and 95 units. For each degree of curve there are 21 units if five spacer buggies are used. Looking at this graph you can see the line showing the 2° curve runs along the 42 unit line. If the curve is 3° the line will run along the 63 unit line. Since the graph paper has only 95 units you must use another method to line curves 4° 30' (96 units) and over. To do this, remove buggies for curves 4°30' and over, then the number of units per degree of curve changes.

9. LINING CURVES USING A GRAPH (Cont'd)

NUMBER OF SPACER BUGGIES	UNIT PER DEGREE	APPROX. MAX. DEGREES OF CURVE
5	21	4°
4	17½	5°
3	14	6°
2	10½	8½°

FIG. 26.

Example: A 6° curve uses three buggies and the number of units per degree is 14, therefore 6 x 14 = 84 and the curve line would run along the 84th unit line.

- In the lesson on track geometry we said that a spiral is an easement into a curve. Actually, the spiral is a length of track on which the curvature changes evenly from straight to the full curve, from the full curve to straight, or between two curves. This allows us to change the super-elevation from zero on straight track to full elevation on the curve, and still have the elevation at that point match the curvature at that point.

This graph shows a desirable curve but when you plot an actual curve in the field it looks like this.

9. LINING CURVES USING A GRAPH (Cont'd)

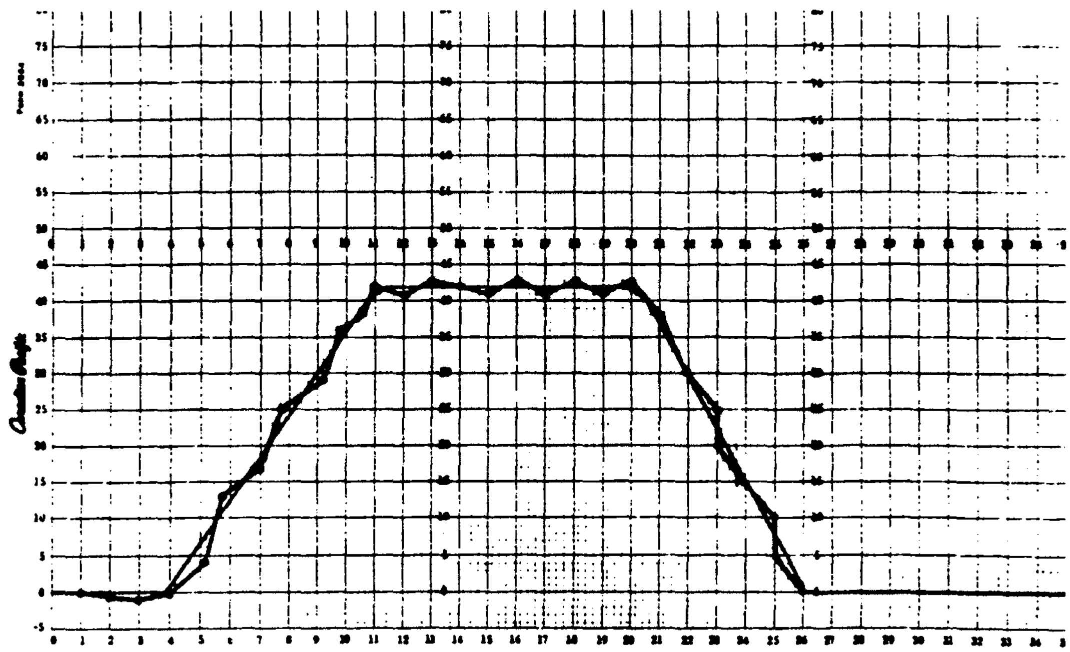


FIG. 27.

To make a good riding curve you simply draw a line half way between each peak and valley on the spiral portion of the plot of actual ordinates. Remember to round off the desired spiral ordinate plot into the tangent and into the average ordinate selected for the full curve. This will give a smooth riding curve with a minimum of throw.

"Remember that as originally laid out, the plot of ordinates in the spiral was not a round curved line, but a straight slope with the zero end at the point where superelevation is required for the curve. Therefore, if the curve is shifted so that the the rate of rise of superelevation goes "out of Synchronization"

9. LINING CURVES USING A GRAPH (Cont'd)

with the rate of increase of the spiral ordinates, the result will be a bad riding spiral and it will be necessary to shift allignment or superelevation, or both to make them correspond, if ride quality is to be restored.

10. LINING STANDARD CURVES

Line tangent for at least five rails approaching the curve. Then continue to line with zero ordinate until the throw scale pointer shows that a minus reading or "in throw" or five units is necessary. You now back up two rail lengths or to the second joint back and begin to read and plot ordinates using the joints on the low rail as stations. At each station, position the liner so that the indicator is at the joint. Then, turn the ordinate adjusting screw until the pointer on the throw scale reads zero.

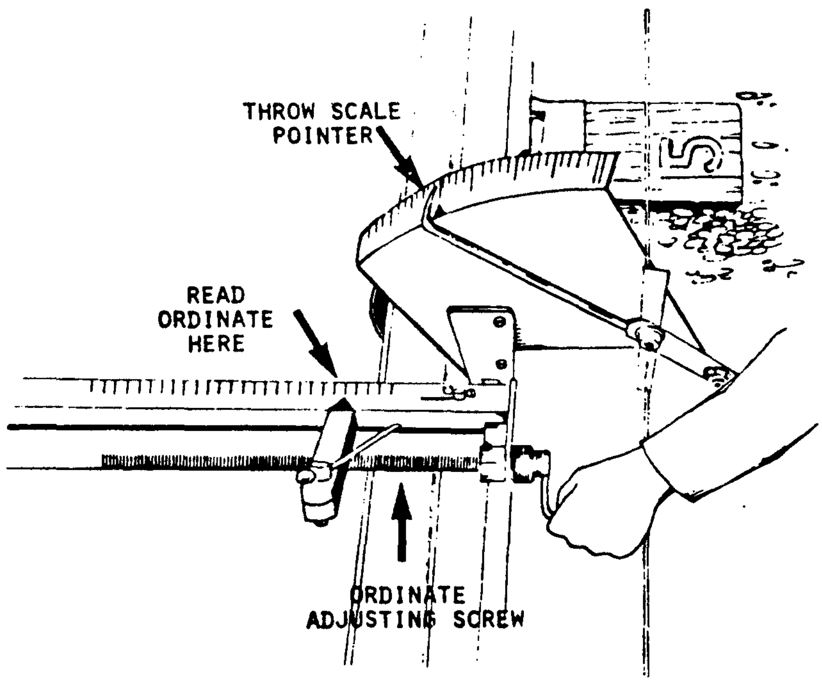


FIG. 28 - SETTING ORDINATE READING.

Plot this ordinate reading on the graph at the proper station. Then continue reading and ploting the ordinates through the spiral, marking each joint or station number on the tie.

10. LINING STANDARD CURVES (Cont'd)

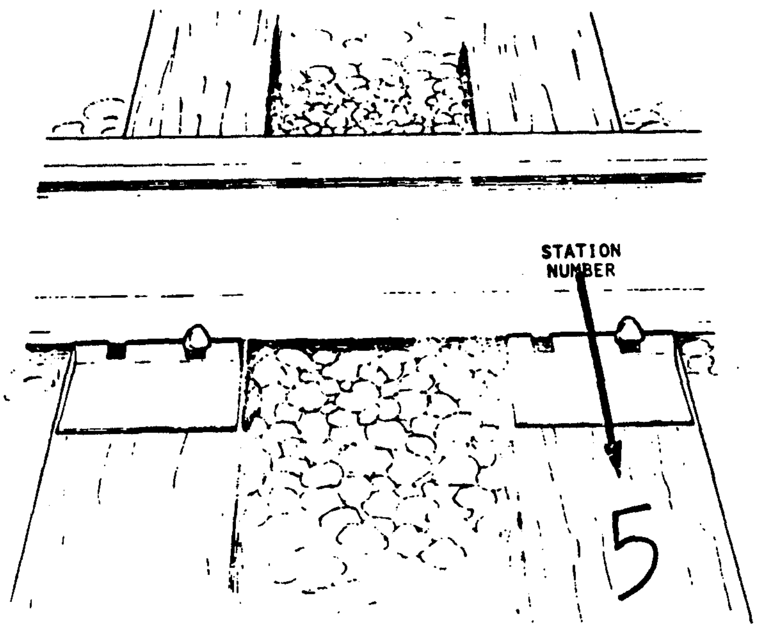


FIG. 29 - NUMBERING JOINTS.

When the ordinates begin to give a flat curve, (a straight line on the graph) the body of the curve has been reached.

When you have finished plotting the curve, select an average ordinate for the full body of the curve. Set this ordinate on the scale and move the machine slowly around the curve. The pointer of the throw scale should move about the same distance on each side of the zero, the average is then correct.

When the complete desired ordinate has been drawn for the curve, move the lining unit back to station zero "0". Start around the curve again and as the track liner reaches each lining point, (every 1/4 rail) the correct ordinate is set on the ordinate scale. If the pointer on the throw scale is not at zero, the track must be lined until the pointer is on zero. Continue this operation until you reach the full body of the curve. Then lock the ordinate scale at the average ordinate for the full body of

10. LINING STANDARD CURVES (Cont'd)

the curve and line the curve. When you reach the leaving spiral unlock the ordinate scale and place the desired ordinate on the ordinate scale and keep lining until you reach a zero reading. When you reach the zero reading, lock the ordinate adjusting screw and continue to line the tangent.

11. COMPOUND CURVES

Compound curves are curves that turn in the same direction but have different degrees of curvature. The reason for this is usually to find the best route for the track. There is a spiral between each curve on a compound curve. The fact that there is a compound curve is readily noticed using the line indicator, because the average ordinate changes. Where this change occurs is the location of the spiral between the two curves. Plot a new curve on the graph.

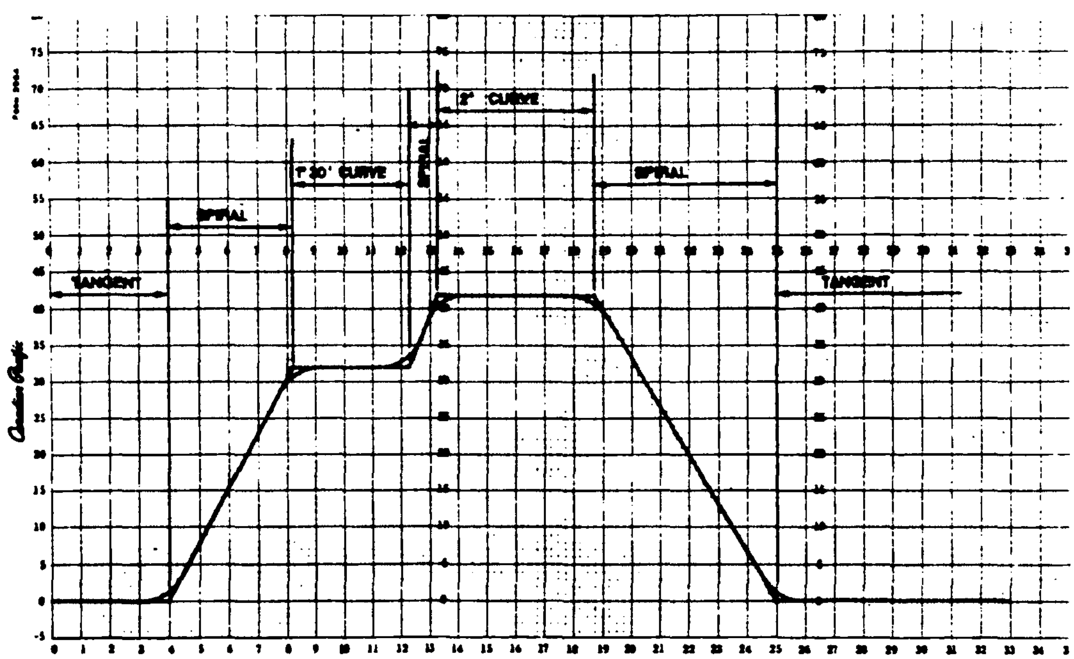


FIG. 30.

12. <u>REVERSE CURVES</u>

Reverse curves are two consecutive curves turning in different directions. The length of tangent between the two curves should be at least two rail lengths. However, you will run into situations where the tangent between the reverse curves is much shorter. Such a pair of curves would be made as follows:

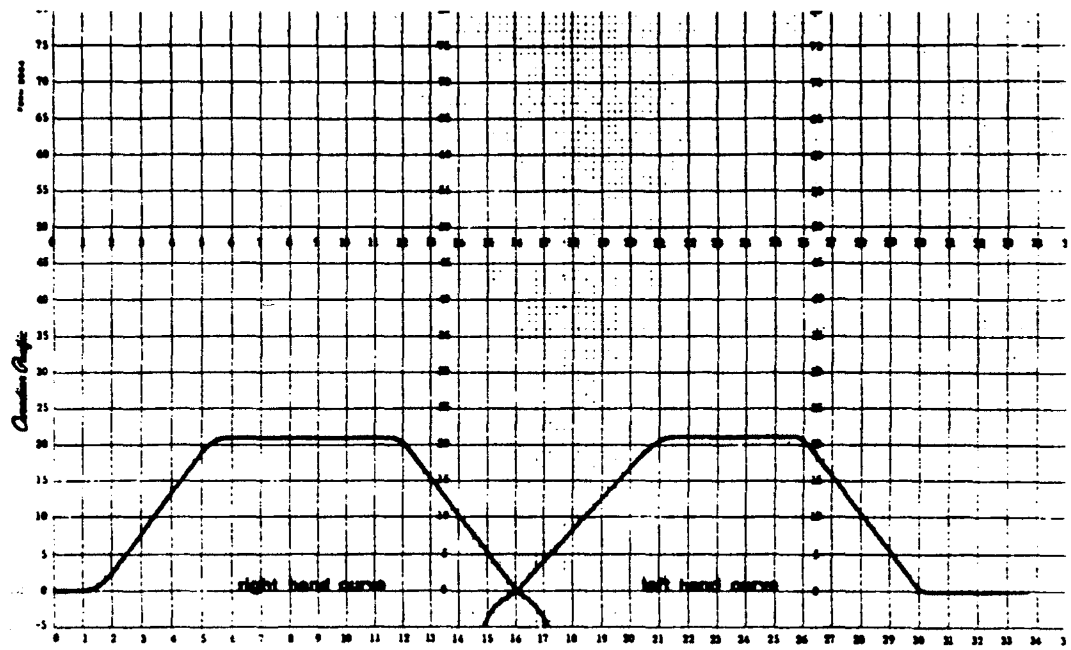


FIG. 31.

Plot the first curve as usual and when you reach the end of the spiral continue reading until the indicator buggy reads zero. The front buggies, however, will be already on the left hand curve, but you see on the graph that minus readings start at station 16 and the curve plots overlap. This is caused by the minus readings. As soon as the indicator buggy is at zero, reverse the line indicator buggies to allow the wire to be on the low side of the second curve.

12. REVERSE CURVES (Cont'd)

To plot the second curve start where the ordinate is as great as possible in the minus direction. This will be on the tangent or even on the leaving spiral of the first curve.

The numbering of the stations may be carried out from the first curve into the second curve. This method will give a smooth transition from one curve into the next regardless of the length of tangent between them.

13. PLOTTING FIXED POINTS ON A GRAPH

When bridges or road crossings are found in a curve and cannot be moved you must make the curve fit the track as it is. In order to do this more accurately it is recommended that ordinates be read at each 1/2 rail length through the obstruction and for at least two stations on either side of it.

You can see in the sketch below that the desired ordinate would be slightly higher than it would have been without the readings at the half stations.

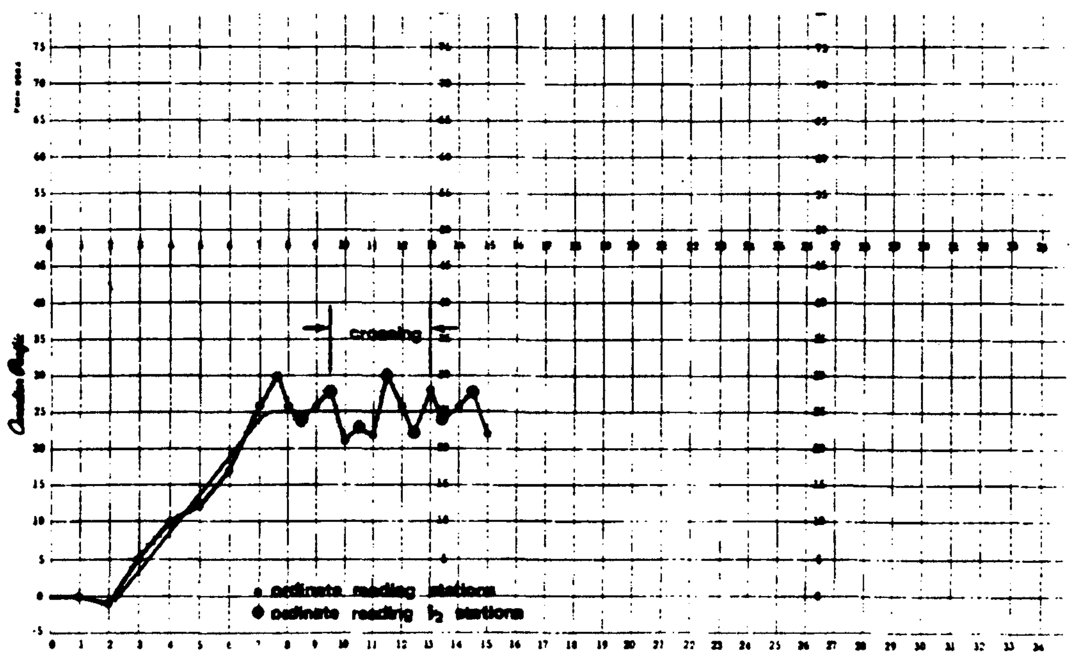


FIG. 32.

13. PLOTTING FIXED POINTS ON A GRAPH (Cont'd)

Another method that can be used is to compound the curve through the obstruction. This in not desirable but doing it using the line indicator will result in a good ride.

14. REMOVING SWINGS

In tangent track the line indicator will remove swings of 300' or less to a point where they will not be detected by eye. For longer swings a lining scope could be used ahead of the liner or you might use more buggies ahead of the liner and use a longer lining wire.

15. SOLVING PROBLEMS IN CURVE LINING

1) When lining into a dog leg curve, always continue lining with zero ordinate until the "in throw" becomes five to seven units.
2) Excessive throws are usually caused by using a straight edge to draw the desired ordinate curve. Use free hand when averaging curves.
3) Other causes include not enough blend (Correction Curve) between tangents and spirals and incorrect average ordinates for the curve.

16. SAFETY PRECAUTIONS

1) When travelling to and from work the line indicator should be carried on the lining unit, on the straddle bracket. Never travel with the indicator attached.
2) Do not attempt to line track when the rail temperature is too high, or in CWR territory when the rail temperature is more than 10° F above the laying temperature. The laying temperature is shown on a metal tag at both ends of each string.

16. SAFETY PRECAUTIONS (Cont'd)

3) Maintain the side clearances as per SPC-3.

4) Maintain the track centre clearances as per SPC-3.

17. MORE ABOUT CURVE CHARTS

In railways we talk about:

BS - Beginning of spiral

BC - Beginning of curve

EC - End of curve

ES - End of spiral

The sharpness or degree of curve on railway curves can be measured by the ordinate. If a two degree curve has ordinate readings of, say 42, then a four degree will read 84. At the BS there is no curve. At the BC we are on the full curve. The spiral between them should increase evenly from no curve to full curve. So the ordinate readings should increase evenly. If there is no spiral the ordinates would go from 0 to the full amount in one measure.

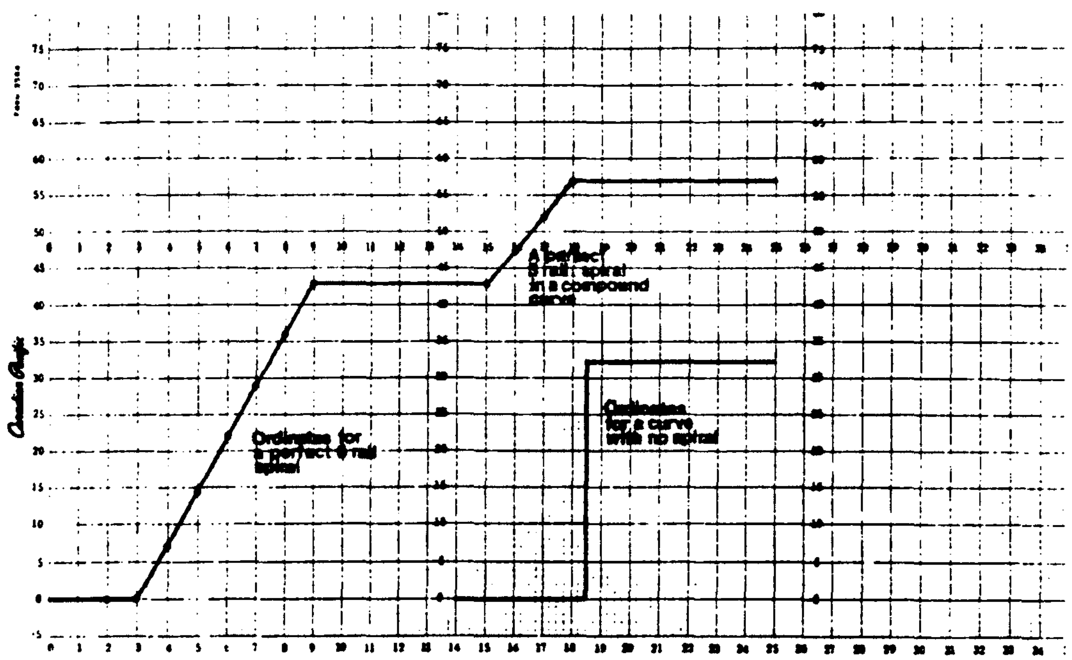


FIG. 33.

17. MORE ABOUT CURVE CHARTS (Cont'd)

The Engineers should mark the curve points with permanent marks or stakes, and the spiral should be drawn to meet them. It won't always look right because often the spiral has gotten out of place.

Sometimes it is hard to make a curve fit without too much lining. Then it may be best to re-draw the graph and re-line part of the curve.

On Figure 34 between joint 12 and joint 21 the ordinate is being decreased so the throw would be inward, but you might get to 28 and find that the throw is still inward and you can see that it's going to get worse.

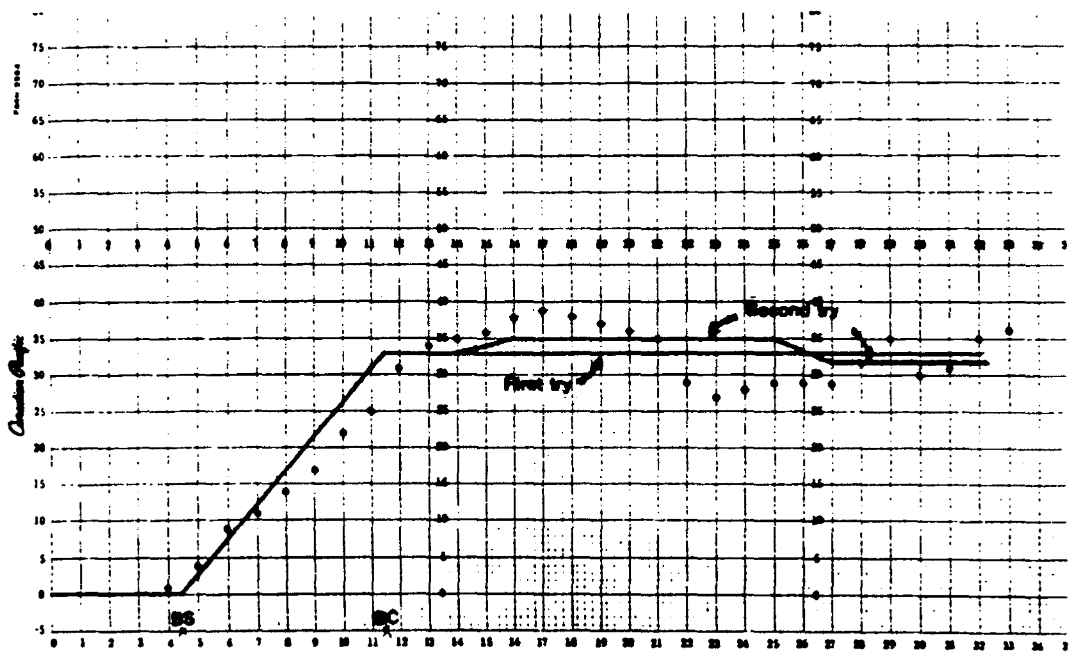


FIG. 34.

17. MORE ABOUT CURVE CHARTS (Cont'd)

All it may need is to back up to, say 15 or 16 and increase the ordinate slightly. Then re-line to this ordinate until the throws become small and then go back to the original line. Or it may be necessary to decrease the ordinate to make up for the increase.

What we try to do is make a circular curve out of an irregular curve.

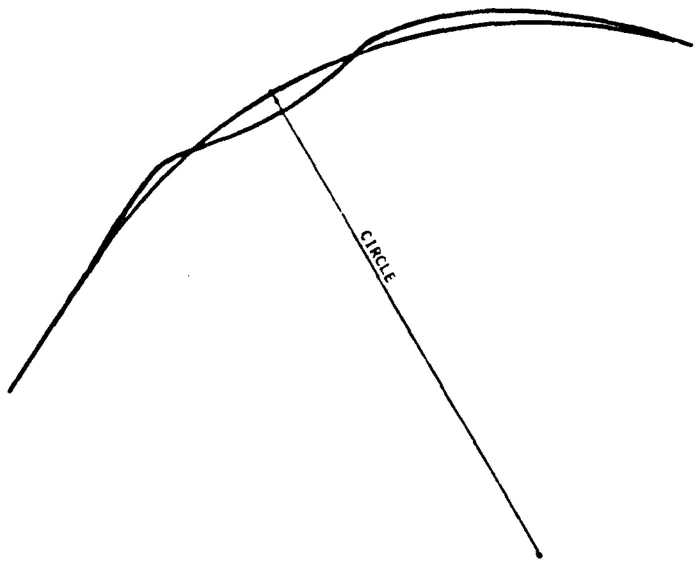


FIG. 35.

17. MORE ABOUT CURVE CHARTS (Cont'd)

But sometimes this happens.

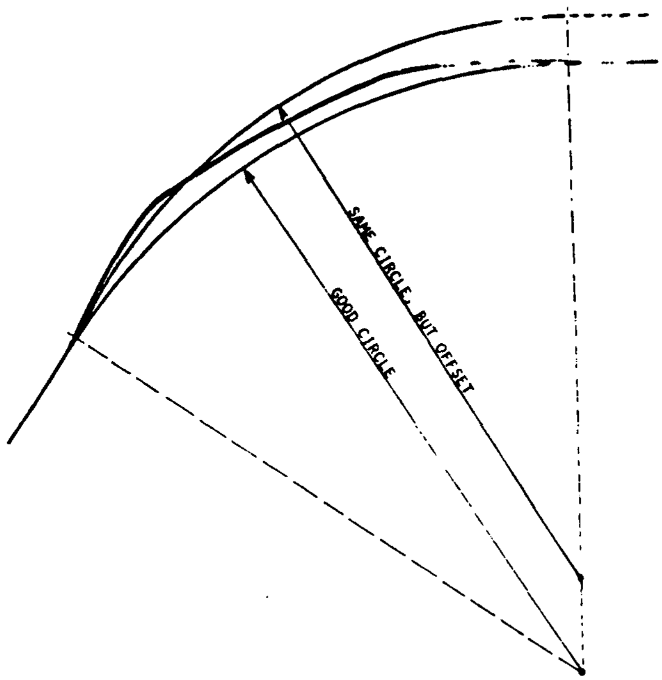


FIG. 36.

The curve is good but has been shifted over and won't come out right at the other end. It can be fixed this way. Increase the ordinates for a bit and then decrease the ordinates, and then come back to the good ordinate. The part where the diagram shows a reverse curve where the ordinates are decreased is not really a reverse curve but, looks that way because the diagram is exaggerated.

17. MORE ABOUT CURVE CHARTS (Cont'd)

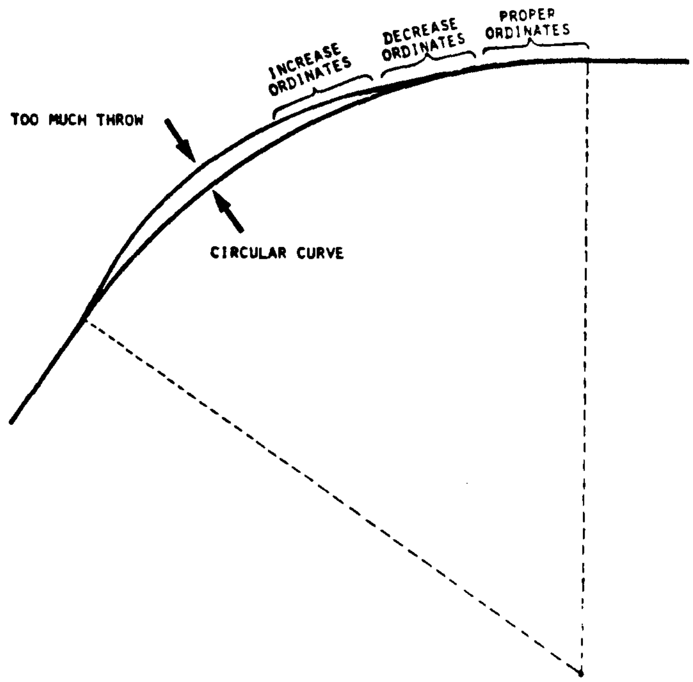


FIG. 37.

Sometimes you'll find curves so bad that they can't be lined properly, so the new graph line has to be drawn to fit the actual curve more than the circular curve. This one is supposed to be a simple curve but has to be lined as if it was compound.

17. MORE ABOUT CURVE CHARTS (Cont'd)

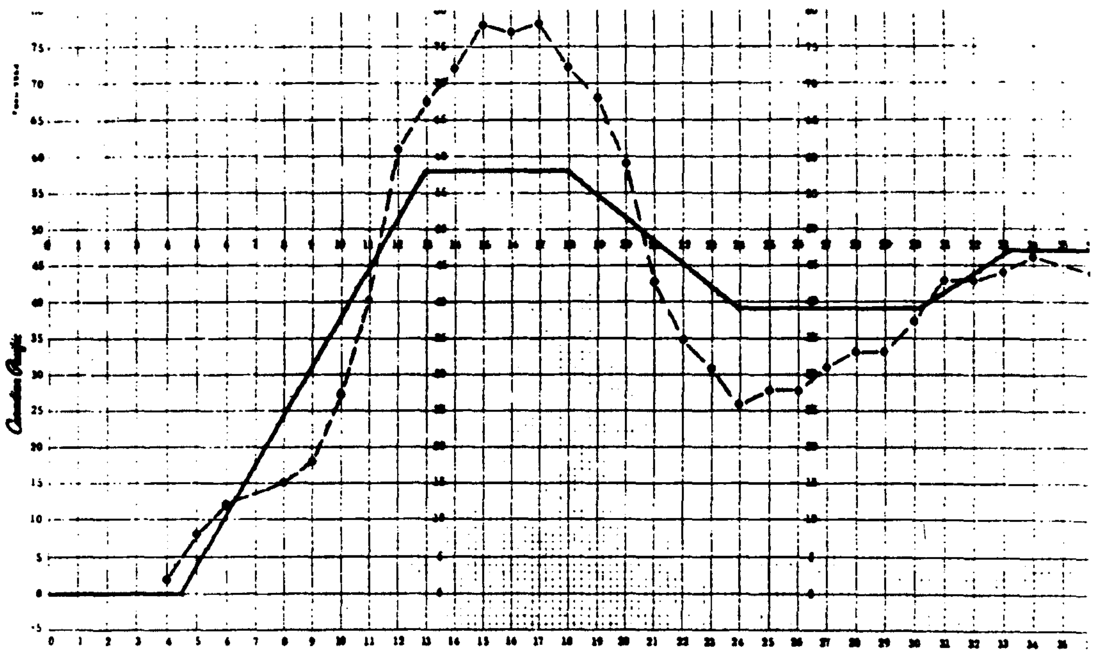


FIG. 38.

We hope that the next time this curve is lined it will be improved again and finally it will be made circular.

You should be given a curve list to tell you the length of the spirals and if the curve is compounded. You should also be given the curve charts that were made the last time the curve was lined.

How to Cheat a Curve in

Another way to fix the end of a curve that doesn't come out right is this. Suppose you come out the end and find the pointer is showing a steady 15 units to throw outward. Back up to the last place where a throw was made and line it back

17. MORE ABOUT CURVE CHARTS (Cont'd)

How to Cheat a Curve in (Cont'd)

(inward) 15 marks. Keep backing up and throwing inward, but reduce the throw, say, two marks per rail until down to no throw. Then re-measure and plot that end of the curve on the graph to make sure you have a smooth curve.

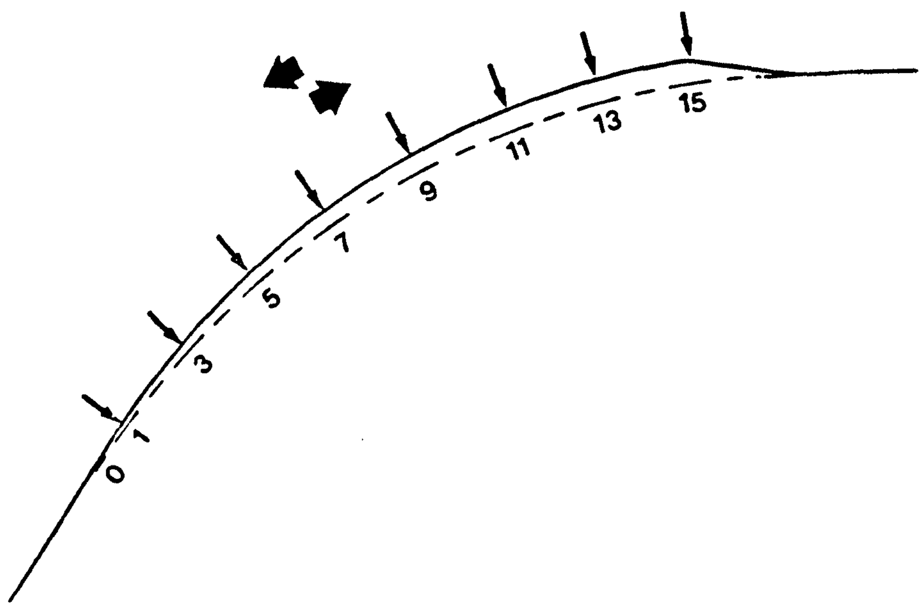


FIG. 39.

The same trick can be used when lining to fixed points such as bridges or crossings. If the curve has been lined before, and you find that you are lining the same amount or nearly the same amount all the way, then you are trying to relocate the curve from where the last liner put it. Then you should try to match your curve up better with the old curve.

The Correction Curve

There is still one more gimmick. Suppose the liner is close to a curve and the front buggy is standing on the spiral. If you take a reading it will show a curve, but the liner is still on the tangent.

17. MORE ABOUT CURVE CHARTS (Cont'd)

The Correction Curve (Cont'd)

Similarly, if the liner is just on the curve, the rear buggy is still on the spiral, so although the liner is on the curve, the ordinate reading would be a little too low.

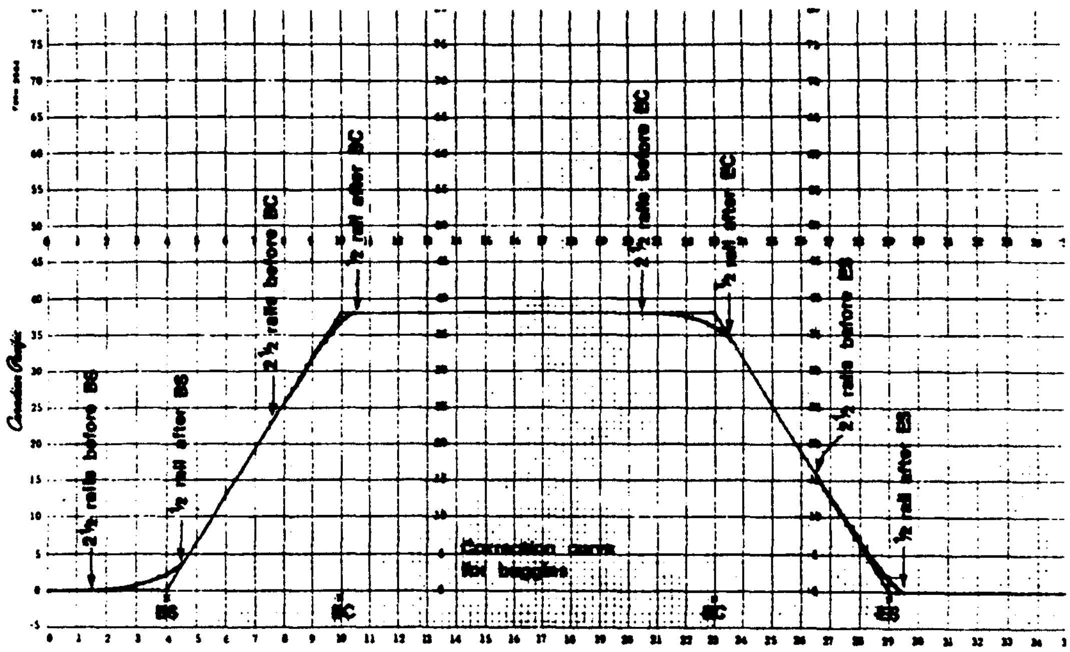


FIG. 40.

So, we take care of this by drawing a little curve, freehand, on the graph. The curve runs from the buggy lengths before the liner to the length after the liner. With normal buggies this correction has to start 2-1/2 rails before the curve point and goes on until the liner is 1/2 rail beyond the curve point. If you are on a sharp curve and have fewer front spacer buggies, then the "before" will be less than 2-1/2 rails. Keep your curve charts in good shape and send them to the Division Engineer for safekeeping. Mark the curve mileage, date and your name on every sheet.

17. MORE ABOUT CURVE CHARTS (Cont'd)

One Curve Rule

If you want to know some more about how the curve graphs work, you might want to remember this rule.

The total of all the ordinates must be the same for the old curve and the new curve. This is true even if the new and old curves are different lengths. If the ordinates don't have the same total, then the curves won't turn the same angle.

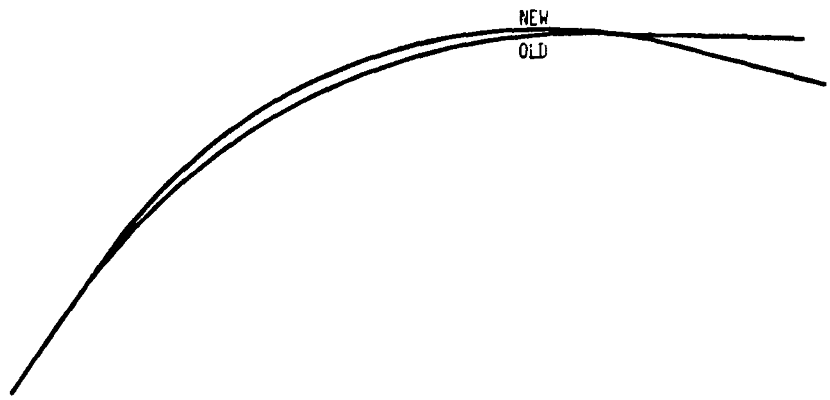


FIG. 41 - TOTAL OF NEW ORDINATES MORE THAN TOTAL OF OLD ORDINATES.

This is the same as saying that the plus and minus areas between the old and new ordinate lines must be the same.

There is another rule that is a bit too complicated to describe, but what it says is that even if the total of the ordinates is the same, the curve can come out with the right angle, but shifted over.

17. MORE ABOUT CURVE CHARTS (Cont'd)

One Curve Rule (Cont'd)

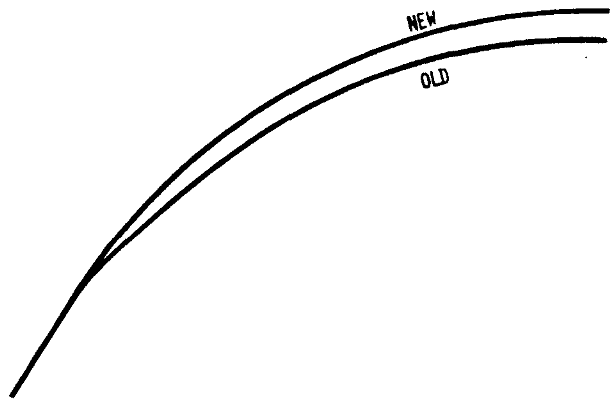


FIG. 42.

The liner operator takes care of that one by adjusting his curve line as he goes so that the throw doesn't become too big.

REFERENCES

Regulations

U.C.O.R.	Nil
R.T.C.	Nil
Railway Act	Nil
Provincial	Nil

TECHNICAL REFERENCES

M/Way Rules	Nil
S.P.C.'s	- 3
Standard Plans	Nil
Other	Nordberg, Kershaw & Fairmont

CP
Rail

Maintenance of way training

Lesson 110
Subject: VISUAL & SCOPE LINING

First issued: 79-03-16
Revised: 80-02-12

Maintenance
of way
training

INTRODUCTION

Poor line causes rough ride, wear and tear on rolling stock and excessive wear on the rail, especially on curves. If poor line is not corrected it could develop into an unsafe condition that will have to be protected with a slow order and thus delay traffic. It is important to remember that line, gauge and level all work together or else all work against each other. If track gets out of level a train will lurch into the out of level spot and if this goes on long enough the pressure from the lurching cars will cause the track to go out of line and the gauge to widen.

Don't be fooled into thinking that you can't become a good track liner. With practice and by following a few simple rules you can become a very good track liner. It is true that we have lining machines to do most of the lining but there are many times that you will have to line a piece of track by eye or with a lining scope. To become a good track liner you must:

1) Want to be a good liner.
2) Must know how to line.
3) Not be satisfied with anything less than good line.
4) Learn from your mistakes and avoid repeating them.

Lining Tips

1) Dark or coloured glasses cut down the glare and make it easier on your eyes.
2) Cloudy days are best for lining, however whether cloudy or clear it has been found that lining facing towards the sun is best because you can see the rail better.

2. DESCRIPTION OF OUT OF LINE TRACK

Spotting out of line track on tangents is no problem since good line on tangents is a straight line. However, don't confuse

2. DESCRIPTION OF OUT OF LINE TRACK (Cont'd)

wide gauge with poor line. To tell the difference you look at both rails and if one rail is out of line and the other is in line then the problem is poor gauge not poor line.

Poor line on tangents could be short kinks or long swings. Short kinks should be corrected as soon as possible as they cause a rough ride. Long swings, on which trains ride satisfactorily should be left until an instrument is available to correct them. The wire lining machines will fix them eventually, after several passes.

Line on curves is more difficult to spot than on tangents, however there are several ways to check for poor line on curves:

1) Watch for movement of ties.
2) Watch for lurching of the cars when trains go around the curve. Stand on the inside of the curve.
3) Look for uneven rail wear.
4) Check with the train crews and ask them how the track is riding.
5) Check the gauge of the track.
6) By eye.

Line on curves is very important and to keep good line you must keep sound ties, (hardwood ties are best for curves) keep sufficient ballast in the cribs and on the shoulder, keep the track well surfaced and finally the gauge of the track must be good.

2.1 Causes of Poor Line

The most frequent causes of poor line are:

- Low joints, soft track, poor cross level and improper elevation will cause the track to go out of line because of the lateral forces that they cause.

?.1 Causes of Poor Line (Cont'd)

- Poor tie conditions and lack of ballast in cribs and on the shoulder make for a weakened track structure which cannot hold the track in line.
- Tight steel and frozen joints will not allow the rail to expand or contract properly and this will cause line kinks.
- Lack of rail anchors allowing the rail to creep and the ties to bunch up will cause kinks.
- Frost heaving - acts the same as out of surface track. Often one side of the track will heave more than the other side and will move the track out of line.
- Excessive speed and the irregular motion of rolling stock will play havoc with the track line. Elevation on curves is set for a certain track speed and if trains exceed this speed, too much force is applied to the high rail forcing it out of line.
- Crossings are another source of trouble for surface and line. Heavy traffic and equipment tend to move the crossing out of line. Trucks and cars put on their brakes at the crossing, this gradually moves the crossing. Very often one end of the crossing is moved in one direction and the other end is moved in the opposite direction. To reduce this keep the crossing smooth so the traffic will not have to apply brakes.

3. GENERAL DESCRIPTION OF LINING PROCEDURES

More track is lined each year by a foreman and two men using lining bars and track jacks or Sinning liners than is generally realized. The lining gang might consist of anywhere from 2 to 16 men depending on the weight of the rail and the type of ballast. Too many men on the gang can result in overthrowing the track causing loss of time, so make sure you have the right number of men.

3. GENERAL DESCRIPTION OF LINING PROCEDURES (Cont'd)

Your first duty as a foreman is to teach your men safe practices. Show them how to line with the strain on their legs, not on their back.

Teach them to pull with their knees bent and their back straight to prevent back injury. Never let a man straddle the lining bar, have him pull with both feet on one side of the bar. One foot should be well back so he won't fall if the bar slips.

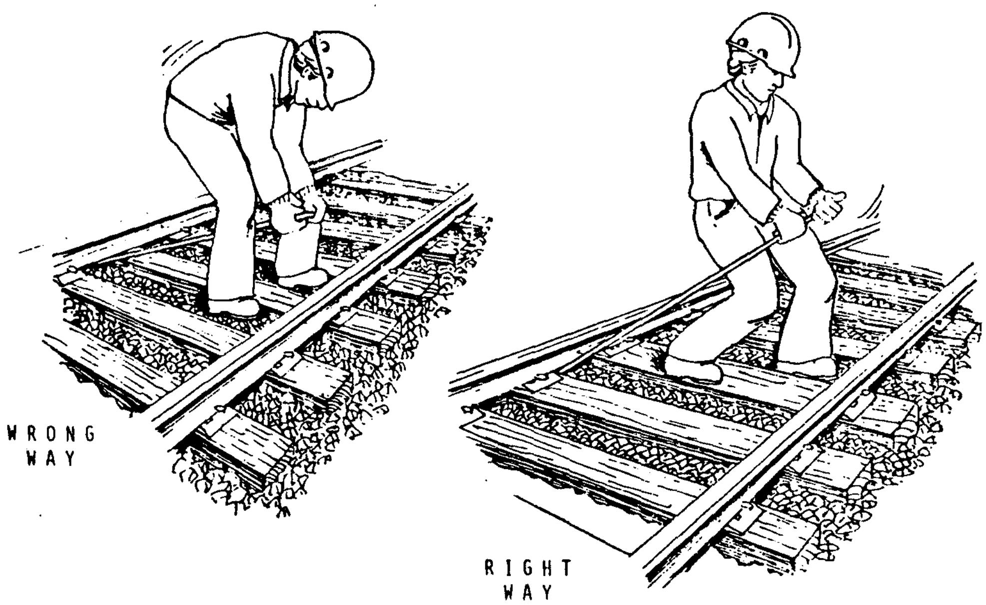


FIG. 1 - USE OF A LINING BAR.

The lining bars should be stabbed into the ballast under the rail. The bars push against the base of the rail and they should be sloped, but not so much that they lift the track. The pull on the bars should be steady without jerking.

Never let a man carry a lining bar over his shoulder where it could strike a man following too closely behind.

3. GENERAL DESCRIPTION OF LINING PROCEDURES (Cont'd)

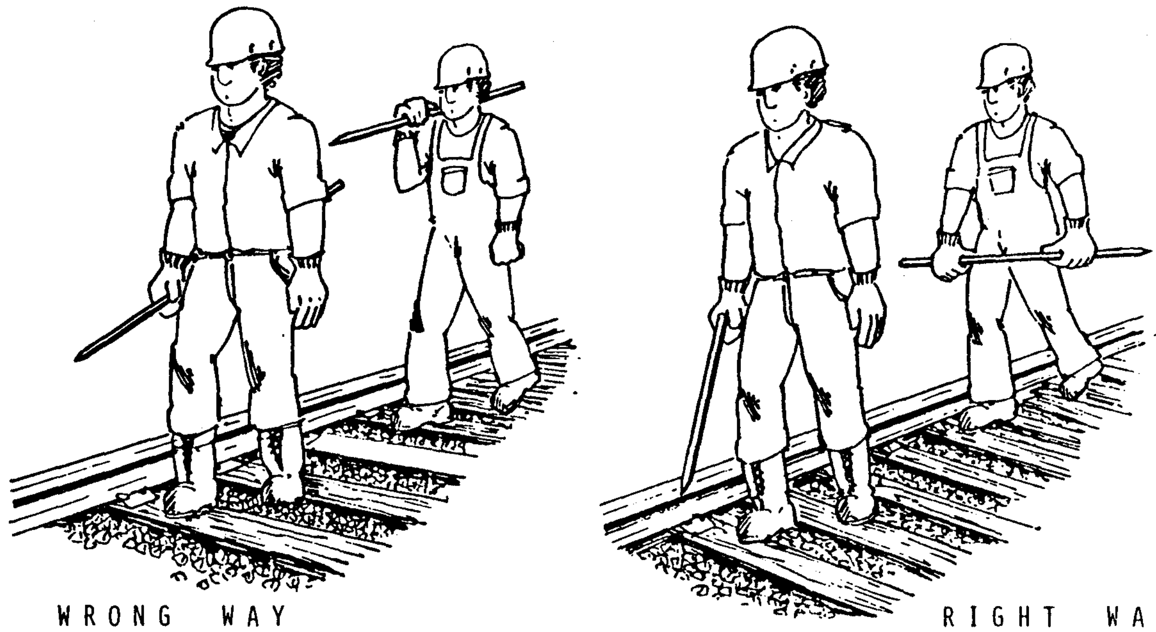


FIG. 2 - CARRYING A LINING BAR.

3.1 Lining With A Sinning Liner

When lining with a Sinning liner the ballast must be dug out so that the liner can be placed under the rail at an angle. With the liner at an angle it will push the rail rather than lift it.

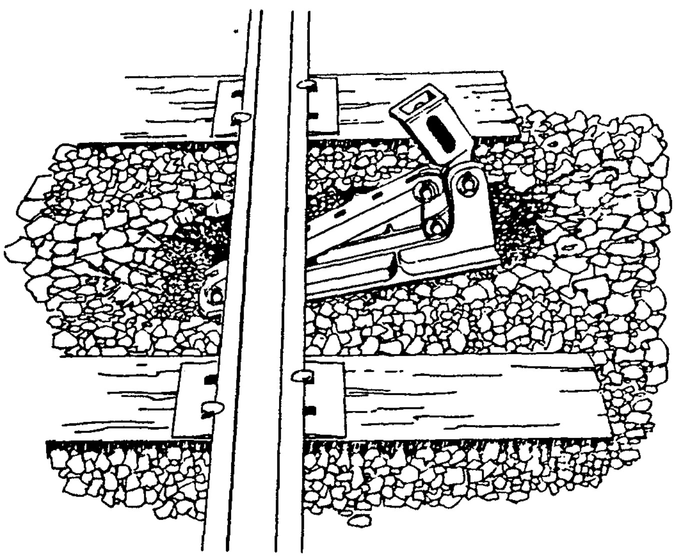


FIG. 3 - LINER POSITIONED UNDER RAIL.

3.1 Lining With A Sinning Liner (Cont'd)

When placed inside the rail the liner is positioned as shown in Figure 4.

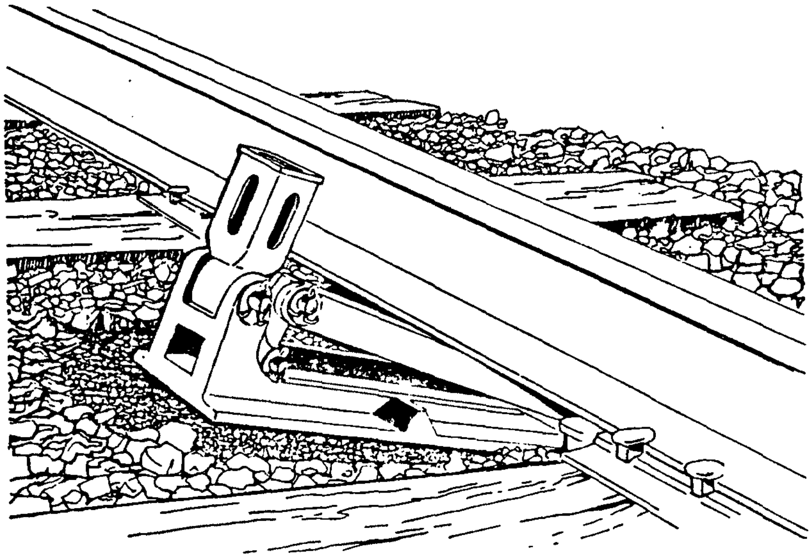


FIG. 4 - LINER PLACED FOR LINING.

The bar is put into the liner so that it is in an upright position.

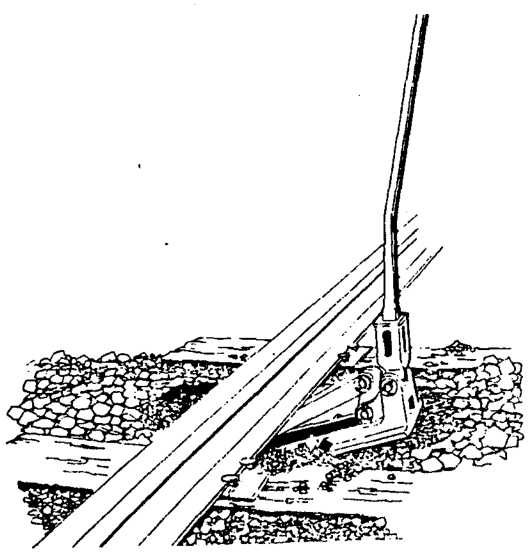


FIG. 5 - LINER AND BAR IN POSITION.

When three Sinning liners are used together, one liner is on the rail in the direction of throw and 2 liners are on the opposite rail both of them at an equal distance from the single

?.1 Lining With a Sinning Liner (Cont'd)

liner. On a signal from the foreman, the men operate the liners together.

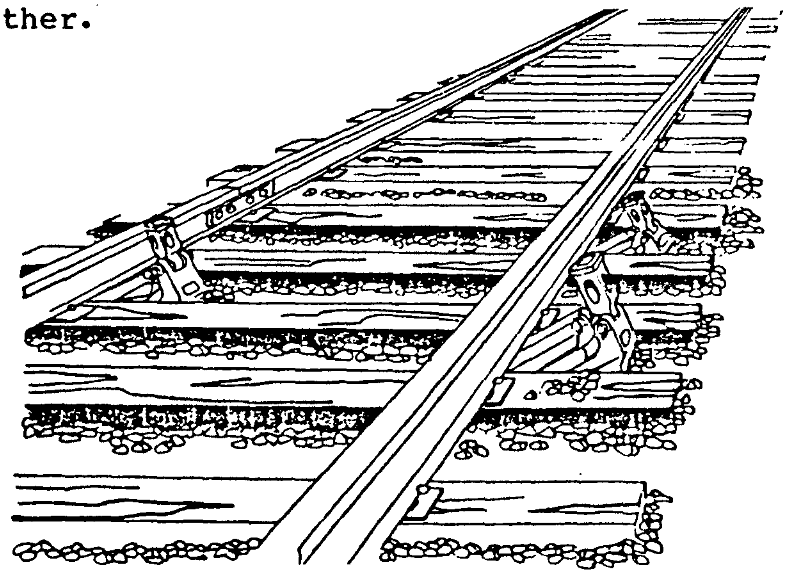


FIG. 6 - THREE LINERS IN POSITION.

If the inside liner is above the top of the rail then there must be protection.

3.2 Lining With Track Jacks

A lot of lining is done by two or three men using track jacks. Many foremen file a small notch in the lifting head of the jack so that it will catch on the base or head of the rail.

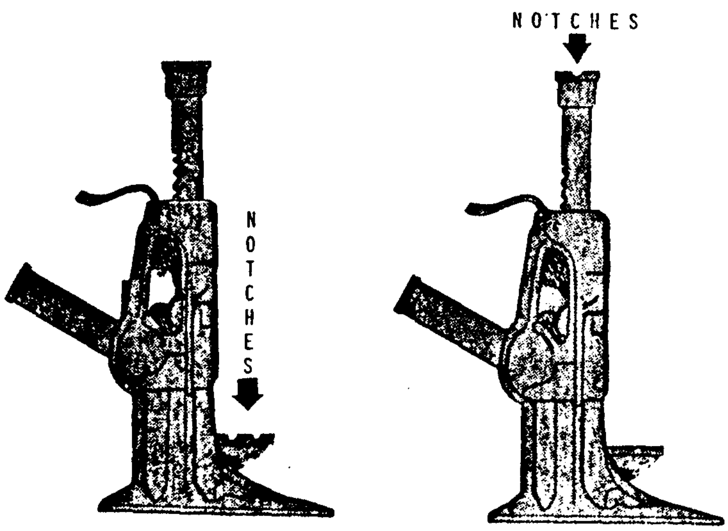


FIG. 7 - NOTCHES IN TRACK JACK.

3.2 Lining With Track Jacks (Cont'd)

One scoop of a shovel or a few stabs with the bar will make a seat in the ballast big enough to take the jack base.

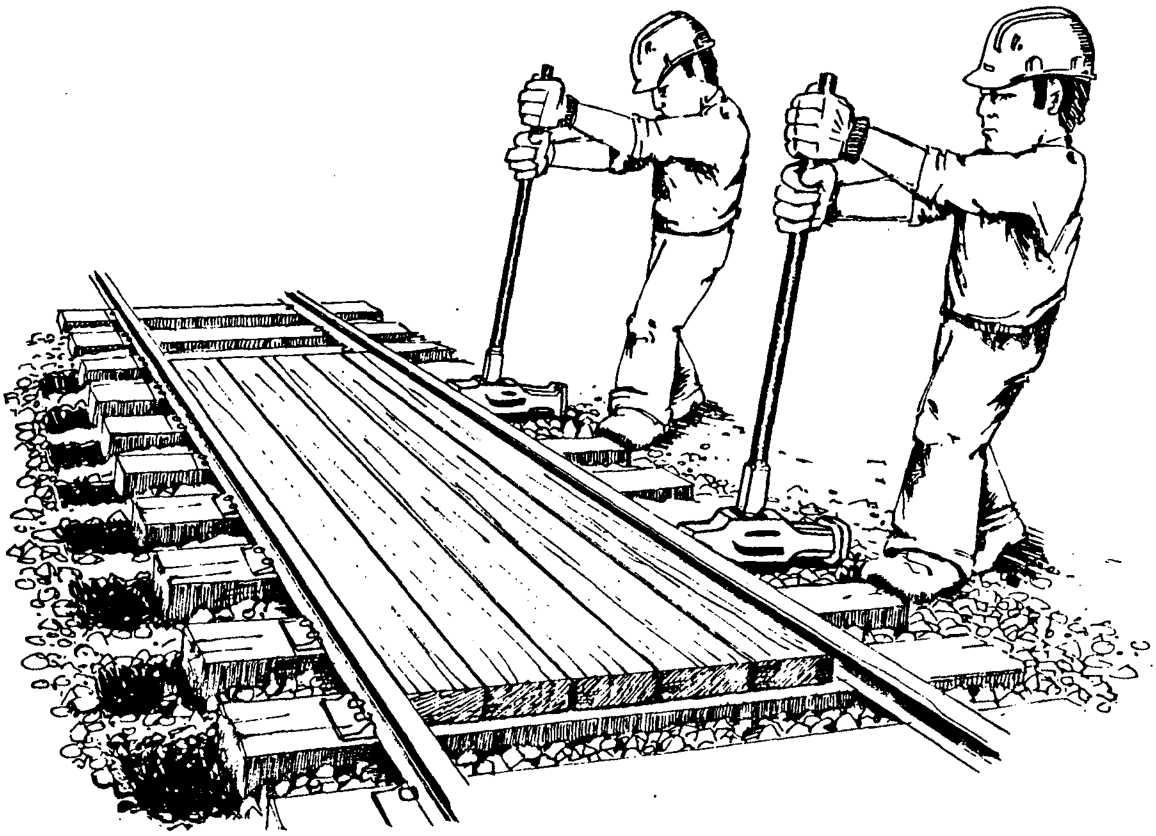


FIG. 8 - LINING A CROSSING.

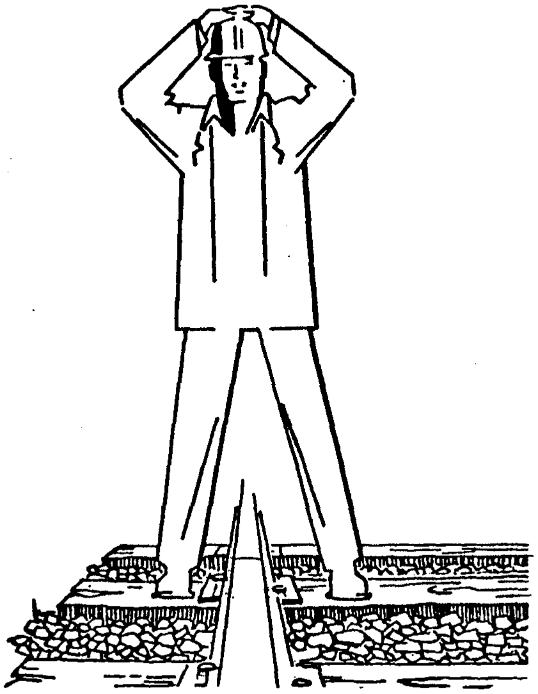
4. HAND SIGNALS

Save your voice, use hand signals. If you are calling out to your crew all day, when you are over 100' from them, when it is windy or if there are noises in the working area, you will be pretty hoarse before the day is done.

Before you start lining make sure your lead man and your outside man know the following hand signals.

4. HAND SIGNALS (Cont'd)

JOINT - HANDS JOINED TOGETHER ABOVE HEAD.



JOINT - JOINT TO BE MOVED TO THE RIGHT.

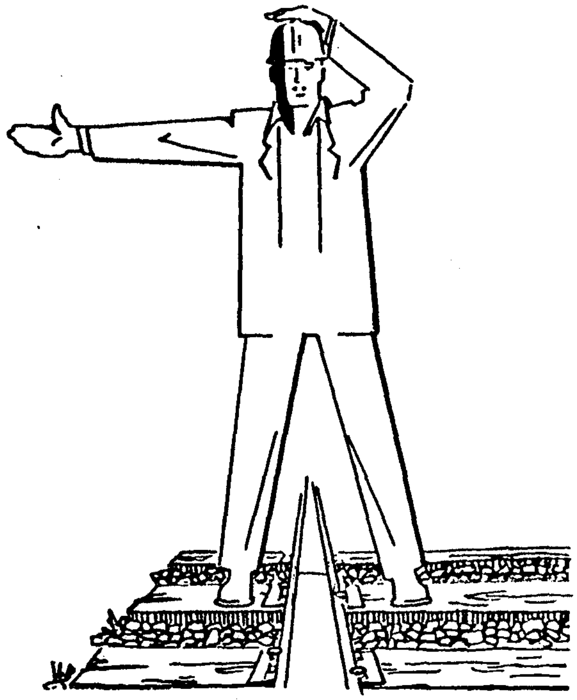
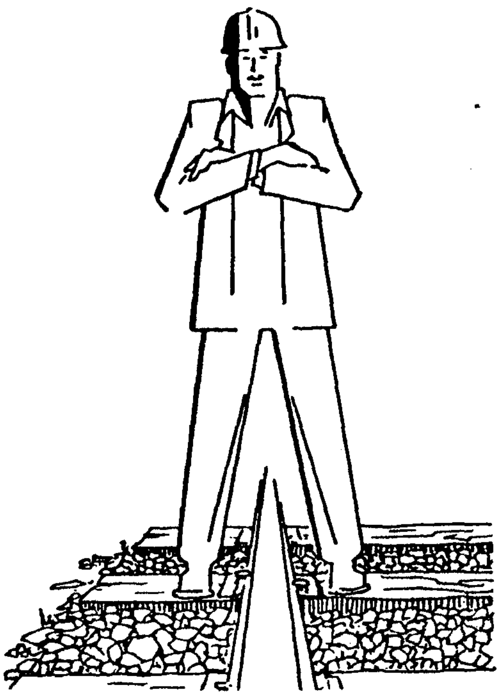


FIG. 9.

QUARTER - CROSSING THE FOREARMS. SAYS GO TO THE QUARTER WHICH IS MIDWAY BETWEEN THE JOINT AND THE CENTRE OF THE RAIL.



QUARTER - QUARTER TO BE MOVED TO THE RIGHT.

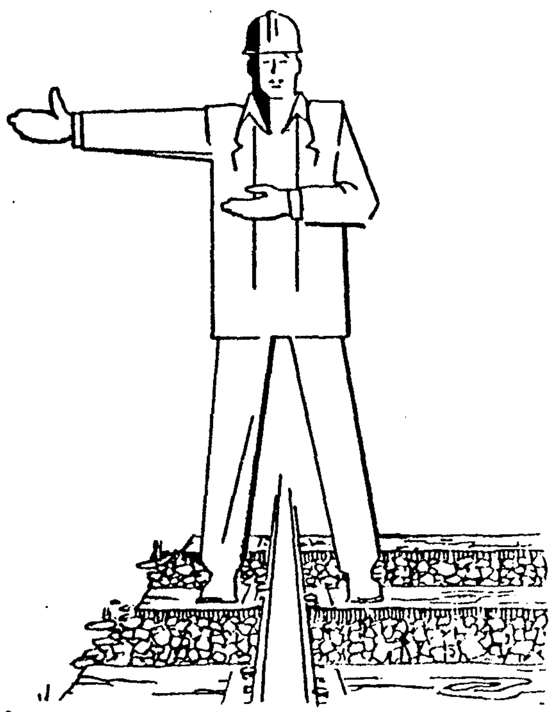
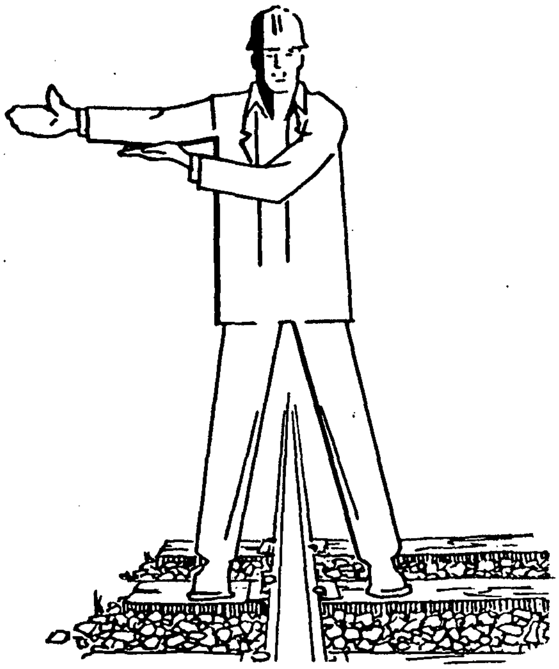


FIG. 10.

4. <u>HAND SIGNALS</u> (Cont'd)

<u>CENTRE</u> - TOUCHING THE ELBOW WITH THE HAND AND POINTING SAYS THE CENTRE OF THE RAIL AND DIRECTION OF THE THROW.



<u>FORWARD</u> - ARM OUTSTRETCHED INDICATES FOR THE MEN TO MOVE FORWARD.

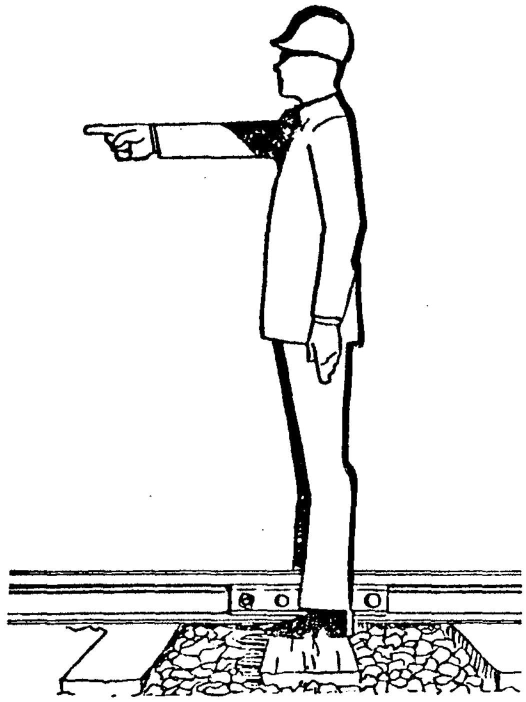


FIG. 11.

<u>MOVE BACKWARD</u> - BOTH ARMS INDICATING A SEMI-CIRCLE SAYS TO THE MEN TO COME BACK.

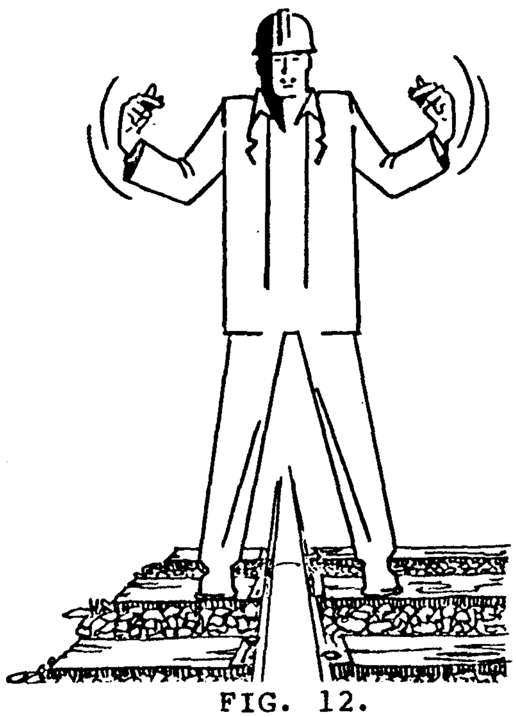


FIG. 12.

LINE RAIL

On tangent track the south or east rail is the line rail, except on double track use the outer rail (the same side as the tie ends are lined). On curves the line rail is the outside or high rail.

6. THE LEAD MAN

One man in the crew should act as "lead man". He should be at the head of the gang and farthest from the foreman. His job is to watch for the foreman's signal. As soon as he sees the foreman's signal he moves to the next throw point and the rest of the gang follows his lead. A good lead man is worth his weight in gold so you should not be satisfied until you find a good one. Either the lead man or someone else should call out "yo HEAVE" so that all the gang will pull at the same time. The caller will determine whether you have a good lining gang or not, so pick out a good man with an instinct for leadership. The outside man in the gang is the man closest to the foreman. In large gangs the lead man may not be able to see the foreman so the outside man watches for signals and calls out the location of the next throw to the rest of the gang.

7. HOW TO START LINING

You will not be able to do a good job of lining unless you start right, so where do you begin? First you should walk back several rail lengths from the spot where you first think you should begin. Then walk ahead sighting the rail carefully until you find the last rail that is straight. This is very important as usually the first throw is so slight that you wonder if you should bother with it at all. The rule is "If you can see it, throw it". If you are not sure how far to move the track, throw it a little more than needed then move it back into line.

7. <u>HOW TO START LINING</u> (Cont'd)

Some foremen stand up to line while others prefer to sit down, the choice depends on your view. If you stand you should line from a distance of about five rail lengths from your men and if you prefer the sitting position you should be about four rail lengths from your men. When your men move forward or backwards you should always maintain the same distance. At this distance you are close enough to see the rail clearly but far enough to see when the track is straight.

To get straight track concentrate on one rail at a time. When the rail is lined you then line the next rail straight away from the last rail lined, making sure it is straight throughout its entire length. This is called projecting a straight line. You should be directly over the rail and sight down the centre of the rail instead of lining to the gauge corner.

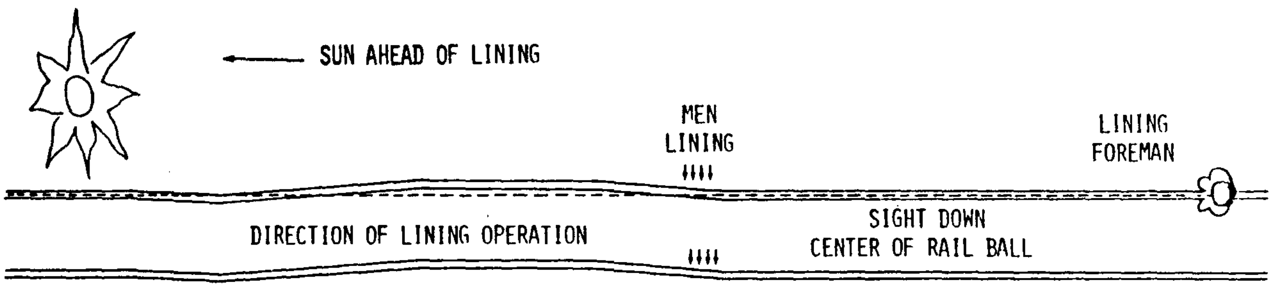


FIG. 13 - PROJECTING A STRAIGHT LINE.

If each rail is kept straight from the last lined rail it will never be necessary to back up and go over your work a second time.

Lining track is the same as building a fence. If you had to build a fence you would sight over three or four posts to make a straight line. If you didn't sight over three or four posts and just concentrated on running your line towards a distant flag you would end up with a lot of zigs and zags.

LINING CURVES

Now let's see how we line unstaked curved track. The principles of lining tangents also apply when lining curves. However, instead of lining a straight rail from a straight rail you simply line to an imaginary curved line (a curved rail from the last curved rail).

The difficulty many track liners experience in working on a curve is that they try to throw all the flat spots outward to make the curve appear round. The expert studies a curve with the idea of finding how much of the curve can be thrown inward. He watches carefully for the first rail that deflects outside of his imaginary curved line. He then throws inward at that point, and still projects the same normal curve line. In many cases this will eliminate the flat spots without any outward throws being necessary. Only rarely are outward throws needed, and then usually because of either bad level or too much elevation through part of the curve. Also on a curve that is badly out of line it may be necessary to make some outward throws to take care of rail expansion. Curves that are badly out of line should be centre staked.

A good eye liner can produce a good ride on curves that will handle trains up to 60 M.P.H. but above that speed it would be too much to expect a foreman to produce good riding track unless the curve is in good general line and requires only a little touching up. When lining curves the foreman should be standing and about 120' from his men, this distance will vary depending on the degree of the curve.

Don't forget that flattening one sharp spot is going to make adjacent spots sharper.

8.1 Lining Curves to Centre Stakes

The Wrong Way

What does an inexperienced track liner do when he enters a curve that has been staked? Nine times out of ten he will start by throwing the track at each centre stake. He will then go back around the curve and make a throw between the stakes. When he is finished the curve, he then makes a third trip to check the line at each stake. He will find that many points are off centre. The reason for this is that when he makes the throws between the stakes the track tends to move at the stakes, putting the track out of line. Then the foreman gets mad and kicks the stakes to fit his line.

The Proper Way

The right way to line the curve to stakes is to measure and line the track to centre at the first stake. An assistant then goes to the next stake and gives the foreman a mark to show how far off centre the track is at this point. Using the sighting method the foreman makes two throws between the centre stakes to move the track into line. The foreman uses the same procedures at each stake until the curve is lined. By using this method you will only go around the curve once to get good line.

So that the track will be exactly right at the centre line stakes it is important to have the men properly placed with their lining bars. If the centre line stakes are 39' apart, locate the men so that 2/3 of the crew are beyond the stakes when the track is thrown at the stake, because the track behind is already loosened and has been moved part way.

Lining a curve to stakes sometimes presents another problem. Some types of ballast tend to move with the ties when the track is moved. When this happens the centre line stake will move

1 Lining Curves to Centre Stakes (Cont'd)

when the track is thrown. To stop this, remove a shovel full of ballast from the pressure side of the stake.

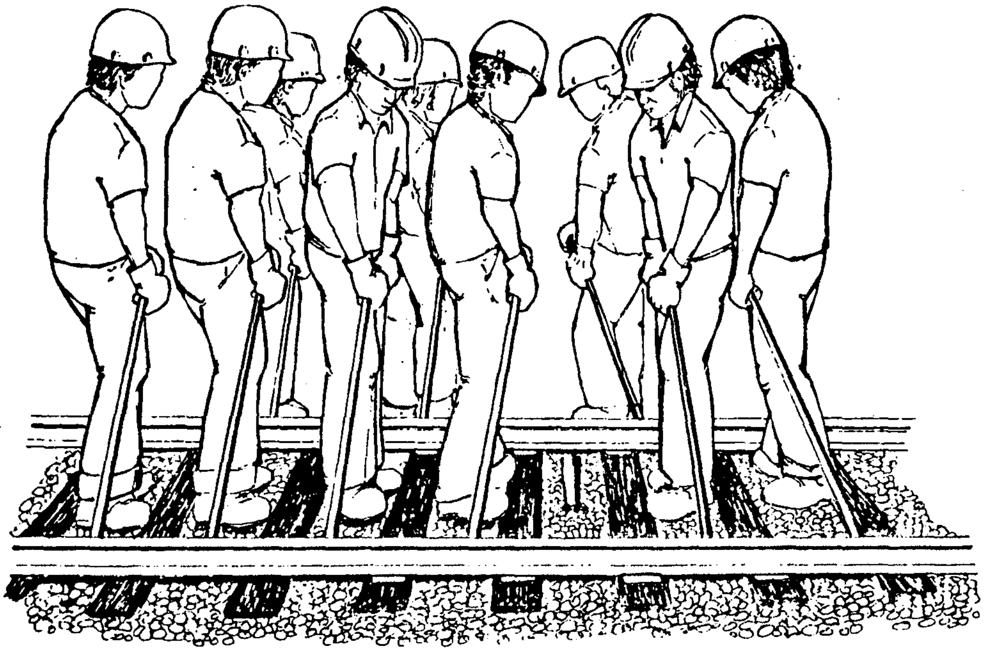
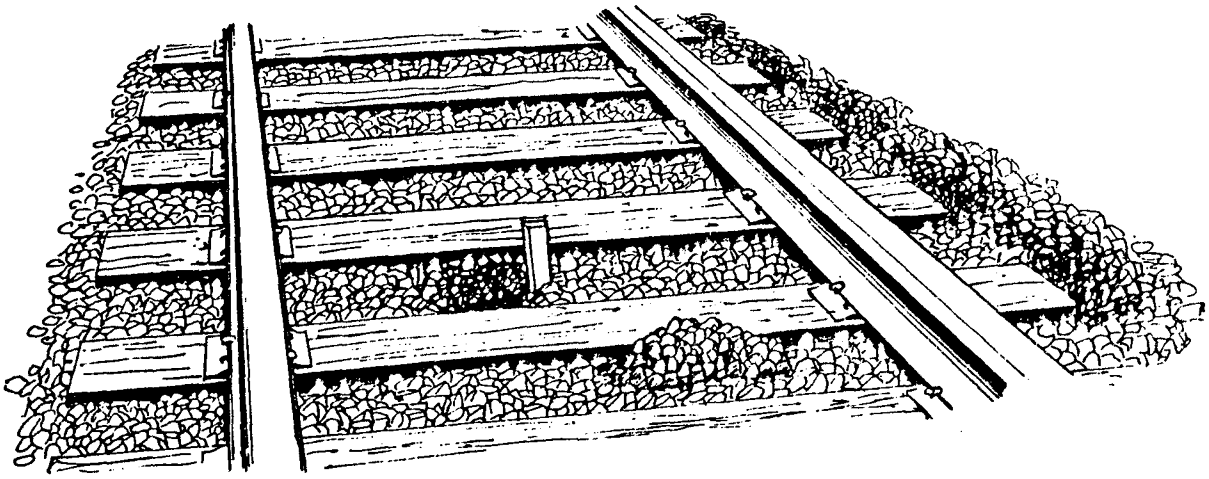


FIG. 14 - THROWING AT CENTER STAKE.

If stakes are used on tangent track they should be no more than 300' apart.



DIRECTION OF THROW →

FIG. 15 - PREVENTING CENTER STAKE MOVEMENT.

8.1 Lining Curves to Centre Stakes (Cont'd)

Also do not forget to remove ballast from the ends of the ties, if necessary, so the track will not hump and ruin the surface.

9. LINING TANGENT TRACK USING A LINING SCOPE

The Lining Scope is seldom used and the following is included for general information only.

To manually line track on high speed track a foreman should be able to use a lining scope.

This instrument when properly used will give excellent results. Just as with eye lining it is most important to get started right. The first thing you do is pick a spot on a part of the track that is in line and then set up the lining scope and level it.

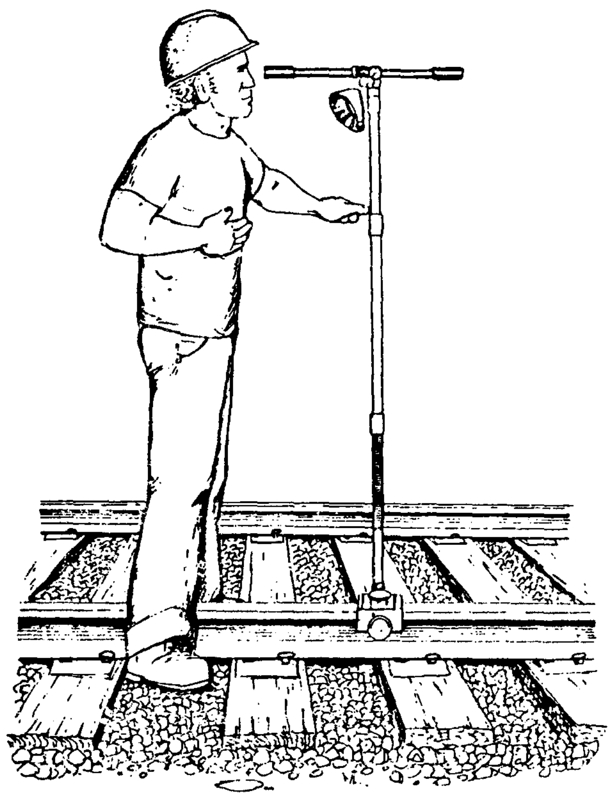


FIG. 16 - SCOPE LINING.

LINING TANGENT TRACK USING A LINING SCOPE (Cont'd)
Next sight to the most distant point you can see clearly and adjust the cross hairs to fit along the gauge corner of the rail at this point. If possible have a target board placed at this spot to use as a reference point. If there is some intermediate point such as a bridge or turnout etc., it should be used as the point to line towards, so you will pick up the line of the stretch of track that cannot be moved.

Next, sight the instrument to the rail a few feet ahead of you. If the cross hairs line up with the gauge side of the rail your setting is right. If not check the adjustment again. If it is still not right, it may be necessary to move the scope ahead or back a few feet and try again. Do not attempt to line until the cross hair lines up on the rail at both reference points. When lining 33' rail, line at the joint and the centre; when lining 39' rail, line at 3 points on the rail to avoid any kinks.

When lining with a lining scope you should move the scope ahead every eight or ten rail lengths.

10. TIGHT RAIL AND SUN KINKS

When attempting to straighten out a sun kink you should first set up protection. If you have time, wait till the rail cools off. Next loosen the bolts. Then place your men exactly in the centre of the kink. If they line just a little to one side, the track will just roll away and get worse, while if they line at the exact centre you can usually straighten it out.

When the sun kink has been lined have your men shovel ballast into the cribs in the centre of the track to hold it down. Ballast thrown in the centre, between the ties, will do more to hold a sun kink than the same amount of material piled against

13. LINING A TURNOUT (Cont'd)

7) If a switch is badly out of line, it may be necessary to pull the spikes from the turnout rails and then line the main track, after which you respike the turnout rails to the offsets shown on the standard plans.

The frog area is also a part of the turnout that requires lining. Lining this part of a turnout requires quite a lot of effort and a track jack is usually needed.

A Note of Caution

Do not forget that anytime you have worked around a switch and you have made adjustments or have turned the switch, you must make sure that the switch is properly lined and locked before you leave.

14. SPIKE LINING

In CWR spike lining should be avoided and must not be done when the rail temperature is above the temperature shown on the temperature tags. It is necessary to spike line at locations where the ties cannot be moved such as at diamonds, road crossings and bridges. It is also necessary when the ground is frozen and when you are shimming. When spike lining you first make sure that you are working under protection. You cannot spike line one rail at a time and keep the track safe for trains, as there would be too much bad gauge. Then you pull the spikes on the line rail, remove the tie plates, plug the holes and adze if necessary. Next, line the rail to its proper position, set the tie plates and spike every third or fourth tie throughout. Then you pull the spikes on the opposite rail, plug and adze as before. Next spike the rail to gauge on the same ties as the line rail was spiked. Finally you complete the spiking in accordance with SPC - 18.

15. SAFETY PRECAUTIONS

1) Provide protection when required. Don't forget that flag protection is required when jacks are set between the rails.
2) Before passage of trains make sure the run offs are adequate for the track speed. If not, contact the engineman and arrange for proper speed.
3) Watch the rail temperature. If it is too hot don't disturb the track.
4) In C.W.R. territory follow SPC-28 closely.
5) See that your men handle the tools properly and that they work safely.
6) Don't stare at the rail for too long, look away once in a while and rest your eyes.

TECHNICAL REFERENCES

M/W Rules	-	109, 174, 194
S.P.C.'s	-	3, 18, 23
Standard Plans	-	Turnout plans if required
Other	-	Nil