NEW SOUTH WALES GOVERNMENT RAILWAYS AND TRAMWAYS.

# Standard Rules

## and

# Formulæ for Design.

*4156—A

# TABLE OF CONTENTS.


| Subject. | No. of Article. | Page. |
|---|---|---|
| Structure Gauge ... | 1 | 3 |
| Load Gauge ... | 2 | 3 |
| Track Curvature ... | 3 | 3 |
| Speed allowance for Curves | 4 | 3 |
| Super-elevation on Curves | 5 | 3 |
| Grades and Vertical Curves | 6 | 3 & 4 |
| Spacing of Tracks | 7 | 4 |
| Curves in Tunnels | 8 | 4 |
| Rails and Fastenings | 9 | 4 |
| Check Rails | 10 | 4 |
| Switches and Crossings ... | 11 | 4 |
| Weight of Materials | 12 | 5 |
| Underbridges—Loading ... | 13 | 6 |
| Overbridges—Loading | 14 | 6 & 7 |
| Footbridges and Platforms—Loading ... | 15 | 7 |
| Roofs and Walls—Wind Loading | 16 | 7 |
| Allowable Unit Stresses | 17 | 7, 8 & 9 |
| General Structural Notes | 18 | 10 |
| Rivets | 19 | 10 & 11 |
| Bolts and Pins ... | 20 | 11 |
| Plate Girders and Rolled Beams | 21 | 11, 12 & 13 |
| Crane Runway Girders ... | 22 | 13 & 14 |
| Truss Bridges | 23 | 14, 15 & 16 |
| Bearings ... | 24 | 16 |


## TABLE OF PLATES.


| | Diagram No. | |
|---|---|---|
| Minimum Structure Gauge | 1 | 17 |
| Transition Curve Table ... | 2 | 18 |
| Super-elevation on Curves | 3 | 19 |
| Standard Rail Sections ... | 4 | 20 |
| Standard Crossings | 5 | 21 |
| Formulæ for Leads and Angles of Crossing | 6 | 22 |
| Conventional Engine Loadings | 7 & 8 | 23 |
| Impact Allowance | 9 | 24 |
| Tramway Loading | 10 | 25 |
| Motor Truck Loading | 11 | 26 |
| Riveting Details ... | 12 | 27 |

NEW SOUTH WALES GOVERNMENT RAILWAYS AND TRAMWAYS

# STANDARD RULES AND FORMULÆ FOR DESIGN.

**1. Minimum Structure Gauge.**—No portion of any structure shall project within the limits shown by the Minimum Structure Gauge, Diagram No. 1, and the clearances there provided (except the clearance between cars) shall be, under all conditions, the minimum permissible.

**2. Maximum Load Gauge.**—In estimating clearances on curves the maximum load shall be considered as a solid figure, having the cross section, shown in Diagram No. 1, for a length of 72 ft. 8 in., the whole symmetrically pivoted on two points on the track centre line 51 ft. 4 in. apart.

**3. Track Curvature.**—On all main lines, other than the Metropolitan Electric Railways, 4-chain transition curves of parabolic form shall be introduced between tangents and any curve between 12 and 40 chains radius. On lines where curves of less than 12-chains radius are permitted, transitions shall be as long as possible, consistent with economy of location and the limit of the cubic parabola.

For the Metropolitan Electric Railways no curve shall be less than 500 feet radius. A curve may be directly compounded with another or with tangent, providing the difference of curvature—C—does not exceed 0·00076. If C be greater than 0·00076, a cubic parabolic transition shall be used, the minimum length of which shall be C x 85,000 feet; curvature to be measured by the reciprocal of the radius in feet.

Diagram No. 2, appended gives all necessary information for the computation of transition curves.

**4. Maximum Speed allowable on Curves.**—The maximum speed allowable on curves shall be $1{\cdot}1\sqrt{R}$ miles per hour.

Where R = Radius of curve in feet. Limiting speed not to exceed 50 miles per hour.

**5. Super-elevation on Curves.**—On curves the inner rail shall be laid to the grade shown on longitudinal section, and the outer rail super-elevated by an amount given by the equation—

$$E = \frac{4{\cdot}S^2}{R}$$

where E = Super-elevation in inches.
S = Speed in miles per hour.
R = Radius of curve in feet.
E shall not exceed $4\frac{1}{2}$ inches.

In every case the speed shall be the maximum probable on the section under consideration, having due regard to local conditions of grade and traffic. On steam railways, excepting where local conditions indicate otherwise, the super-elevation shall be arranged in accordance with table, Diagram No. 3. On electric railways S shall be determined from the speed-distance curves for multiple unit equipments.

**6. Grades and Vertical Curves.**—The ruling grade for steam railways shall be as directed for the section under consideration. For the Metropolitan Electric Railways the ruling grades shall not be steeper than 1 in 30 down or 1 in 40 up.

In all cases compensation shall be allowed for curves on grades, a curve being considered equivalent to a grade of 1 in 0·5 R, where R is the radius in feet.

Gradients shall be connected by vertical easement curves of parabolic form of such length that the rate of change of grade shall not exceed the following :-

| | Concave Eases. | Convex Eases. |
|---|---|---|
| | Per cent. | Per cent. |
| On lines where goods trains will operate ...................... | 0·33 per chain ......... | 0·67 per chain. |
| On lines wholly for passenger services ...................... | 1·0 „ ......... | 1.5 „ |

**7. Spacing of Multiple Tracks.**—The minimum distance, centre to centre, of adjacent tracks is to be 12 feet, as shown on Diagram No. 1. On curves of 40 chains or less radius the spacing of adjacent tracks shall be—

$$D = 12{\cdot}0 + \frac{660}{R} + \frac{e}{6}$$

Where D = Distance in feet centre to centre of tracks.
R = Radius of curve in feet.
e = Difference in inches between super-elevation of outer and inner curves, and is only to be reckoned when the former is the greater.

**8. Displacement of Tunnel Centre Line on Curves.**—The centre line of a tunnel on curve shall be displaced from the track centre line towards the centre of curvature by an amount equal to $\frac{4}{3}$ of the super-elevation. In double-track tunnels the displacement of centre line shall be $\frac{4}{3}$ of the super-elevation of the inner track.

**9. Rails and Fastenings.**—Rails and fastenings to be Australian standards. Profiles shown on Diagram No. 4.

**10. Check Rails.**—Where the working train speed on tangent exceeds 30 miles per hour a check rail shall be fitted to the inner rail of all curves 14 chains or less radius. The checks shall be at the following distances from the running edge of the inner rail.

| | | | |
|---|---|---|---|
| Curves | 14 to 12 chains radius | ... ... | 2 inches. |
| Curves under 12 „ | 10 „ „ | ... ... | $2\frac{1}{4}$ „ |
| Curves under 10 „ | 8 „ „ | ... ... | $2\frac{1}{2}$ „ |

The ends of check rails shall be splayed in accordance with the standard splays adopted for crossings built of the respective rails.

**11. Switches and Crossings.**—The outer rail of turnout curve shall be tangential to the switch rail. Switch rails shall be 15 feet long for 60-lb. and 70-lb. rails, 16 ft. 6 in. long for 80-lb. rails, and 20 feet long for 90-lb. and 100-lb. rails. The distance at heel of switch, between running edges of switch rail and stock rail, shall be $4\frac{5}{8}$ inches for 60-lb. and 70-lb. rails, 5 inches for 80-lb. rails, and $5\frac{3}{8}$ inches for 90-lb. and 100-lb. rails. Where a turn-out is from a curve the normal to the turn-out curve and the normal to the curve shall intersect at the heel of the switch, the angle between them being equal to the switch angle.

If X = theoretical angle of frog,
frog number N = cot. X.

For computations the turn-out curve between theoretical frog point and heel of switch shall be regarded as circular arc.

As far as possible crossings are to be confined to the standards listed in table, Diagram No. 5.

Diagram No. 6 shows formulæ for determining all necessary particulars for any type of turn-out.

12. **Weight of Materials.**—The following unit weights of materials shall be used for purposes of design.

*Weights of Materials.*

| | lb. per cub. ft. |
|---|---|
| Air (32° F. one "atmosphere") | 0·0807 |
| Ashes, see Cinders | ... |
| Asphalt (natural) | 130 |
| Asphalte (Neuchatel) and Val de Travers | 149 |
| Asphalte (paving) | 120 |
| Ballast (broken metal) | 120 |
| Ballast (screened gravel) | 130 |
| Basalt, solid | 180 |
| Brick | 125 to 150 |
| Brickwork (ordinary and Sand-Lime) | 120 |
| ,, (special hard) | 140 |
| Cement, Portland | 90 |
| Cinders (dry) | 40 |
| Cinders (moist) | 45–50 |
| Clay (dry) | 100 |
| ,, (moist) | 120 |
| Coal, Anthracite (solid) | 100 |
| ,, ,, (loose) | 55 |
| ,, Bituminous (solid) | 85 |
| ,, ,, (loose) | 50 |
| Coke | 65 |
| ,, loose (Breeze) | 40 |
| Concrete, blue metal (reinforced) | 160 |
| ,, ,, (plain) | 150 |
| ,, Sandstone ,, | 140 |
| ,, Cinder ,, | 110 |
| ,, Coke ,, | 80 |
| Earth (moist) | 120 |
| ,, (dry) | 100 |
| Glass, Crown | 160 |
| ,, Plate | 180 |
| Grain— | |
| Barley | 40 |
| Maize | 45 |
| Oats | 30 |
| Wheat, bulk | 50 |
| Wheat, bagged 12 bags per ton | ... |
| Granite | 170 |
| Gravel (unscreened) | 120 |
| Gunpowder | 60 |
| Hardwood, see under Timber | ... |
| Lime | 55 |
| Limestone | 170 |
| ,, broken | 110 |
| Marble | 170 |
| Mortar (Cement) | 140 |
| ,, (Lime) | 110 |
| Metals (Alloy)— | |
| Brass, cast | 505 |
| ,, rolled | 525 |
| Bronze | 525 |
| Copper, cast | 540 |
| ,, rolled | 555 |
| Gold | 1,150 |
| Iron, cast | 450 |
| ,, wrought | 480 |
| Lead | 710 |
| Mercury | 850 |
| Silver | 655 |
| Steel (cast) | 485 |
| ,, (rolled) | 490 |
| Tin | 460 |
| Zinc | 440 |
| Quartz | 165 |

| | lb. per sq. ft. |
|---|---|
| Roof Coverings— | |
| Corrugated Iron, No. 16 G | $3\frac{1}{2}$ |
| ,, ,, No. 20 G | 2 |
| ,, ,, No. 24 G | $1\frac{1}{2}$ |
| ,, ,, No. 26 G | 1 |
| Fibro-cement Slates (including battens) | 4 |
| Oregon Battens (3 in. x 1 in. x 10 in. crs.) | 1 |
| Oregon Boarding, 1 in. thick | 3 |
| Slates (wet) including battens | 10 |
| Tiles (wet), shingle | 18 |
| ,, ,, French | 14 |
| Zinc (excluding boarding) | 1 to 2 |
| | lb. per cub. ft. |
| Sandstone, solid | 150 |
| Sand, moist | 120 |
| ,, dry | 100 |
| Shale, solid | 160 |
| ,, loose | 90 |
| ,, Kerosene, loose | 70 |
| Slag | 160 to 180 |
| Slate | 175 |
| Tar | 60 |
| Tarred Metal | 120 |
| Tiles | 115 |
| Timber, Seasoned (dry)— | |
| Ironbark, Grey | 70 |
| Grey Box | 70 |
| Tallow wood | 70 |
| Grey Gum | 70 |
| Jarrah | 60 |
| White or Cypress Pine | 45 |
| Oregon | 35 |
| Cedar | 30 |
| Redwood | 25 |
| Kauri | 40 |
| Colonial or Moreton B. Pine | 55 |
| Baltic | 35 |
| Sleepers, H.W.— | per ton. |
| 8 ft. x 10 in. x 5 in. | 11 |
| 8 ft. x 9 in. x $4\frac{1}{2}$ in. | 13 |
| 8 ft., round backs | 13 |
| | lb. per cub. ft. |
| Water (fresh) | $62\frac{1}{2}$ |
| ,, (sea) | 64 |

**13. Railway Under-Bridges Live Loading.**

(*a*) *Train Load.* For trunk and main branch lines the train loading shall be considered equivalent to that shown by Diagram No. 7. For pioneer lines the train loading shall be considered equivalent to that shown by Diagram No. 8. Piers, foundations, and abutments for bridges exceeding 66 feet span on pioneer lines shall be designed to carry superstructure and loading specified for trunk and main lines.

(*b*) *Impact Allowance.* For bridges to carry steam trains the dynamic stress in all members shall be calculated by the formula—

$$I = \frac{f}{1 + \frac{L^2}{30,000}}$$

I = Dynamic stress caused by the impact of the moving load.

f = Calculated stress in member due to live load only.

The value of $\frac{I}{f}$ for values of L ranging from 0 to 400 feet is shown on Diagram No. 9.

For bridges to carry electric trains only the impact allowance above shall be reduced by 50 per cent.

*For Trusses and Main Girders.*—

L = Actual length in feet of single track on bridge.

*For Stringers.*—

L = Actual length of member in feet.

*For Floor Beams and Hip Verticals.*—

L = Length in feet of single track carried by all stringers connected to floor beam under consideration.

*For Steel Trestles.*—

L = Length in feet of single track carried by spans supported by trestle under consideration.

**Note.**—The dynamic stress due to impact shall be included in the stresses of all bridge members carrying live load, including the shoes or bearing plates and for all steel trestles or piers, but may be neglected in designing brick or masonry piers or abutments.

In brick, masonry, or reinforced concrete arch bridges, with earth-filled spandrils, impact may be neglected.

(*c*) *Wind Loading.*—The wind loading shall be taken as equal to 30 lb. per square foot on one and half times the vertical projection of the structure, together with a moving lateral load of 300 lb. per lineal foot applied 6 feet above top of rail.

(*d*) *Longitudinal Force.*—Bearing and supports, piers, &c., shall be designed to provide for a longitudinal force of 20 per cent. of the train load, applied at top of rail.

(*e*) *Centrifugal Force.*—Bridges and viaducts and their supports carrying curved track shall be designed to provide for the centrifugal force due to a speed of $1 \cdot 1 \sqrt{R}$ miles per hour, the force being applied at the top of the rails.

**14. Highway Bridges Live Loading.—**

(*a*) *Tramway Loading.*—Highway bridges, unless otherwise specified, are to be designed to accommodate a double track tramway with a continuous load as shown by Diagram No. 10 on each track.

(*b*) *Motor Truck Load.*—Highway bridges shall be designed to carry on any part of the roadway a single truck with axle loading and dimensions shown by Diagram No. 11.

(*c*) *Distributed Live Load.*—The deck of the bridge unoccupied by a truck as specified by a truck in Clause 14b, or the tramway load as specified in Clause 14a, shall be considered covered by a live load of 100 lb. per square foot.

(*d*) *Wind Load.*—The wind load shall be taken as equal to 30 lb. per square foot on one and a half times the vertical projection of the bridge, together with a moving horizontal load of 150 lb. per lineal foot.

**15. Structures to carry Pedestrian Traffic only.**—Footbridges, stairways, floors, &c., are to be designed to carry a live load of 100 lb. per square foot.

Train platforms are to be designed to carry a load of 150 lb. per square foot. Structures carrying pedestrian traffic only, if in exposed positions, shall also be designed for a wind load of 30 lb. per square foot on one and a half times the vertical projection of the structure.

**16. Roofs and Walls, Wind Loading.**—The wind load normal to the surface of roof, walls, &c., shall be that given by the formula :—

$$Pn = 30 \times \frac{2 \sin A}{1 + \sin^2 A}$$

Pn = Normal pressure, lb, per square foot.

A = Angle of inclination of surface to horizontal.

The minimum wind load shall be assumed equal to 10 lb. per sq. ft. acting normally to the surface, and 2 lb. per sq. foot acting tagentially to the surface.

**17. Maximum Unit Stresses.**—Each member of a structure shall be so proportioned that the unit stress due to any combination of live and dead loading will not exceed the particular value set out in list hereunder. Where this loading is further combined with longitudinal or wind or both of these forces, the allowable unit stress may be increased 25 per cent. beyond the value in list, provided the section so determined is not less than that required for dead and live loads. In this connection live load is considered to include impact and centrifugal forces.

(*a*) *Working Stresses in Steelwork* :—

| | lb. per sq. in. |
|---|---|
| Tension axial, on net section ... ... ... ... ... | 18,000 |
| Compression axial on gross section with a maximum of 15,000 lb. per square inch ... ... ... ... | $18{,}000 - \frac{80\,L}{R}$ |
| L = Length of member in inches. | |
| R = Least radius of gyration of member in inches. | |
| Direct compression on steel castings ... ... ... | 18,000 |
| Bending— | |
| On extreme fibre of rolled or built sections, girders and steel castings (net section) ... ... ... | 18,000 |
| On extreme fibres of pins ... ... ... ... | 27,000 |
| Shearing— | |
| Rivets, pins and turned bolts ... ... ... ... | 13,500 |
| Plate girder webs (gross sections) ... ... ... | 12,000 |
| Bearing— | |
| Rivets, pins and turned bolts ... ... ... ... | 27,000 |
| Expansion plates ... ... ... ... ... ... | 5,000 |
| Expansion rollers (lb. per lin. inch) ... ... ... | 675d |
| Where d is diameter of roller in inches. | |

(b) *Working Stresses in Masonry, Concrete, &c.*

| | lb. per sq. in. |
|---|---|
| Tension.—Concrete, 1 : 3 : 6 or richer concrete, not reinforced, cross breaking stress ... ... ... | 60 |
| Shear.—Concrete 1 : 3 : 6 or richer concrete, brickwork or sandstone ... ... ... ... ... ... | 40 |
| Compression— | |
| Granite ... ... ... ... ... ... ... | 400 |
| Concrete 1 : 2 : 4 ... ... ... ... ... | 400 |
| Concrete 1 : 3 : 6 ... ... ... ... ... | 350 |
| Brickwork (set in Portland cement) ... ... ... | 350 |
| Sandstone masonry ... ... ... ... ... | 350 |

In walls, piers, &c., when the unstayed height (h) exceeds 8 times the thickness (t), the allowable compressive stress p is to be that given by the formula :-

$$p = (1{\cdot}24 - 0{\cdot}03\frac{h}{t})\ P.$$

where p is the allowable compressive stress listed above.

In designing retaining walls, piers or other similar structures subject to combined compression and bending or compression not acting axially the sum of the computed compression in the extreme fibre due to the bending moment reduced by 20 per cent., and the direct compression stress shall not exceed the amounts listed above, or as modified by the equation for cases where the unstayed height exceeds eight times the thickness.

(c) *Working Stresses in Reinforced Concrete.*

**Note.**—Concrete to be 1 : 2 : 4 or richer mixture.

| | lb. per sq. in. |
|---|---|
| Tension— | |
| Steel reinforcement ... ... ... ... ... | 18,000 |
| Concrete ... ... ... ... ... ... ... | 0 |
| Compression— | |
| Concrete—Extreme fibre of beams ... ... ... | 650 |
| Extreme fibre adjacent to support of continuous beams ... ... ... ... | 750 |
| Columns with longitudinal reinforcement not less than 1 per cent. and not more than 4 per cent., with suitable lateral ties ... ... ... ... | 450 |
| Columns with not less than 1 per cent. and not more than 4 per cent. longitudinal reinforcement, together with circular spiral hooping not less than 1 per cent. of the volume of enclosed concrete, L/B of column less than 10 ... ... ... ... ... ... ... | 675 |

Shear and Diagonal Tension—

$$\text{Unit Shear} = v = \frac{V}{jd.b}$$

Where V = total shear.

jd = effective depth of beam.

b = breadth of beam.

(*a*) Beams with horizontal bars only ... ... ... 40
(*b*) Beams with bent-up bars properly arranged ... ... 60
(*c*) Beans with web reinforcement, designed exclusive of bent-up bars, to resist ⅔rds of vertical external shear 120
(*d*) Punching shear, if all tension normal to the shearing plane, is provided for by reinforcement ... ... 120

Bond, Concrete and Steel—
Plain rods ...... ... ... ... ... ... ... 80
Drawn wire... ... ... ... ... ... ... 40

Modulus of Elasticity—
Ratio, steel to concrete = 15 for design
= 8 for calculating deflections.

(*d*) *Working Stresses in Timber*—

| Nature of Stress. | Ironbark. | Tallow-wood, Grey Gum Grey Box. | Oregon. |
|---|---|---|---|
| | lb. sq. in. | lb. sq. in. | lb. sq. in. |
| Tensile.................................. | 2,200 | 1,800 | 1,000 |
| Compression— | | | |
| $\frac{L}{D}$ less than 10.................. | 1,300 | 1,200 | 700 |
| $\frac{L}{D}$ from 10 to 24 ............... | $1{,}500 - 20\frac{L}{D}$ | $1{,}400 - 20\frac{L}{D}$ | $800 - 10\frac{L}{D}$ |
| Across grain | ........... | ........... | 100 |
| Bending— | | | |
| Extreme fibre .................. | 2,200 | 1,800 | 1,000 |
| Shearing— | | | |
| Selected timber ................. | 240 | 180 | ........... |
| General ........................... | 200 | 150 | 100 |

(*e*) *Bearing Pressure on Masonry and Brickwork*—

| | lb. per sq. in. |
|---|---|
| Granite or bluestone ... ... ... ... ... | 800 |
| Concrete 1 : 2 : 4 ... ... ... ... ... ... | 600 |
| Concrete 1 : 3 : 6 ... ... ... ... ... ... | 500 |
| Brickwork (set in Portland cement mortar) ... ... | 400 |
| Sandstone Masonry ... ... ... ... ... ... | 400 |

In designing bearings to carry the ends of two adjacent spans or for other similar cases where through partial loading the resultant pressure is not central on the bearing, the sum of the computed max. bearing pressure due to bending moment reduced by 20 per cent., and the direct bearing pressure shall not exceed the amounts listed above.

(*f*) *Working Pressure on Foundations*—

| | lb. per sq. ft. |
|---|---|
| Solid sandstone ... ... ... ... ... ... | 60,000 |
| Compact gravel and hard shale ... ... ... ... | 20,000 |
| Hard deep clay interposed with shale and sandstone bands, soft rock ... ... ... ... ... | 12,000 |
| Soft shale ... ... ... ... ... ... ... | 6,000–10,000 |
| Clay, moist or mixed with sand or soil bands ... ... | 4,000–6,000 |

**18. General.—**

(*a*) *Thickness of Metal.*—The minimum thickness of metal shall be $\frac{3}{8}$ inch in railway and $\frac{5}{16}$ inch in highway bridges and roofs, except for packing plates.

(*b*) *Accessibility of parts.*—Structures shall be so designed that all parts will be accessible for inspection, cleaning and painting.

(*c*) *Pockets.*—Pockets or depressions which would hold water shall have drain holes or be filled with waterproof material.

(*d*) *Open Floors.*—Hardwood transoms in open decks shall be proportioned to carry the maximum wheel load plus 100 per cent. impact, distributed over three (3) transoms. They shall be not less than nine (9) feet long, spaced with not more than ten (10) inch openings and secured against bunching.

(*e*) *Skew-spans.*—Skew crossings shall be avoided whenever possible, but in all cases deck trusses and girders and the floor systems of through bridges shall be built square. Main through girders and trusses shall preferably be built square.

**19. Rivets.—**

(*a*) *Proportions*—

1. Rivets shall be proportioned according to Table 1, Diagram 12.
2. In proportioning rivets the nominal diameter of the rivet shall be used; but in proportioning tension members the diameter of rivet holes shall be taken as $\frac{1}{8}$ inch larger than the nominal diameter of the rivet for full headed, and $\frac{1}{4}$-inch larger for countersunk rivets.

(*b*) *Spacing*—

1. Pitch.—The distance between centres of rivets shall be not less than three diameters of the rivet and preferably not less than three and one-half diameters. The maximum pitch in the line of stress for members composed of plates and shapes shall not exceed 6 inch for $\frac{7}{8}$ inch and larger rivets, and 5 inch for $\frac{3}{4}$-inch rivets, nor in any case twelve times the thickness of the thinnest outside piece. For angles with two gauge lines and rivets staggered the maximum pitch shall be twice the above in each line. In tension members composed of two angles in contact or with a packing between them a pitch of 12 in. will be allowed for riveting the angles together.
2. Staggered Pitch.—The stagger of rivets required to maintain net section is shown in Table 2, Diagram 12.
3. Pitch at ends of posts.—The pitch of rivets at the end of built compression members shall not exceed four diameters of the rivets for a length, measured from the end, of one and one-half times the maximum width of the member.
4. Edge Distance.—The minimum distance from the centre of any rivet hole to a sheared edge shall not be less than two diameters and to a rolled edge one and one-half diameters, except in the case of lattice bars, where $\frac{7}{8}$ inch rivets may be used in bars $2\frac{1}{2}$ in. wide. The maximum distance from any edge shall be eight times the thickness of the plate or 6 inch, whichever is the less.
5. Rivets in lattices.—Five-eighth ($\frac{5}{8}$) inch rivets shall be used for latticing flanges less than $2\frac{1}{2}$ inches wide, $\frac{3}{4}$ inch for flanges from $2\frac{1}{2}$ inch to $3\frac{1}{2}$ inches wide, and $\frac{7}{8}$ inch for flanges $3\frac{1}{2}$ inches wide and upwards. At least two rivets shall be used for latticing flanges over 5 inches wide.

6. Rivets in joggled angles.—The distance "b" shall be 1½ inch plus the thickness of the flange angle, with a minimum value of 2 inch. See Table 3, Diagram 12.

7. Clearance for riveting.—Rivets shall be spaced to afford clearances not less than those shown in Table 4, Diagram 12.

(c) *Strength, &c.*—

1. Double Shear.—The value of shear in rivets in double shear shall be taken as 1·75 times the specified stress in single shear.

2. Field Rivets.—No reduction of the specified working stresses shall be made in the case of field rivets, machine driven.

3. Hand-driven rivets.—The maximum shearing stress on rivets driven by hand shall not exceed 11,000 lb. per square inch.

4. Long Rivets.—Rivets carrying calculated stress whose grip exceeds four diameters shall be increased in number at least 1 per cent. for each additional $\frac{1}{16}$ inch of grip.

5. Rivets through Packings.—Rivets carrying stress and passing through packings shall be increased 50 per cent. in number and the excess rivets shall, when possible, be outside of the connected member.

6. Indirect Splices.—Where splice plates are not in direct contact with the parts which they connect, rivets shall be used on each side of the joint in excess of the number theoretically required to the extent of one-third of the number for each intervening plate.

(d) *Conventional signs.*—On drawings the conventional signs used to indicate full headed or countersunk rivets shall be as shown in Table 5, Diagram 12.

## 20. Bolts and Pins.—

(a) *Proportions, &c.*—

1. Bolts.—Where turned bolts are used in place of rivets the turned portion shall be long enough to extend through the metal. A washer at least one quarter (¼) inch thick shall be used under the nut.

2. Pins.—In bearings pins shall be long enough to insure a full bearing of all the parts connected upon the turned body of the pin. They shall be adequately secured against displacement.

3. Anchor Bolts.—These shall be embedded in the masonry to a depth equal to twenty diameters and shall have square anchor plates, of thickness and width not less than one-half and four diameters of the bolt respectively. Anchor bolts for trestles shall be sufficiently long to engage a mass of masonry weighing at least one and one-half (1½) times the uplift.

## 21. Plate Girders and Rolled Beams.—

(a) *Proportions*—

1. Effective Span.—Effective spans shall be taken as follows:—Stringers, the distance between centres of cross girders; cross girders, the distance between centres of main girders or trusses; all other beams or girders, the distance between centres of supports.

2. Depth ratio.—Plate girders and rolled beams used as girders in railway bridges shall have a depth of not less than one-twelfth and preferably not less than one-tenth of the span. In highway bridges these proportions shall be one-twentieth and one-fifteenth respectively. If shallower girders or beams are used than one-tenth and one-fifteenth of the span in railway and highway bridges respectively the section shall be increased so that the deflection will not be greater than if these limiting ratios had not been exceeded.

3. Flange Section.—When the web plate is in one piece, or is properly spliced for bending, one-eighth of its gross section may be considered as flange area.

4. Minimum thickness of metal.—The minimum thickness of metal shall be $\frac{3}{8}$ inch in railway and $\frac{5}{16}$ inch in highway bridges and roofs, except for packing plates.

5. Camber.—Plate girders 30 feet long and upwards shall be built with a camber such that the lower flange will be horizontal when the girder is fully loaded.

(b) *Flanges*—

1. Length of Plates.—At least one upper flange plate when used, except when embedded in concrete or where the web plate is flush with the upper surfaces of the flange angles, shall extend from end to end of the girder. Any additional plates used to make up the flange section shall be made of such lengths as to allow at least two rows of rivets of the regular pitch being placed at each end of the plate beyond the theoretical point required, and there shall be a sufficient number of rivets at the ends of each plate to transmit its full value before the theoretical point of the next outside plate is reached.

2. Minimum Thickness.—Flanges of girders and built members without cover plates shall have a minimum thickness of at least one-twelfth of the outstanding leg.

3. Splices.—All flange plates subject to either tension or compression spliced in the length of the girder shall be properly covered with an extra amount of material equal in section to the material spliced, with sufficient rivets on either side to transmit the stresses from the parts cut.

4. Stays for top flanges.—Through plate girders shall have their top flanges stayed at each end of every cross girder or, in the case of solid floors, at distances not exceeding twelve (12) feet, by knee braces or gusset plates.

5. Strength.—The gross section of the compression flange of a plate girder shall not be less than the gross section of the tension flange, nor shall the stress per square inch in the compression flange of any beam or girder exceed $21{,}000-180\frac{l}{b}$ with a maximum of 18,000 lb. per square inch where $l$ = unsupported distance and $b$ = breadth of flange. In computing the cross sectional area of compression flanges of girders and beams all bolt holes occurring in any cross section shall be deducted.

6. Rivets.—The flanges of plate girders shall be connected to the web with a sufficient number of rivets to transfer the total shear at any point in a distance equal to that between the mean lines of rivets of the upper and lower flanges. When any load is applied directly on the flange the number of rivets shall be increased to provide for such extra loading.

(c) *Webs*—

1. Minimum thickness.—In addition to the provisions of Clause 18 (*a*) above, the thickness of web plates shall in no case be less than one one-hundred-and-sixtieth ($\frac{1}{160}$) of the unsupported distance between the flanges.

2. Splices.—Web splices where required should preferably be placed at the quarter or third points and not at the point of maximum moment. In cases where the web plate is considered as contributing to the flange area of the cross section, web splices, when required, shall be designed to transmit as directly and efficiently as possible all stresses which actually occur in the web at the location of the splice. Splice plates on each side of the web shall preferably be in one piece for that portion of the web not covered by flange angles and of sufficient width to take two rows of rivets through each section of the web spliced. If necessary, cover plates shall be used on the flange angles over the web joints.

3. Web Stiffeners.—There shall be web stiffeners, generally in pairs, over bearings, at points of concentrated loading, at points where the intensity of shearing stress exceeds 10,000 lb. per square inch and at points where the web thickness is less than one-sixtieth ($\frac{1}{60}$) of the unsupported distance between flange angles. The distance between stiffeners shall not exceed that given by the following formula, with a maximum length of six feet or 160 times the thickness of the web :—

$$d = \frac{t}{50}(14{,}000 - s)$$

where d = clear distance between stiffeners.
t = thickness of web.
s = shear in lbs. per square inch.

The stiffeners at ends and at points of concentrated loading shall be proportioned by the ordinary formula for compression in columns, the effective length being assumed as one half the depth of girder End stiffeners and those under concentrated loads shall be packed and have their outstanding legs as wide as the flange angles will permit and shall be a tight fit between them. Intermediate stiffeners may be joggled and their outstanding legs shall not be less than one-thirtieth ($\frac{1}{30}$) of the depth of girders plus 2 inch. The rivet spacing shall not exceed about six times the rivet diameter and be as nearly uniform as possible. A sufficient number of rivets must be provided to transmit the concentrated loads or reactions to the web.

**22. Crane Runway Girders.**—

(*a*) *Impact.*—Provision shall be made for impact and vibration in crane girders by the addition of 25 per cent. to the static live load stresses.

(*b*) *Proportions and Construction.*—Crane girders shall generally be of plate construction and designed to resist all the vertical and lateral forces to which they may be subjected by the travelling crane. The upper flange shall be of a width not less than one twenty-fifth of the length and shall preferably be trough-shaped. The crane rail shall be riveted to the girder by rivets spaced from 9 inches to 12 inches alternate pitch. The cross sectional area of the rail shall not be included in the sectional area of the top flange of the girder for purposes of computing the necessary section.

(c) *Expansion.*—Provision shall be made for expansion due to temperature in all crane girders under cover to the extent of one-sixteenth ($\frac{1}{16}$) inch for each ten (10) feet of length. When not under cover the provision for expansion shall be in accordance with Clause 21 (*b*) hereafter.

(*d*) *Columns to Crane Girders.*—Columns carrying crane girders shall preferably be constructed so that a shaft is provided under each girder, but where the girders are carried by brackets from the columns the resulting bending stresses shall be provided for.

**23. Truss Bridges.—**

(*a*) *Proportions—*

1. *Depth ratio.*—Trusses shall have a depth of not less than one-tenth and preferably not less than one-eighth of the span.

2. *Effective Spans.*—Effective spans shall be as defined in Clause 21 (*a*)1.

3. *Limiting Lengths.*—The length of main compression members shall not exceed 100 times, and in wind and sway bracing 120 times the least radius of gyration of the member. The length of riveted tension members in horizontal or inclined positions shall not exceed 200 times the least radius of gyration about the horizontal axis. The orizontal projection of the unsupported portion of the member is to be considered as the effective length.

4. *Camber.*—Truss spans shall be constructed with a camber of 1 inch for every 100 feet in length.

5. *Pony Trusses.*—Pony trusses shall not be used for greater spans than 110 feet. They shall be riveted structures with double-webbed chords and shall have all members effectively stiffened. They shall have their top chords effectively stayed at every panel point. The intensity of stress in the top chord shall not exceed that given by the formula—

$$f = 21{,}000 - 180\,\frac{l}{b}$$

with an upper limit of 15,000.

where f = stress in lbs. per square inch.
l = length of the span.
b = width of flanges,

provided that the intensity of stress so ascertained does not exceed that given by the ordinary formula for compression members, Clause 17 (*a*).

(*b*) *Floor System—*

1. *Stringers.*—Stringers shall preferably be riveted to the webs of cross girders by means of connection angles not less than one-half ($\frac{1}{2}$) inch thick. Brackets provided to support the stringer during erection shall not be considered as carrying any of the reaction. End stringers shall preferably be carried on end cross girders. Where end cross girders cannot be used, stringers resting on masonry shall have cross bracing near their ends connected where practicable to girder or truss bearings.

2. *Cross Girders.*—Cross girders shall be square to the trusses or main girders. They shall be riveted directly to the trusses or main girders in through bridges, and may be placed on the top chords or flanges of deck bridges.

(c) *Main Members*—

1. *Triangulation.*—Main members shall be so designed that the neutral axis will be as nearly as practicable in the centre of the section, and the neutral axis of intersecting main members of trusses shall meet at a common point.

2. *Alternate Stresses.*—Members subject to alternate stresses of tension and compression shall be proportioned for the stress giving the larger section. If the alternate stresses occur in succession during the passage of one train, as in stiff counter-braces, each stress shall be increased by 50 per cent. of the smaller. The connections shall in all cases be proportioned for the sum of the stresses. Whenever the live and dead load stresses are of opposite character, only two-thirds of the dead load stresses shall be considered as effective in counter-acting the live load stress.

3. *Compression Members.*—In compression members the metal shall be distributed so as to provide a section of maximum stiffness. The thickness of each web plate shall not be less than one-thirtieth ($\frac{1}{30}$) of the distance between its connections to the flanges. Cover plates shall have a thickness not less than one-fortieth ($\frac{1}{40}$) of the distance between gauge lines of rivets. Built chords and columns, when faced for bearing at joints, shall be spliced on four sides to prevent displacement, and the splice shall be capable of transmitting not less than 50 per cent. of the chord or column stress. In all other cases the splice shall be capable of developing the full strength of the member.

4. *Latticing, &c.*—The open sides of compression members shall be provided with latticing or batten plates, and in the former case shall have batten plates as near each end as possible and at intermediate points where the latticing is interrupted. In main members the end batten plates shall have a length not less than the distance between the lines of rivets connecting them to the flanges, and intermediate ones not less than one-half this distance. The thickness of batten plates shall be not less than one-fiftieth ($\frac{1}{50}$) of the distance between rivets connecting them to the flanges.

The distance between the connections of lattice or batten plates shall be such that the individual members between them composing the column shall be as strong as the column as a whole, and in no case shall this distance exceed eight (8) times the least width of these members. The latticing of compression members shall be proportioned to resist a shearing stress equal to two (2) per cent. of the direct stress. The thickness of lattice bars shall not be less than one-fortieth ($\frac{1}{40}$) of the distance between end rivets for single, and one-sixtieth ($\frac{1}{60}$) for double lattice. Shapes of equivalent strength may be used. See also 19 (*b*) 5 for sizes of rivets in flanges.

Single lattice bars shall generally be inclined at an angle of sixty degrees (60°) to the axis of the member, and double lattices at an angle of forty-five (45°), with a rivet at their intersection. When the distance between rivet lines in the flanges exceeds fifteen (15) inches, either double lattices riveted at intersections, or single lattices with two or more rivets at each end, shall be used.

(*d*) *Lateral Systems*—

1. *Bracing.*—Lateral, longitudinal, and transverse bracing shall preferably be composed of rigid members. Through truss spans, excepting pony trusses, shall have riveted portal bracing rigidly connected to the end posts and top chords, and as deep as the clearance will allow.

Intermediate sway bracing shall be used at each panel of through spans having vertical truss members where, and as deep as, the clearance will permit. Deck spans shall be provided with horizontal and vertical bracing capable of carrying all lateral loads to the supports.

2. *Counter-bracing.*—In main trusses counter-bracing shall be avoided whenever possible and web members designed for reversal of stress.

3. *Connections.*—Connections shall be proportioned to develop the full strength of the member, notwithstanding that the calculated stress may be less. Not less than two rivets shall be used in making connections except in the case of latticing.

**24. Bearings.**—

(*a*) *Fixed Bearings.*—Fixed bearings shall be so anchored as to be capable of transmitting all reactions in whatever direction to the masonry.

(*b*) *Provision for Expansion.*—Provision shall be made for expansion in all bridge structures to the extent of 1 inch for each 100 feet length. Arrangements shall be made to prevent excessive motion at any point.

(*c*) *Expansion Bearings.*—Girders 75 feet long and upwards resting on masonry shall have turned rollers, full or segmental, at one end, and those of less length shall be arranged to slide on smooth surfaces. Expansion bearings shall be designed to permit motion in one direction only and to transmit the maximum reactions in other directions.

(*d*) *Hinges.*—Bridges 75 feet long and upwards shall have hinged bearings at each end. Bolsters or shoes shall be so designed that the load will be uniformly distributed over the entire bearing.

(*e*) *Expansion Rollers.*—Expansion rollers shall be of not less diameter than that given by the formula—

$$d = 3 + 0{\cdot}03L$$

where d = diameter of roller in inches.

L = span in feet.

They shall be coupled together with substantial side bars, which shall be so arranged that the rollers can be readily cleaned.

(*f*) *Inclined Bearings.*—Bridges on an inclined grade without pin bearings shall have the underside of the upper bearing or base plates planed to a horizontal surface.

NEW SOUTH WALES GOVERNMENT RAILWAYS

# MINIMUM STRUCTURE DIAGRAM

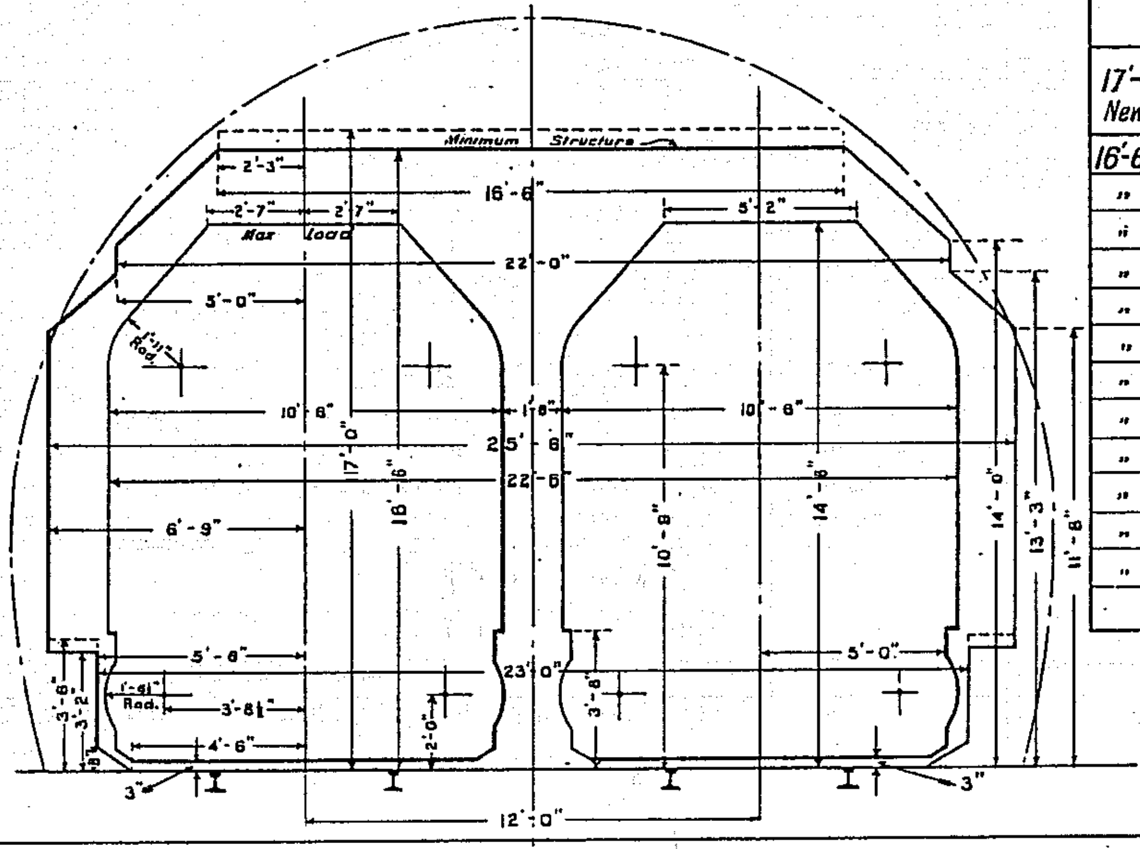
## 1921

NOTE :- Additional width must be allowed on curves of 40 chs. or under as shown in table :-

| Rad in Chs. | Additional width in inches | Track Centres | Rad in Chs | Additional width in inches | Track Centres |
|---|---|---|---|---|---|
| 8 | 15 | 13'-3" | 22 | 5½ | 12'-5½" |
| 9 | 13 | 13'-1½" | 24 | 5 | 12'-5" |
| 10 | 12 | 13'-0" | 25 | 4¾ | 12'-4¾" |
| 11 | 11 | 12'-11" | 26 | 4½ | 12'-4½" |
| 12 | 10 | 12'-10" | 28 | 4¼ | 12'-4¼" |
| 13 | 9¼ | 12'-9¼" | 30 | 4 | 12'-4" |
| 14 | 8½ | 12'-8½" | 32 | 3¾ | 12'-3¾" |
| 15 | 8 | 12'-8" | 35 | 3½ | 12'-3½" |
| 16 | 7½ | 12'-7½" | 36 | 3¼ | 12'-3¼" |
| 18 | 6¼ | 12'-6¼" | 40 | 3 | 12'-3" |
| 20 | 6 | 12'-6" | | | |

In addition to the above, an amount equal to twice the difference in superelevation of the inner and outer roads must be added, but only when the superelevation on the outer road is greater than that on the inner. (See Specification Clause 7)

1906 Max. Load to remain in force till roads are widened to 12'-0" and structure altered throughout when the Max. Load shown is to be adopted. (For Existing Lines only)




NOTE :- Height of Minimum Structure

| | | | |
|---|---|---|---|
| 17'-0" Outside Sydney and Newcastle Suburban Areas | | | |
| 16'-6" | Sydney | to | Waterfall |
| " | Sydenham | to | Bankstown |
| " | Sydney | to | Campbelltown |
| " | Strathfield | to | Hornsby |
| " | Clyde | to | Carlingford |
| " | Lidcombe | to | Regent's Park |
| " | Granville | to | Penrith |
| " | Blacktown | to | Richmond |
| " | Milson's Pt. | to | Hornsby |
| " | Newcastle | to | Fassifern |
| " | Fassifern | to | Toronto |
| " | Newcastle | to | West Maitland |

DIAGRAM 1

## DIAGRAM Nº 2

NEW SOUTH WALES GOVERNMENT RAILWAYS.

# TRANSITION CURVE TABLE.

| $\frac{x_c}{R}$ | $\phi$° ° | ′ | ″ | Log. $(m R^2)$ | $\frac{x'}{R}$ | $\frac{y_c}{R}$ | $\frac{h}{R}$ | $\frac{s}{R}$ | $\frac{K}{R} = \frac{2\phi}{R}$ |
|---|---|---|---|---|---|---|---|---|---|
| 0·00 | 0 | 0 | 0·0 | · ∞ | 0·000000 | 0·000000 | 0·000000 | 0·000000 | 0·000000 |
| 0·01 | 0 | 17 | 11·3 | 1·221855 | 0·005000 | 0·000017 | 0·000004 | 0·010000 | 0·010001 |
| 0·02 | 0 | 34 | 22·9 | 0·920878 | 0·010001 | 0·000067 | 0·000017 | 0·020000 | 0·020002 |
| 0·03 | 0 | 51 | 34·8 | 0·744872 | 0·015003 | 0·000150 | 0·000038 | 0·030001 | 0·030008 |
| 0·04 | 1 | 8 | 47·2 | 0·620049 | 0·020008 | 0·000267 | 0·000067 | 0·040002 | 0·040019 |
| 0·05 | 1 | 26 | 0·4 | 0·523287 | 0·025016 | 0·000417 | 0·000104 | 0·050004 | 0·050037 |
| 0·06 | 1 | 43 | 14·5 | 0·444376 | 0·030027 | 0·000601 | 0·000150 | 0·060006 | 0·060063 |
| 0·07 | 2 | 0 | 29·6 | 0·377552 | 0·035043 | 0·000818 | 0·000204 | 0·070009 | 0·070100 |
| 0·08 | 2 | 17 | 46·1 | 0·319806 | 0·040064 | 0·001069 | 0·000266 | 0·080013 | 0·080150 |
| 0·09 | 2 | 35 | 4·0 | 0·268932 | 0·045092 | 0·001354 | 0·000337 | 0·090018 | 0·090214 |
| 0·10 | 2 | 52 | 23·6 | 0·223487 | 0·050126 | 0·001673 | 0·000416 | 0·100025 | 0·100294 |
| 0·11 | 3 | 9 | 45·0 | 0·182442 | 0·055168 | 0·002026 | 0·000503 | 0·110034 | 0·110392 |
| 0·12 | 3 | 27 | 8·5 | 0·145034 | 0·060218 | 0·002413 | 0·000599 | 0·120044 | 0·120510 |
| 0·13 | 3 | 44 | 34·2 | 0·110687 | 0·065278 | 0·002835 | 0·000703 | 0·130056 | 0·130650 |
| 0·14 | 4 | 2 | 2·4 | 0·078953 | 0·070348 | 0·003291 | 0·000814 | 0·140070 | 0·140813 |
| 0·15 | 4 | 19 | 33·2 | 0·049474 | 0·075429 | 0·003782 | 0·000933 | 0·150086 | 0·151002 |
| 0·16 | 4 | 37 | 6·9 | 0·021966 | 0·080522 | 0·004308 | 0·001061 | 0·160104 | 0·161219 |
| 0·17 | 4 | 54 | 43·7 | 9·996194 | 0·085628 | 0·004870 | 0·001197 | 0·170125 | 0·171465 |
| 0·18 | 5 | 12 | 23·7 | 9·971962 | 0·090747 | 0·005467 | 0·001341 | 0·180149 | 0·181744 |
| 0·19 | 5 | 30 | 7·4 | 9·949111 | 0·095881 | 0·006100 | 0·001493 | 0·190176 | 0·192058 |
| 0·20 | 5 | 47 | 54·8 | 9·927502 | 0·101031 | 0·006770 | 0·001653 | 0·200206 | 0·202408 |
| 0·21 | 6 | 5 | 46·2 | 9·907018 | 0·106198 | 0·007476 | 0·001821 | 0·210239 | 0·212797 |
| 0·22 | 6 | 23 | 41·9 | 9·887559 | 0·111382 | 0·008219 | 0·001997 | 0·220276 | 0·223227 |
| 0·23 | 6 | 41 | 42·1 | 9·869036 | 0·116585 | 0·009000 | 0·002181 | 0·230317 | 0·233701 |
| 0·24 | 6 | 59 | 47·1 | 9·851375 | 0·121808 | 0·009818 | 0·002372 | 0·240361 | 0·244221 |
| 0·25 | 7 | 17 | 57·2 | 9·834510 | 0·127051 | 0·010674 | 0·002571 | 0·250409 | 0·254790 |
| 0·26 | 7 | 36 | 12·5 | 9·818382 | 0·132317 | 0·011569 | 0·002777 | 0·260462 | 0·265411 |
| 0·27 | 7 | 54 | 33·6 | 9·802939 | 0·137606 | 0·012503 | 0·002991 | 0·270520 | 0·276087 |
| 0·28 | 8 | 13 | 0·5 | 9·788135 | 0·142919 | 0·013477 | 0·003212 | 0·280582 | 0·286820 |
| 0·29 | 8 | 31 | 33·8 | 9·773930 | 0·148258 | 0·014491 | 0·003440 | 0·290650 | 0·297614 |
| 0·30 | 8 | 50 | 13·6 | 9·760287 | 0·153625 | 0·015547 | 0·003676 | 0·300723 | 0·308473 |
| 0·31 | 9 | 9 | 0·4 | 9·747173 | 0·159021 | 0·016644 | 0·003919 | 0·310802 | 0·319399 |
| 0·32 | 9 | 27 | 54·4 | 9·734558 | 0·164447 | 0·017783 | 0·004169 | 0·320886 | 0·330395 |
| 0·33 | 9 | 46 | 56·2 | 9·722417 | 0·169905 | 0·018965 | 0·004426 | 0·330997 | 0·341466 |
| 0·34 | 10 | 6 | 6·1 | 9·710725 | 0·175396 | 0·020191 | 0·004689 | 0·341074 | 0·352616 |
| 0·35 | 10 | 25 | 24·5 | 9·699461 | 0·180922 | 0·021462 | 0·004959 | 0·351179 | 0·363848 |
| 0·36 | 10 | 44 | 51·9 | 9·688605 | 0·186485 | 0·022778 | 0·005236 | 0·361291 | 0·375167 |
| 0·37 | 11 | 4 | 28·7 | 9·678130 | 0·192087 | 0·024140 | 0·005519 | 0·371410 | 0·386578 |
| 0·38 | 11 | 24 | 15·5 | 9·668046 | 0·197730 | 0·025550 | 0·005807 | 0·381538 | 0·398085 |
| 0·39 | 11 | 44 | 12·7 | 9·658313 | 0·203417 | 0·027009 | 0·006101 | 0·391674 | 0·409693 |
| 0·40 | 12 | 4 | 20·9 | 9·648927 | 0·209149 | 0·028517 | 0·006401 | 0·401818 | 0·421408 |
| 0·41 | 12 | 24 | 40·8 | 9·639875 | 0·214928 | 0·030077 | 0·006706 | 0·411972 | 0·433237 |
| 0·42 | 12 | 45 | 13·0 | 9·631147 | 0·220758 | 0·031688 | 0·007016 | 0·422137 | 0·445185 |
| 0·43 | 13 | 5 | 58·0 | 9·622733 | 0·226642 | 0·033353 | 0·007331 | 0·432312 | 0·457257 |
| 0·44 | 13 | 26 | 56·9 | 9·614624 | 0·232581 | 0·035074 | 0·007651 | 0·442497 | 0·469462 |
| 0·45 | 13 | 48 | 9·9 | 9·606814 | 0·238580 | 0·036851 | 0·007974 | 0·452694 | 0·481807 |
| 0·46 | 14 | 9 | 38·4 | 9·599295 | 0·244642 | 0·038687 | 0·008301 | 0·462903 | 0·494301 |
| 0·47 | 14 | 31 | 23·1 | 9·592062 | 0·250770 | 0·040583 | 0·008631 | 0·473125 | 0·506951 |
| 0·48 | 14 | 53 | 24·9 | 9·585110 | 0·256968 | 0·042543 | 0·008963 | 0·483361 | 0·519768 |
| 0·49 | 15 | 15 | 45·0 | 9·578435 | 0·263242 | 0·044568 | 0·009298 | 0·493612 | 0·532762 |
| 0·50 | 15 | 38 | 24·5 | 9·572035 | 0·269595 | 0·046660 | 0·009634 | 0·503878 | 0·545944 |
| 0·51 | 16 | 1 | 24·7 | 9·565907 | 0·276032 | 0·048822 | 0·009970 | 0·514160 | 0·559326 |
| 0·52 | 16 | 24 | 46·9 | 9·560051 | 0·282560 | 0·051058 | 0·010307 | 0·524460 | 0·572923 |
| 0·53 | 16 | 48 | 32·8 | 9·554465 | 0·289184 | 0·053370 | 0·010643 | 0·534778 | 0·586748 |
| 0·54 | 17 | 12 | 43·8 | 9·549151 | 0·295911 | 0·055761 | 0·010976 | 0·545116 | 0·600818 |
| 0·55 | 17 | 37 | 22·1 | 9·544112 | 0·302749 | 0·058236 | 0·011306 | 0·555475 | 0·615152 |
| 0·56 | 18 | 2 | 29·6 | 9·539349 | 0·309706 | 0·060801 | 0·011633 | 0·565857 | 0·629769 |
| 0·57 | 18 | 28 | 8·6 | 9·534869 | 0·316792 | 0·063459 | 0·011954 | 0·576264 | 0·644692 |
| 0·58 | 18 | 54 | 21·9 | 9·530677 | 0·324018 | 0·066216 | 0·012267 | 0·586698 | 0·659947 |
| 0·59 | 19 | 21 | 12·4 | 9·526782 | 0·331395 | 0·069078 | 0·012570 | 0·597160 | 0·675563 |
| 0·60 | 19 | 48 | 43·5 | 9·523193 | 0·338937 | 0·072052 | 0·012861 | 0·607654 | 0·691572 |
| 0·61 | 20 | 16 | 59·2 | 9·519923 | 0·346659 | 0·075147 | 0·013138 | 0·618182 | 0·708014 |
| 0·62 | 20 | 46 | 4·0 | 9·516917 | 0·354581 | 0·078372 | 0·013397 | 0·628748 | 0·724932 |
| 0·63 | 21 | 16 | 3·1 | 9·514405 | 0·362723 | 0·081738 | 0·013635 | 0·639355 | 0·742376 |
| 0·64 | 21 | 47 | 2·9 | 9·512199 | 0·371111 | 0·085259 | 0·013847 | 0·650009 | 0·760409 |
| 0·65 | 22 | 19 | 11·0 | 9·510399 | 0·379774 | 0·088949 | 0·014028 | 0·660715 | 0·779105 |
| 0·66 | 22 | 52 | 36·5 | 9·509041 | 0·388751 | 0·092827 | 0·014170 | 0·671479 | 0·798551 |
| 0·67 | 23 | 27 | 30·8 | 9·508171 | 0·398085 | 0·096916 | 0·014265 | 0·682310 | 0·818858 |
| 0·68 | 24 | 4 | 8·0 | 9·507848 | 0·407835 | 0·101245 | 0·014301 | 0·693219 | 0·840163 |

DIAGRAM Nº 3

NEW SOUTH WALES GOVERNMENT RAILWAYS

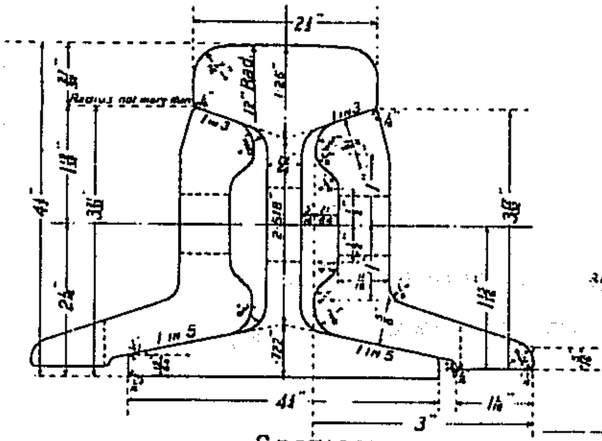
# SUPERELEVATION ON CURVES

| Radius in Chains | Up Grades | | | | | | | | | | | | Level or Down Grades |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1/33 | 1/40 | 1/50 | 1/60 | 1/66 | 1/80 | 1/100 | 1/150 | 1/200 | 1/250 | 1/400 | 1/1,000 | |
| 8 | ¾" | 1" | 1½" | 2¼" | 2½" | 3½" | 4½" | 4½" | 4½" | 4½" | 4½" | 4½" | 4½" |
| 9 | ¾" | 1" | 1½" | 2" | 2¼" | 3" | 4¼" | 4½" | 4½" | 4½" | 4½" | 4½" | 4½" |
| 10 | ¾" | ¾" | 1¼" | 1¾" | 2" | 2¾" | 3¾" | 4½" | 4½" | 4½" | 4½" | 4½" | 4½" |
| 11 | ½" | ¾" | 1" | 1¾" | 2" | 2½" | 3½" | 4½" | 4½" | 4½" | 4½" | 4½" | 4½" |
| 12 | ½" | ¾" | 1" | 1½" | 1¾" | 2¼" | 3¼" | 4½" | 4½" | 4½" | 4½" | 4½" | 4½" |
| 15 | ½" | ½" | ¾" | 1¼" | 1½" | 1¾" | 2½" | 4¼" | 4½" | 4½" | 4½" | 4½" | 4½" |
| 20 | ¼" | ½" | ¾" | 1" | 1" | 1½" | 2" | 3" | 4" | 4½" | 4½" | 4½" | 4½" |
| 25 | ¼" | ¼" | ½" | ¾" | ¾" | 1" | 1½" | 2½" | 3¼" | 3¾" | 4½" | 4½" | 4½" |
| 30 | ¼" | ¼" | ½" | ½" | ¾" | 1" | 1¼" | 2" | 2¾" | 3" | 4" | 4½" | 4½" |
| 35 | ¼" | ¼" | ½" | ½" | ½" | ¾" | 1" | 1¾" | 2¼" | 2½" | 3½" | 4¼" | 4½" |
| 40 | ¼" | ¼" | ¼" | ½" | ½" | ¾" | 1" | 1½" | 2" | 2¼" | 3" | 3¾" | 3¾" |
| 60 | - | ¼" | ¼" | ¼" | ¼" | ½" | ½" | 1" | 1¼" | 1½" | 2" | 2½" | 2½" |
| 80 | - | - | ¼" | ¼" | ¼" | ¼" | ½" | ¾" | 1" | 1¼" | 1½" | 1¾" | 1¾" |

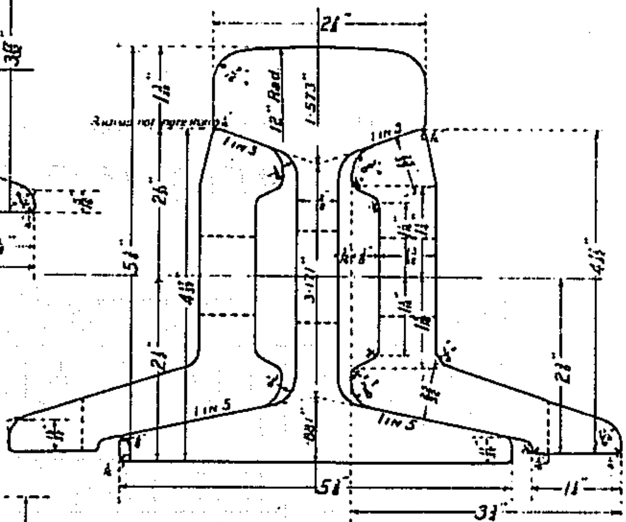
DIAGRAM No. 4

NEW SOUTH WALES GOVERNMENT RAILWAYS

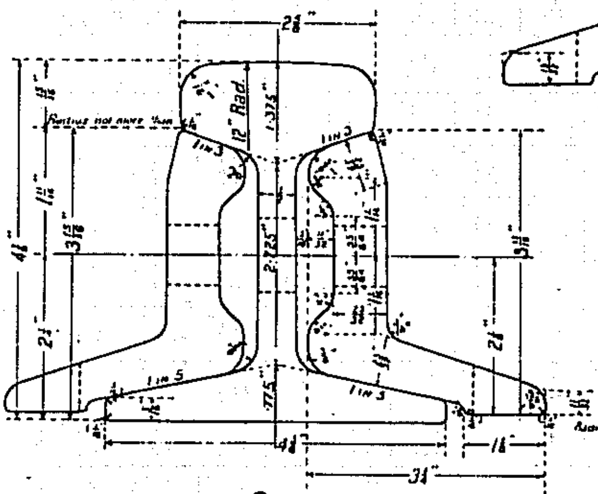
# STANDARD RAIL SECTIONS



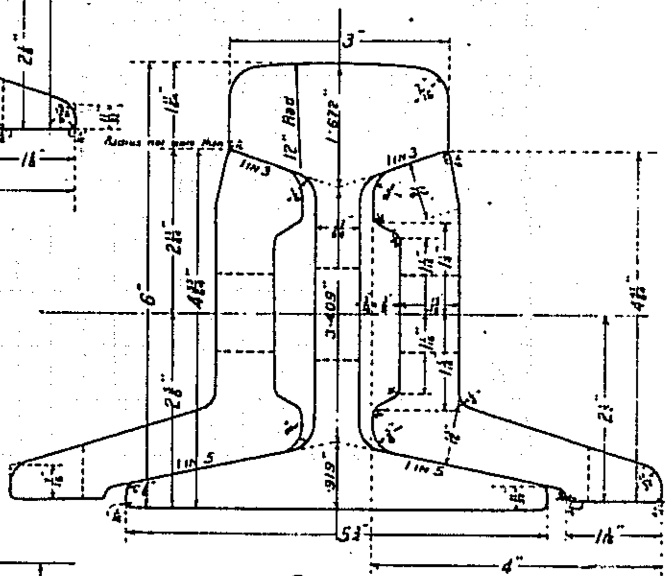
SECTION
Standard 60 lb. Rail



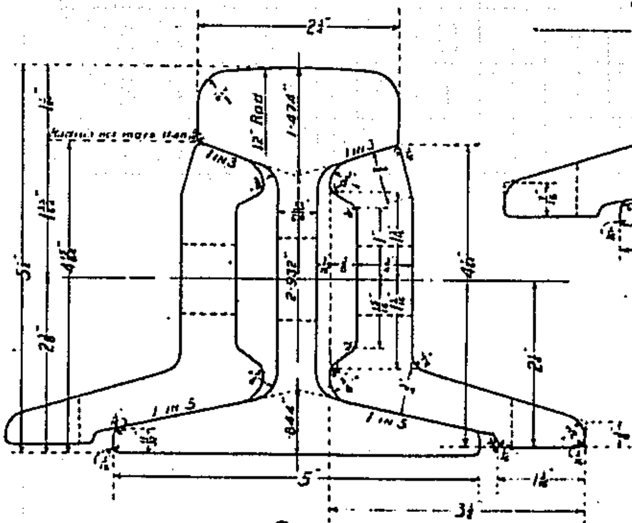
SECTION
Standard 90 lb. Rail



SECTION
Standard 70 lb. Rail



SECTION
Standard 100 lb. Rail



SECTION
Standard 80 lb. Rail

DIAGRAM Nº 5

NEW SOUTH WALES GOVERNMENT RAILWAYS

# LEAD AND RADIUS OF STANDARD CROSSINGS

| WEIGHT OF RAIL | | 60 lb. and 70 lb. | | 80 lb. | | 90 lb. and 100 lb. | |
|---|---|---|---|---|---|---|---|
| LENGTH OF POINTS | | 15' 0" (4⅝" BASE) | | 16' 6" (5" BASE) | | 20' 0" (5¾" BASE) | |
| SWITCH ANGLE | δ | 1° 28' 20·44" | | 1° 26' 49·26" | | 1° 22' 22·23" | |
| CROSSING | | LEAD | RADIUS | LEAD | RADIUS | LEAD | RADIUS |
| | | FEET | FEET | FEET | FEET | FEET | FEET |
| 1 IN 11 | 5° 11' 39·94" | 89·215 | 1142·293 | 90·460 | 1130·640 | 93·708 | 1104·830 |
| 1 IN 10½ | 5° 26' 25·20" | 86·569 | 1033·231 | 87·813 | 1022·979 | 91·041 | 1000·416 |
| 1 IN 9 | 6° 20' 24·69" | 78·304 | 744·766 | 79·551 | 737·924 | 82·732 | 723·157 |
| 1 IN 8¼ | 6° 54' 40·42" | 73·978 | 620·898 | 75·229 | 615·390 | 78·393 | 603·615 |
| 1 IN 7½ | 7° 35' 40·71" | 69·515 | 509·722 | 70·773 | 505·343 | 73·927 | 496·071 |
| 1 IN 6 660' OFF | 9° 27' 44·35" | 60·394 | 635·848 | 61·680 | 625·820 | 64·857 | 605·457 |
| 1 IN 5¼ 528' OFF | 10° 37' 10·76" | 56·086 | 495·406 | 57·387 | 487·851 | 60·570 | 472·602 |

Lead is measured along rail of main line, from point of switch, to theoretical point of crossing.

DIAGRAM No 6

## NEW SOUTH WALES GOVERNMENT RAILWAYS

## TABLES OF FORMULAE FOR CALCULATING LEADS AND ANGLES OF CROSSINGS

The following symbols are used throughout:-

- $g$ *the gauge of the line.*
- $d$ *the distance between the running faces of the switch and the stock rail, at heel of switch.*
- $\delta$ *the angle between the switch and the stock rail* $= \sin^{-1} \frac{d}{\text{length of switch}}$.
- $\alpha$ *the angle of crossing.*
- $r$ *the radius of the centre line of the main-line curve.*
- $R$ *the radius of the turn-out curve measured to the rail on which the crossing lies.*
- $L_s$ *the lead, measured along the main-line rail from heel of switch, to theoretical point of crossing, when the main line is straight.*
- $L_c$ *the lead, similarly measured, when the main line is curved.*
- $T$ *the length of the turn-out curve, measured along the rail, from heel of switch, to theoretical point of crossing.*

### MAIN LINE STRAIGHT

To find lead, etc. with given crossing and switch

| | |
|---|---|
| Lead $L_s$ | $(g-d)\cot\frac{\alpha+\delta}{2}$ |
| Radius R | $\frac{g-d}{\cos\delta-\cos\alpha}$ or $\frac{g-d}{2\sin\frac{\alpha+\delta}{2}\sin\frac{\alpha-\delta}{2}}$ |
| Length of Curve T | $(\alpha-\delta)^{*}.\,R$ |
| Middle offset of T | $R.\ \text{vers}\frac{\alpha-\delta}{2}$ |

* *In this and similar formulae the angle must, of course, be taken in radian measure.*

### VALUES OF α AND COS α FOR SOME CROSSINGS

If the Crossing is 1 in $n$, then $n = \cot\alpha$.

| Crossing | α | Cos α |
|---|---|---|
| 1 in 11 | 5° 11′ 40″ | 0·9958932 |
| 1 " 10½ | 5 26 25 | 0·9954956 |
| 1 " 9 | 6 20 25 | 0·9938835 |
| 1 " 8¼ | 6 54 40 | 0·9927337 |
| 1 " 7½ | 7 35 41 | 0·9912277 |
| 1 " 6 | 9 27 44 | 0·9863942 |
| 1 " 5⅓ | 10 37 11 | 0·9828721 |

### MAIN LINE CURVED AND CROSSING ON INNER RAIL OF CURVE.

To find lead, etc., with given crossing and switch. *Similar Flexure.*

| | |
|---|---|
| $\beta$ | $2\tan^{-1}\left(\frac{g-d}{2r}\cot\frac{\alpha+\delta}{2}\right)$ or $2\tan^{-1}\frac{L_s}{2r}$ |
| Lead $L_c$ | $\beta.\left(r-\frac{g}{2}\right)$ |
| Radius R | $\left(r-\frac{g}{2}\right)\frac{\sin\beta}{\sin(\alpha+\beta)-\sin\delta}$ or $\left(r-\frac{g}{2}\right)\frac{\sin\beta}{2\sin\frac{\alpha+\beta-\delta}{2}\cos\frac{\alpha+\beta+\delta}{2}}$ |
| Length of Curve T | $(\alpha+\beta-\delta).\,R$ |
| Middle offset of T | $R.\ \text{vers}\frac{\alpha+\beta-\delta}{2}$ |

### MAIN LINE CURVED AND CROSSING ON OUTER RAIL OF CURVE.

CURVES OF MAIN LINE AND TURN-OUT OF SIMILAR FLEXURE.

To find lead, etc., with given crossing and switch.

| | |
|---|---|
| $\beta$* | $2\tan^{-1}\left(\frac{g-d}{2r}\cot\frac{\alpha+\delta}{2}\right)$ or $2\tan^{-1}\frac{L_s}{2r}$ |
| Lead $L_c$ | $\beta\ \left(r+\frac{g}{2}\right)$ |
| Radius R | $\left(r+\frac{g}{2}\right)\frac{\sin\beta}{\sin(\beta-\alpha)+\sin\delta}$ or $\left(r+\frac{g}{2}\right)\frac{\sin\beta}{2\sin\frac{\beta+\delta-\alpha}{2}\cos\frac{\beta-\alpha-\delta}{2}}$ |
| Length of Curve T | $(\beta+\delta-\alpha).\,R$ |
| Middle offset of T | $R.\ \text{vers}\frac{\beta+\delta-\alpha}{2}$ |

* *If $\beta$ is less than $(\alpha-\delta)$ this combination is impossible, and the curves must be of contrary flexure. If $\beta=\alpha-\delta$ the turn-out is straight.*

### MAIN LINE CURVED AND CROSSING ON OUTER RAIL OF CURVE.

CURVES OF MAIN LINE AND TURN-OUT OF CONTRARY FLEXURE.

To find, lead, etc with given switch and crossing.

| | |
|---|---|
| $\beta$* | $2\tan^{-1}\left(\frac{g-d}{2r}\cot\frac{\alpha+\delta}{2}\right)$ or $2\tan^{-1}\frac{L_s}{2r}$ |
| Lead $L_c$ | $\beta.\left(r+\frac{g}{2}\right)$ |
| Radius R | $\left(r+\frac{g}{2}\right)\frac{\sin\beta}{\sin(\alpha-\beta)-\sin\delta}$ or $\left(r+\frac{g}{2}\right)\frac{\sin\beta}{2\sin\frac{\alpha-\beta-\delta}{2}\cos\frac{\alpha-\beta+\delta}{2}}$ |
| Length of Curve T | $(\alpha-\beta-\delta).\,R$ |
| Middle offset of T | $R.\ \text{vers}\frac{\alpha-\beta-\delta}{2}$ |

* *If $\beta$ is greater than $(\alpha-\delta)$ this combination is impossible, and the curves must be of similar flexure. If $\beta=\alpha-\delta$ the turn-out is straight.*

### GIVEN THE CURVES OF MAIN LINE AND TURN-OUT, TO FIND THE CROSSING REQUIRED.

$r$ = *radius of centre line of main-line curve.*
$r_1$ = " " " " " *turn-out curve.*

| Main Line | Crossing on Inner or Outer Rail | Flexure of Curves | Value of cos α: Exact | Value of cos α: Approximate |
|---|---|---|---|---|
| Straight | .. | .. | $\cos\delta-\frac{g-d}{r_1+\frac{g}{2}}$ | $\frac{r_1-\frac{g}{2}}{r_1+\frac{g}{2}}$ |
| Curved | Inner | Similar | $\frac{r+\frac{g}{2}-d}{r-\frac{g}{2}}\cos\delta-\frac{(g-d)\left(r+\frac{d}{2}\right)}{\left(r-\frac{g}{2}\right)\left(r_1+\frac{g}{2}\right)}$ | $\frac{r+\frac{g}{2}}{r-\frac{g}{2}}-\frac{gr}{\left(r-\frac{g}{2}\right)\left(r_1+\frac{g}{2}\right)}$ |
| Curved | Outer | Similar | $\frac{r-\frac{g}{2}+d}{r+\frac{g}{2}}\cos\delta+\frac{(g-d)\left(r+\frac{d}{2}\right)}{\left(r+\frac{g}{2}\right)\left(r_1-\frac{g}{2}\right)}$ | $\frac{r-\frac{g}{2}}{r+\frac{g}{2}}+\frac{gr}{\left(r+\frac{g}{2}\right)\left(r_1-\frac{g}{2}\right)}$ |
| Curved | Outer | Contrary | $\frac{r-\frac{g}{2}+d}{r+\frac{g}{2}}\cos\delta-\frac{(g-d)\left(r+\frac{d}{2}\right)}{\left(r+\frac{g}{2}\right)\left(r_1+\frac{g}{2}\right)}$ | $\frac{r-\frac{g}{2}}{r+\frac{g}{2}}-\frac{gr}{\left(r+\frac{g}{2}\right)\left(r_1+\frac{g}{2}\right)}$ |

NEW SOUTH WALES GOVERNMENT RAILWAYS

# CONVENTIONAL ENGINE LOADINGS

(Loads for one track)

E60 ≈ M267 ≈ M270

## *Loading for Trunk and Branch Lines.*

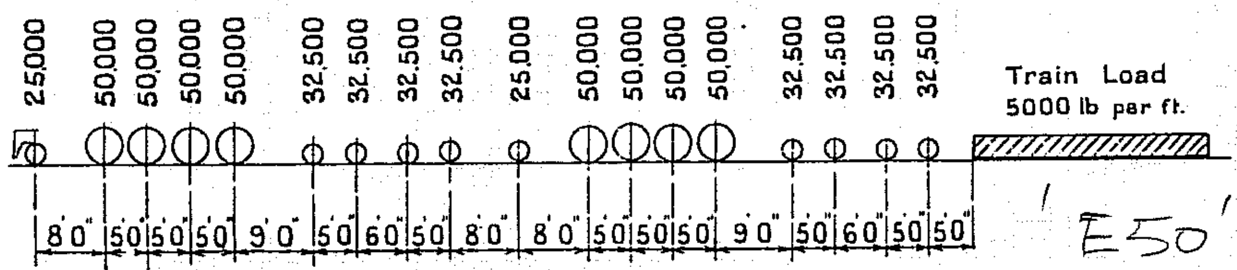
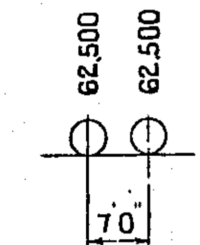



DIAGRAM No 7




Special Loading

## *Loading for Pioneer Lines*

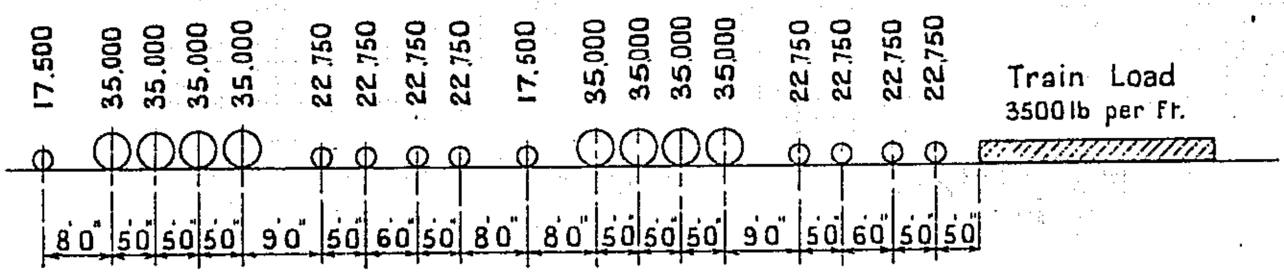
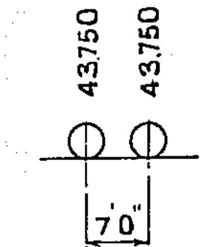



DIAGRAM No 8




Special Loading

DIAGRAM Nº 9

NEW SOUTH WALES GOVERNMENT RAILWAYS

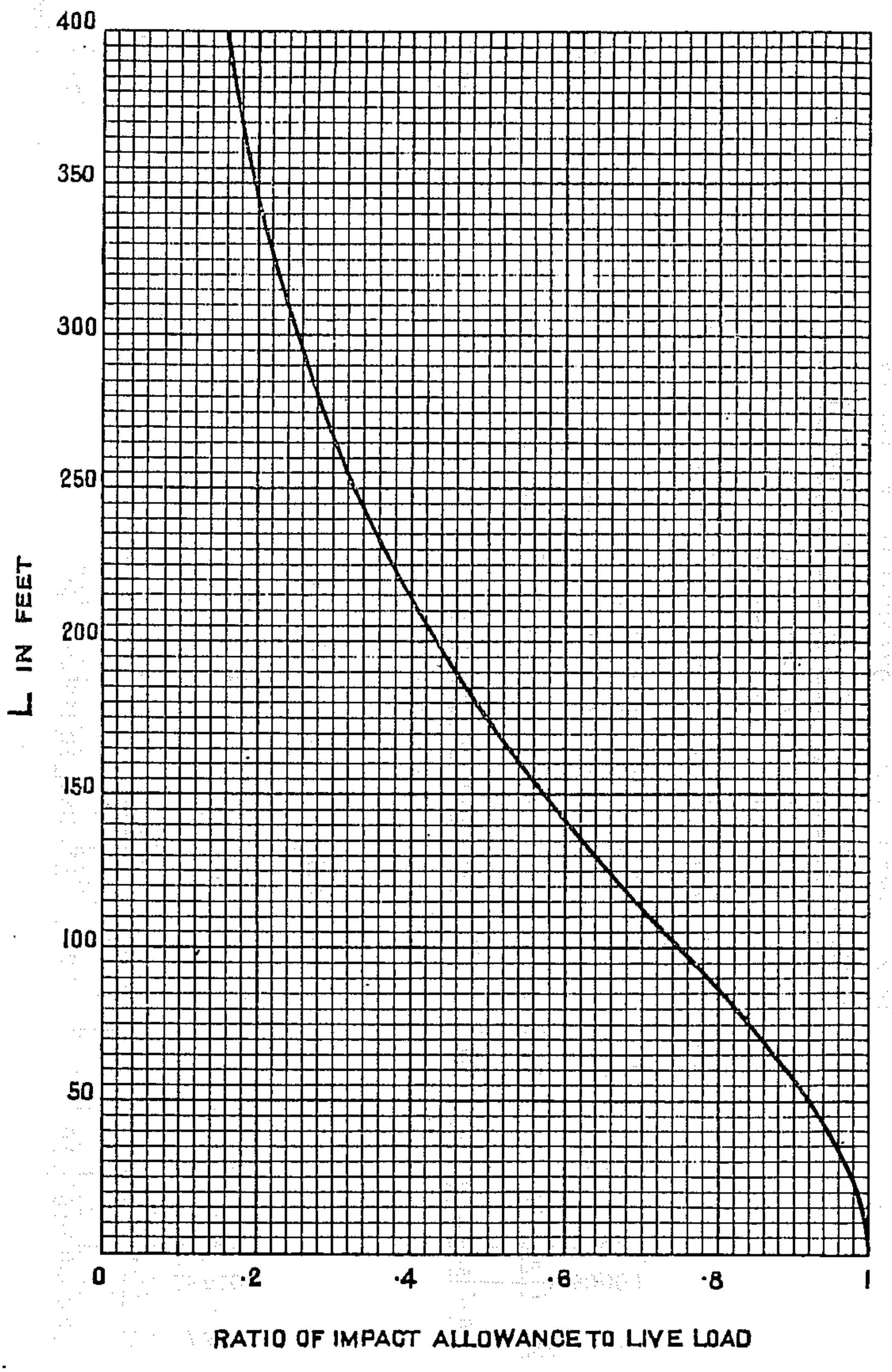
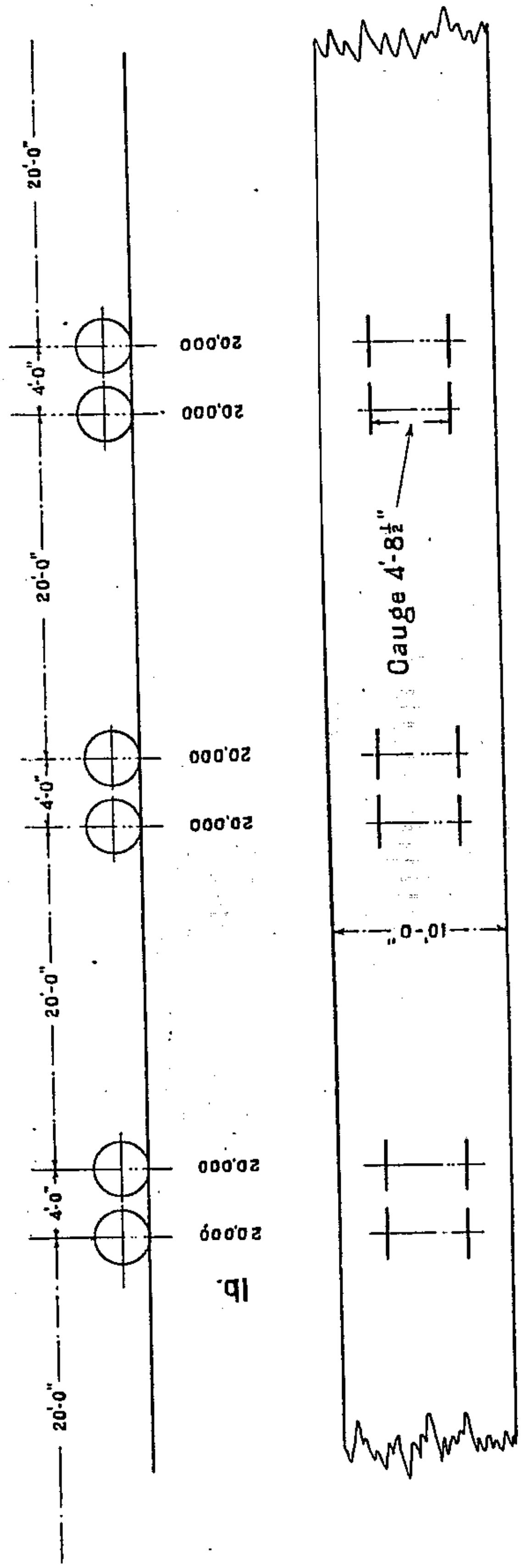


DIAGRAM Nº 10

NEW SOUTH WALES GOVERNMENT RAILWAYS

TRAMWAY LOADING



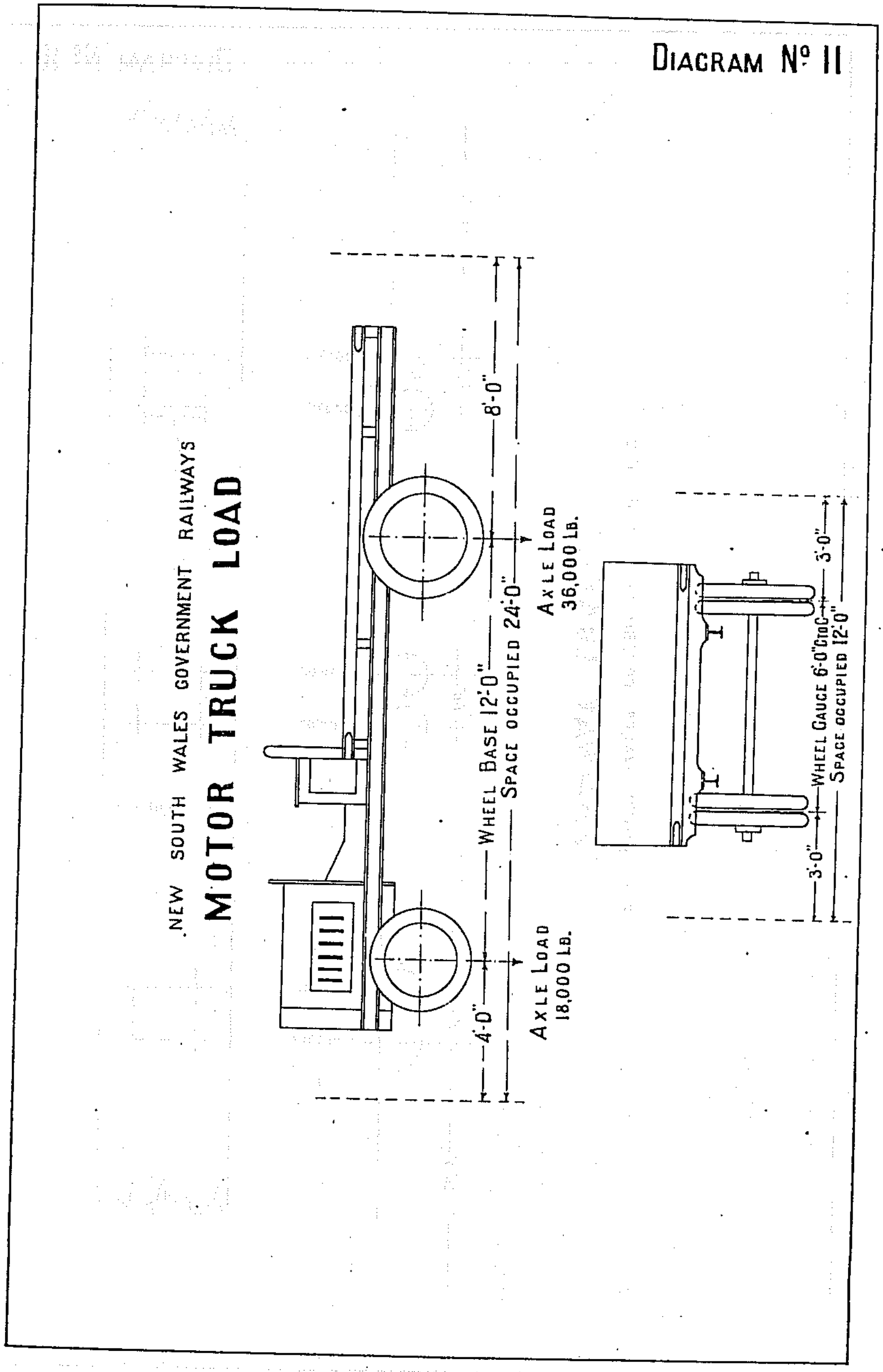



Diagram Nº II

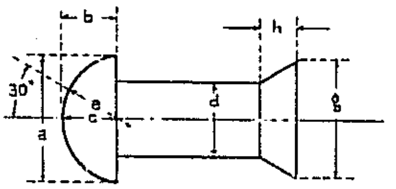
DIAGRAM Nº12

# N.S.W. GOVT RAILWAYS

# RIVETING DETAILS

## TABLE 1

### PROPORTIONS OF RIVETS.

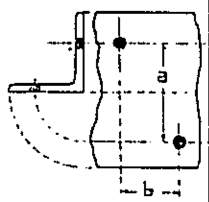



| Diam. of Shank d | Full Head Diam. a | Full Head Height b | Full Head Radii c | Full Head Radii e | Countersunk Diam. g | Countersunk Depth h |
|---|---|---|---|---|---|---|
| 1" | 1 5/8" | 11/16" | 11/16" | 1 1/32" | 1 9/16" | 1/2" |
| 7/8" | 1 7/16" | 39/64" | 39/64" | 59/64" | 1 3/8" | 7/16" |
| 3/4" | 1 1/4" | 17/32" | 17/32" | 51/64" | 1 3/16" | 3/8" |
| 5/8" | 1 1/16" | 29/64" | 29/64" | 43/64" | 1" | 5/16" |
| 1/2" | 7/8" | 3/8" | 3/8" | 9/16" | 25/32" | 1/4" |
| 3/8" | 11/16" | 19/64" | 19/64" | 7/16" | 19/32" | 3/16" |

## TABLE 2

### STAGGER OF RIVETS REQUIRED TO MAINTAIN NET SECTION.

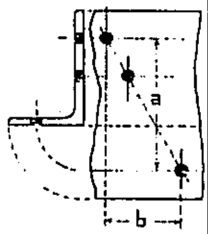
ONE HOLE OUT




$y$ = Diam. of Rivet + 1/8"

$b = \sqrt{2ay + y^2}$

TWO HOLES OUT

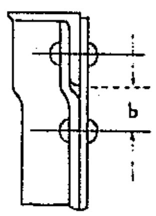



NOTE
"a" SHOULD BE MEASURED ON CENTRE FIBRE OF L.

| Sum of Gauges a | Size of Rivet 5/8" b | Size of Rivet 3/4" b | Size of Rivet 7/8" b | Size of Rivet 1" b |
|---|---|---|---|---|
| 1" | 1 7/16" | 1 5/8" | 1 3/4" | 1 7/8" |
| 1 1/2" | 1 11/16" | 1 7/8" | 2" | 2 3/16" |
| 2" | 1 15/16" | 2 1/16" | 2 1/4" | 2 7/16" |
| 2 1/2" | 2 1/8" | 2 1/4" | 2 1/2" | 2 5/8" |
| 3" | 2 1/4" | 2 7/16" | 2 11/16" | 2 7/8" |
| 3 1/2" | 2 7/16" | 2 5/8" | 2 7/8" | 3" |
| 4" | 2 9/16" | 2 13/16" | 3" | 3 1/4" |
| 4 1/2" | 2 3/4" | 2 15/16" | 3 3/16" | 3 3/8" |
| 5" | 2 7/8" | 3 1/8" | 3 5/16" | 3 9/16" |
| 5 1/2" | 3" | 3 1/4" | 3 1/2" | 3 11/16" |
| 6" | 3 1/8" | 3 3/8" | 3 5/8" | 3 7/8" |
| 6 1/2" | 3 1/4" | 3 1/2" | 3 3/4" | 4" |
| 7" | 3 5/16" | 3 5/8" | 3 7/8" | 4 1/8" |
| 7 1/2" | 3 7/16" | 3 3/4" | 4" | 4 1/4" |
| 8" | 3 9/16" | 3 7/8" | 4 1/8" | 4 7/16" |
| 8 1/2" | 3 11/16" | 4" | 4 1/4" | 4 1/2" |

## TABLE 3

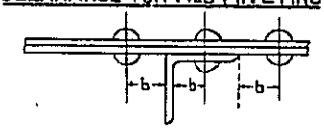
### RIVETS IN JOGGLED ANGLES




DISTANCE "b" SHOULD BE 1½" PLUS THICKNESS OF CHORD ANGLES, BUT NEVER LESS THAN 2".

## TABLE 4

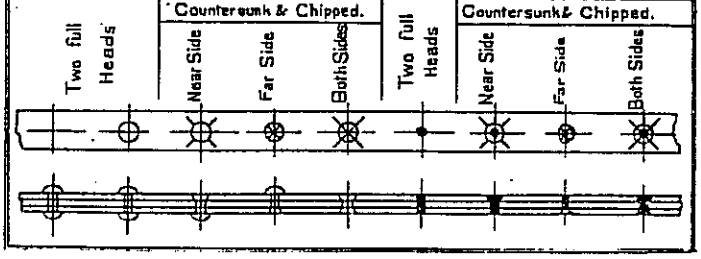
### CLEARANCE FOR WEB RIVETING




| Dia. of Rivet | Dimension "b" Minimum | Dimension "b" Standard |
|---|---|---|
| 1 1/8" | 1 3/8" | 1 5/8" |
| 1" | 1 1/4" | 1 1/2" |
| 7/8" | 1 1/8" | 1 3/8" |
| 3/4" | 1" | 1 1/4" |
| 5/8" | 7/8" | 1 1/8" |

## TABLE 5

### CONVENTIONAL SIGNS FOR RIVETING



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1922.