

Memorandum
on the Lay-out and
Construction of Roads

Memorandum No. 575

(Superseding Memorandum No. 483 (Roads))



MINISTRY OF WAR TRANSPORT

Memorandum on the Lay-out and Construction of Roads

LONDON: PUBLISHED BY HIS MAJESTY'S STATIONERY OFFICE
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1943

(Reprinted 1949)

Price 6d. net

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LAY-OUT AND CONSTRUCTION OF ROADS

1. INTRODUCTION

Memorandum 336 (Roads), which contained notes on the lay-out and construction of roads, was issued in August, 1930, and intimation was then given that the notes would be revised from time to time. In February, 1937, Memorandum No. 483 (Roads) on the lay-out and construction of roads was issued and many new devices were introduced for the better control of traffic and for reducing the risks of the road user. At the outbreak of war the revision of this Memorandum was being undertaken by the Experimental Work on Highways (Technical) Committee, augmented by representatives of the Institution of Municipal and County Engineers and the County Surveyors' Society. It is considered undesirable to incorporate emergency instructions due to the war, as modifications of these are likely to occur from time to time, and the recommendations are therefore published as applicable to post-war conditions.

This Memorandum has been framed and revised mainly in relation to highways in the open country and those portions of urban areas where building development has not yet imposed serious restriction upon road-planning. Nevertheless many of the principles recommended can be adapted in greater or less degrees to built-up areas. The full application of certain standards may require adjustment to fit the special circumstances of local areas, including topography and climate, and industrial or other special development. Subject, however, to such reservation there is wide scope for a greater uniformity of practice than has hitherto been achieved, not only as regards the materials and methods of construction, but also in the selection of the appropriate lay-out of the road within the effective width, according to its category and traffic purpose.

In the application of the recommendations set out hereafter the merit of any scheme should be judged by the extent to which it furthers public safety, promotes the smooth flow of traffic of all kinds, and enhances the amenities of the neighbourhood.

2. PUBLIC SAFETY

The Minister appreciates that the safety of the roads must largely depend upon the care and consideration with which all classes of road-users conduct themselves and upon the systematic observance of the provisions of the Highway Code.

Rational planning and design, based upon study of the known or ascertainable data of traffic and other factors, can materially contribute to a reduction of the accident risk by the adaptation or enlargement of highways to serve the increased volume and changing character of traffic.

Built-up areas should be by-passed by roads so designed that the circulation of through traffic does not interfere with that which is mainly local. Such roads should incorporate the following features :

(a) Restriction of points of access and inter-connection with minor roads.

(b) Discouragement of frontage development. Where this is unavoidable provision should be made for access by way of subsidiary carriage-ways, which should not form part of the road.

- (c) The installation of improved street lighting in urban areas.
- (d) Well-designed road junctions.
- (e) the consistent use of standard road direction signs and traffic markings.
- (f) Cycle tracks, footpaths, and suitable crossings for pedestrians.
- (g) Road surfaces of suitable contour and uniform non-skid character.

The safety of a highway system may be regularly and methodically tested and reviewed by the compilation of map records of accidents, and these should be maintained by the engineer to the Highway Authority in co-operation with the police. The study of such maps and the analyses of the accident records should provide valuable guidance upon the extent and nature of the remedial measures which could most profitably be undertaken.

3. TRAFFIC SURVEY

An investigation of traffic conditions is a necessary preliminary to the construction or improvement of a road. Information should be obtained as to the volume and direction of the main traffic flows, the points of congestion and the causes thereof, the incidence of standing vehicles, and the likelihood of residential and industrial development in the neighbourhood.

Such a survey should deal with an area as a whole rather than with any particular road or junction within that area. Restrictions placed upon the traffic using a particular road are likely to have an influence on the traffic conditions on other roads in the vicinity.

Information of the character indicated above is also indispensable in formulating a scheme of traffic control. A traffic scheme for any particular area should be planned so as to utilise the advantages of roundabouts, refuges, warning and direction signs and traffic control signals, and, where necessary, consideration should be given to the modification of existing lay-outs.

4. AMENITIES

Every care should be taken not merely to safeguard existing amenities, but to add to them. The beauty and interest of the countryside depend largely upon the preservation of ancient cottages and other picturesque wayside buildings, and in considering the proposed alignment of a road the effect upon amenities should be carefully borne in mind.

Trees should not be felled unless such a course is unavoidable; they can often be left standing on grass verges and the line or level of the road deviated so as to secure their preservation. It is, however, undesirable that carriageways should be aligned too closely to existing trees. Tree-planting should be encouraged, but where possible the planting should allow adequate space for the future widening or duplication of the carriageway, and the laying of underground mains and services. The species of trees should be carefully selected with particular regard to their suitability for planting in public roads, and the climate, soil, and subsoil conditions. Their dimensions and spread on attaining maturity should be envisaged. (Fuller reference is made to tree-planting in Section 26.)

Verges and the slopes of cuttings and embankments should be soiled and seeded, or in appropriate cases turfed or planted with suitable shrubs. The treatment of these features should conform to the natural characteristics of the district, and should be made to harmonize as far as possible with the landscape.

Grass verges should be levelled and trimmed, adequately drained, and kept clear of all unnecessary obstructions. Transverse grips or open channels should not be constructed : outlets for surface water drainage should be piped and efforts made to maintain the verges as tracks for horsemen, where this provision can be justified.

Traffic signs should be kept in good condition, and those which are redundant should be removed. The backs of traffic signs should be painted in suitable tints to render them as inconspicuous as possible. Attention is drawn to the Advertisements Regulation Act, 1925, and to Section 47 of the Town and Country Planning Act, 1932, which empower Local Authorities to protect amenities within the vicinity of highways from being spoiled by advertisements.

Section 7 (2) of the Restriction of Ribbon Development Act, 1935, requires Highway Authorities, when dealing with applications for consent to development under the Act, to have regard to the need for preserving the amenities of the locality and for securing well-planned development. In addition, Section 12 of the Town and Country Planning Act, 1932, provides that the responsible authority may regulate the design and external appearance of new buildings in areas dealt with under town-planning schemes. The development of frontages (at junctions and roundabouts) in urban areas affords opportunities for dignified architectural treatment ; where local authorities are themselves owners of such sites they are in a position to impose upon purchasers conditions which will secure suitable treatment, whilst ensuring that full consideration is given to traffic requirements.

Every effort should be made to avoid interference with commons, parks, playing fields, and open spaces for recreational or other public purposes, and with buildings of special architectural or historical interest.

5. ACQUISITION OF LAND

When acquiring land for a new road, no relaxation of any restrictions under the Restriction of Ribbon Development Act, 1935, should be allowed for the purpose of obtaining betterment of abutting or adjacent lands.

LAY-OUT

6. GENERAL

Lay-out depends primarily upon the volume and character of the existing and potential traffic, and may be influenced by the topography of the land, and in some cases by its geological characteristics.

The normal width of a lane in a carriageway with two traffic lanes should be 11 ft. and on a carriageway with more than two traffic lanes, the width should be 10 ft.

In the case of unclassified roads and one-way link roads, the width of the carriageway should not be less than 16 ft.

Under the Restriction of Ribbon Development Act, 1935, Highway Authorities are empowered to prescribe standard widths and should take full advantage of these powers to make ample provision for future traffic requirements. The segregation of certain classes and opposing flows of traffic is of the utmost value in the promotion of safety and convenience and, in determining the standard width, provision should be made for such future widening of the carriageway, or carriageways, and the construction of cycle tracks and footpaths as may become necessary. Ample space for central reservations, margins and verges should be provided for this purpose and for the planting

of trees or shrubs, the laying of underground mains and services, and for ensuring adequate visibility and space for movement of traffic at road junctions. Where the initial works form only a part of the ultimate lay-out, they should be so arranged that future works can be carried out with the minimum interference with existing work.

7. ROAD WIDTHS

In ordinary circumstances* the minimum effective width of the highway required to accommodate the proposed lay-out would be as follows :

PROPOSED LAY-OUT	Minimum Effective Width to be adopted <i>Feet</i>
Single carriageway not exceeding 30 ft. with footpaths	60
Single carriageway not exceeding 30 ft. with footpaths and cycle tracks	80
Dual carriageway (each of two traffic lanes), with foot- paths and no cycle tracks	80
Dual carriageway (each of two traffic lanes), with foot- paths and cycle tracks	100
Dual carriageways (each of three traffic lanes), with footpaths but no cycle tracks	100
Dual carriageways (each of three traffic lanes), with footpaths and cycle tracks	120

Widths additional to the foregoing may be considered desirable for the purposes of improved planning, amenities, the provision of increased accommodation for public services, wider cycle tracks or future development.

Roads which are likely to be used by a large number of heavy industrial and public service vehicles will require a dimension of 70 ft. between outer kerbs of dual carriageways to provide adequate turning space. In such cases the width of roads in the third category above should be increased to 100 ft. and those in the fourth category to 120 ft.

Where it is necessary to provide for large embankments and cuttings, regulations issued in accordance with the Restriction of Ribbon Development Act, 1935, permit the adoption of standard widths in excess of those referred to in the first schedule of the act.

8. ALIGNMENT

(a) **Location.** The alignment of new roads, diversions and by-passes is largely governed by the topography of the locality and regard should be had to public safety, potential requirements and economy of construction. Every effort should be made to avoid the absorption or severance of fertile land.

The road should be planned so that the new work merges into its environment with the least possible disturbance of existing amenities. The same principles should be applied as far as possible in the re-alignment and improvement of existing roads.

(b) **Curves.** Curves should normally be laid out as segmental arcs of the largest practicable radius. If the radius of the segmental arc is less than 5,000 ft. the curve should be approached at each end by a transition curve. Where

* The Committee recommended that in built-up areas it should be permissible to prescribe standard widths increasing by increments of five feet from 60 feet to 120 feet. The matter has been referred to a committee dealing with the lay-out of roads in urban areas.

the total length of the curve is not sufficient to permit the introduction of an adequate length of transition as an approach to a segmental arc, the curve should be made transitional throughout.

If physical conditions render the use of curves of shorter radius than 1,500 ft. unavoidable, the normal width of each traffic lane should be increased by one foot, this allowance to be increased to $1\frac{1}{2}$ ft. for each traffic lane where the radius is less than 1,000 ft. and two feet where the radius is less than 500 ft. Such added width should be obtained by widening the carriage-way at a uniform rate along the length of the transition curve. In the improvement of existing curves the widening should generally be made on the inside of the curve.

(c) **Super-elevation.** The following table is intended to afford general guidance of the super-elevation required for curves of various radii. It is recognised that in built up areas the degrees of super-elevation which can be provided is limited or even fixed by the local conditions ; each case will require separate consideration.

Radius in Feet	Super-elevation
1,200 or less	1 in 14 $\frac{1}{2}$
1,400	1 in 17
1,600	1 in 19
1,800	1 in 22
2,000	1 in 24
2,500	1 in 30
3,000	1 in 36
3,500	1 in 37
4,000	1 in 38
4,500	1 in 39
5,000	1 in 40
5,000 to 7,500	1 in 40 to 1 in 48, according to nature of material.
Over 7,500	Normal camber or cross-fall retained.

The elimination of adverse camber and the attainment of the required super-elevation should be obtained by raising the outer above the inner channel of the carriageway at a uniform rate along the length of the transition, from the end of the straight to the commencement of the circular curve, where the super-elevation should reach its maximum.

9. GRADIENTS

In normal circumstances a gradient of 1 in 30 may be regarded as the maximum but steeper gradients may be necessary to avoid excessive quantities of excavation or filling, particularly in hilly districts.

In order to facilitate surface drainage channels should be graded to a minimum fall of 1 in 250. Where the longitudinal gradient of the road is less than this the normal camber of the carriageway should not be varied, except at the channels which should have frequent outlets. Steep gradients should be avoided at approaches to road junctions, roundabouts, bridges, acute bends, and where the movement of traffic is restricted. All changes of gradient should be gradually effected by means of vertical curves of ample length.

10. VISIBILITY AT CHANGES OF GRADIENT

On a single carriageway road a driver whose eye-level is 3 ft. 9 ins. above the carriageway should have a view of the top of an object on the carriageway 3 ft. 9 ins. high at all distances up to 1,000 ft. Where visibility is less than the standard and cannot be improved traffic should be guided by a white line marked in accordance with Figure 1. On a dual carriageway road a sight distance of 500 ft. will suffice.

11. VISIBILITY AT CORNERS, BENDS, AND JUNCTIONS

In the interest of public safety it is essential that Highway Authorities should take full advantage of their powers under the Restriction of Ribbon Development Act, 1935, and Section 4 of the Roads Improvement Act, 1925, to secure adequate visibility at corners.

The sight lines recommended for open country are indicated on the diagrams of junctions.

In built-up areas, provided that the intensity of traffic limits speed, or drivers have ample warning of the presence of the junction either by direct vision or by means of appropriate traffic signs, the speed of vehicles approaching a junction will rarely exceed 15 to 20 m.p.h. The sight lines may be defined by reference to the nearside kerb line of one road and the centre line of the road entering it from the left, distances being measured from the intersection of these two lines. A line joining a point approximately 50 ft. along the nearside kerb line to a point approximately 55 ft. along the centre line of the intersecting road will generally be suitable. These dimensions are based on traffic requirements and the resultant lay-out at a right-angled junction is not quite symmetrical; if modification is desirable for aesthetic reasons the adjustment should be made by lengthening one of the sight lines.

Where it is desirable to provide that traffic on one road shall proceed at or near the legal speed limit of 30 m.p.h. with minimum interruption, drivers approaching from a minor road should have a view along the major road for a greater distance than at normal junctions. This may be achieved by forming a sight line joining a point approximately 110 ft. along the nearside kerb line of the major road to a point approximately 55 ft. along the centre line of the minor road. If the presence and character of the junction are not obvious to drivers approaching it on the minor road, an appropriate warning sign should be erected.

On the open road the minimum range of visibility of 1,000 ft. between approaching vehicles should apply for single carriageways, and where this is unattainable the marking of traffic lanes is essential.

Verges and slopes of cuttings on the inside of a curve should not be planted with trees or shrubs which at maturity may obstruct the view of drivers.

In cases where the dimensions suggested in this memorandum are unattainable the use of fencing with vertical bars on the inner side of sharp curves should be avoided as this type of fencing tends to obstruct the line of vision.

Telephone kiosks, police boxes and similar structures should in no circumstances be permitted on islands or within sight lines at road junctions on bends, or indeed on any part of the highway.

12. TRAFFIC LANES

The division of the carriageway into traffic lanes by means of suitable markings assists the orderly movement of traffic and promotes greater safety on the highway. On classified roads each lane should be of the widths indicated in Section 6.

Markings should consist of lines four to five inches wide set out in accordance with the following schedule.

TYPE OF ROAD	MARKINGS
<i>Dual Carriageways</i>	
Three lanes in each carriageway ..	Two lines. Mark, 3 ft.; gap, 15 ft.
Two lanes in each carriageway ..	One line. Mark, 3 ft.; gap, 15 ft.
<i>Single Carriageways</i>	
Four lanes	Middle line: mark, 15 ft.; gap, 3 ft. Two side lines: mark, 3 ft.; gap, 15 ft.
Three lanes :	
(a) On straight	Two lines. Mark, 3 ft.; gap, 15 ft.
(b) At bends with less than 1,000 ft. sight lines.	One central continuous line extending 100 ft. in each direction beyond the tangent points. The three lane markings should be terminated 100 ft. from the continuous line.
(c) Near junctions	
(d) At changes of gradient with less than 1,000 ft. sight lines.	See description for (b) and (c) and Figure 1.
Two lanes	One line. Mark, 3 ft.; gap, 15 ft.

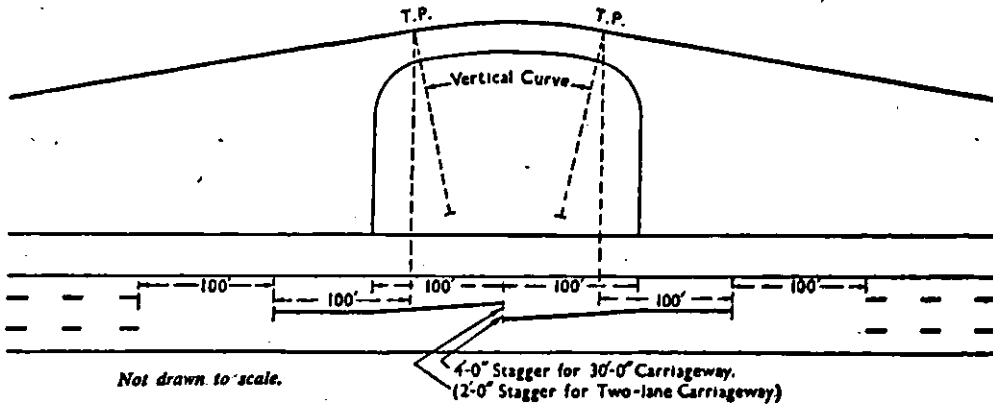


FIG. 1—Lay-out of white lines at summit of two gradients where visibility is below the standard.

In built-up areas traffic lane markings are best omitted on roads on which stationary vehicles frequently occupy a traffic lane on either side of the road.

In concrete construction longitudinal joints should if practicable be made to coincide with the lane markings for carriageways.

13. JUNCTIONS

(a) **General.** The aim of design in the lay-out of road junctions should be to provide for the safe movement of traffic and avoid delay and congestion. The anticipated extent and character of the traffic will largely determine the type of lay-out to be adopted, but physical conditions, the extent of land available and cost are also factors to be taken into account. On main traffic routes the number of road junctions should be kept at a minimum; it should not be assumed that access to the main road need be provided at every crossing with an existing road, and in the case of new roads of high traffic importance consideration should be given to constructing over or under bridges to obtain complete severance of local and through traffic and so allow the local traffic to function without interference.

At all road junctions sufficient space should be reserved for adequate visibility and for the lay-out eventually required for traffic purposes.

The junction of more than four roads should be avoided, except where there is ample space for a suitable roundabout.

At every road junction the requirements of pedestrians as well as other road users should be studied and the best possible provision should be made for them.

The control of traffic at a junction may be effected either by the design of the junction, by means of traffic control signals, or by signs, separately or in combination. In general the following notes will afford guidance as to the appropriate method of control :—

(i) A fly-over junction imposes the minimum of restraint on the flow of through traffic, but causes certain streams of turning traffic to make considerable detours ; pedestrian and cyclist traffic (and often through motor traffic) being compelled to traverse gradients. A junction of this type requires a considerable area of land, involves the construction of bridges, sub-ways, and earthworks, and is consequently costly.

(ii) A roundabout imposes restraint on the speed of all streams and all classes of traffic, but provides for continuance movement. All traffic except that making a left-hand turn is forced to make a detour but even on a large roundabout this is not incommensurate with the advantage gained. On the single level roundabout no traffic is required to negotiate a gradient, and on the two level roundabout the change of level is only approximately half that necessitated by a fly-over. The area of land necessary for a roundabout is less than in the case of a fly-over, and there are no bridges, although sub-ways are needed for pedestrians and cyclists at two-level roundabouts. In general the cost is considerably less for a roundabout than for a fly-over junction.

(iii) A three or four-way junction at which traffic is controlled by light signals cannot deal with such a large volume of vehicular traffic as a fly-over or roundabout, because the traffic moves intermittently instead of continuously. No additional land, carriageways, bridges or earthworks are required and it is, therefore, generally cheaper in the first cost. Where the volume of pedestrian traffic is heavy, and conditions are unfavourable to the construction of adequate sub-ways with easy approaches, public safety may be best assured by means of a suitably designed traffic signal installation. A signal controlled junction does not involve gradients or deviation of route.

In towns where there is heavy pedestrian traffic, guard rails should be placed adjacent to the kerbs, with openings at pedestrian crossings. Where similar precautions are necessary in rural surroundings the object may be more appropriately achieved by planting hedges a few feet behind the kerb and maintaining them at a height not exceeding three feet. In the vicinity of schools guard rails are preferable to hedges.

In the interests of safety pedestrians should be prevented from using the central islands of roundabouts as refuges, and there should be no footpaths around or crossing them.

To screen the glare of on-coming headlights, the surface of the central island of roundabouts should be sloped to a height of at least four feet at the centre, or planted with shrubs.

It is important to ensure that sources of light are so sited as to indicate clearly by their position the course of the route ahead; especially when a change of direction is involved. This is particularly important at road junctions and roundabouts where sources of light should be so placed that a

driver can not only see from some distance away that he is approaching a junction but can also appreciate the route which he should follow.

(b) **Typical Designs of Junctions** (excluding those controlled by traffic signals). A number of typical designs of junctions are shown in Diagrams 1 to 9. It may be necessary to modify them to suit local conditions but in doing so care should be taken to adhere to the principles indicated below, which form the bases of the designs. Where the angle of intersection differs appreciably from that shown on the typical lay-out consideration should be given to the practicability of altering the existing alignment of the roads so as to secure a lay-out approximating to one of those illustrated.

A number of the diagrams indicate dual carriageways of 30 ft. width. Where a width of 22 ft. is adequate for immediate construction the adjustment in width should be made on the central reservation without alteration in the position of the near side kerb line.

The following design data are common to all types of fly-over junctions :—

	<i>ft. ins.</i>
Headroom for bridges	16 6
Headroom for subways for cyclists	7 6
Headroom for subways for pedestrians	7 0
Minimum width of footpaths	6 0
Width of two-way cycle tracks (where existing)	14 0

The width of one-way cycle tracks should normally be nine feet and should only be reduced to six feet in special circumstances. If the traffic warrants, width additional to nine feet may be provided by units of three feet. An additional width of 1 ft. 6 ins. should be allowed in subways to provide clearance.

Diagram 1 shows the intersection of two lightly trafficked roads. The points to be noted are :

- (i) Adequate sight lines are provided extending for a greater distance along the major road than along the minor road.
- (ii) The side road joins the major road at right angles.
- (iii) Passage of traffic from one branch of the minor road to the other is interrupted by a stagger.
- (iv) Vehicles crossing the major road cross the first traffic lane at right angles and turn right-handed into the second traffic lane.
- (v) The radius of the kerb line at the junctions is 35 feet, which is sufficient to enable even the largest vehicles to keep close to the kerb when turning.
- (vi) Additional space for manoeuvring, and particularly for decelerating and accelerating with minimum interference with the flow of traffic on the major road, is provided by tapered widenings of the carriageway to the extent of 8 feet in a length of 200 feet.
- (vii) The normal limits of the lanes for through traffic are indicated by broken white lines painted with 3 ft. markings and 3 ft. gaps across the junctions.
- (viii) No special provision for pedestrians exists on either of the roads and consequently none is provided at either junction. If footpaths are constructed they should be located as is indicated in *Diagram 2* in order that pedestrians should not be encouraged to cross the major road between the entrances to the two side roads.

Diagram 2 illustrates a T junction of two lightly trafficked roads. It includes items (i), (ii), (v), (vi) and (vii) mentioned above, but also indicates the suggested locations of the footpaths affording the most convenient route consistent with safety.

Diagram 3 shows the lay-out recommended for a T junction at which traffic entering and leaving the side road is frequent, or traffic on the through road is fast.

It incorporates points (i), (v); (vi) and (vii) referred to above but introduces two further features. The first is the provision of an island to ensure that traffic on the minor road is constrained to approach the major road at low speed. A "Keep Left" sign should be erected at the apex of the island, and traffic on the minor road must first negotiate a left-hand bend of 50 ft. radius and then a right-hand bend which should not be less than 35 ft. radius. The width of this branch road should be 16 ft., as although it is normally intended only for single lane traffic it might be necessary to pass a stationary vehicle, or a vehicle which by mistake had entered the branch road from the major road.

The second feature is an easy route for traffic turning left from the major road to a minor road. By this means traffic may turn whilst maintaining reasonable speed, and the risk of a following vehicle colliding with the turning vehicle will be reduced.

The tapered widening of the carriageway to provide additional space is maintained opposite the island for the full extent of the junction. The locations of the footpaths are those involving least risk to pedestrians.

Diagram 4 illustrates the treatment recommended at a four-way junction of a lightly trafficked road with an important road having dual carriageways and cycle tracks. It is assumed there will be some turning traffic and some cross traffic from the minor roads, but not enough to warrant slowing down the traffic on the major road nor so little as to justify complete separation of the two roads. It is therefore essential to enforce restraint of traffic from the minor roads, and this is done by means of islands as in *Diagram 3*, though of different form.

It should be noted that the openings in the central reservation are opposite the exits from the minor roads, so that emerging traffic makes a direct cut across the traffic on the major road. This has been found in practice to be safer than the lay-out recommended in Memorandum No. 483 (Roads), which had a single island in the central reservation, the ends of which were offset from the side roads. The new design reduces the amount of weaving necessary and involves less strain on drivers of large vehicles. The islands across the minor roads are however essential, as they perform the primary function of the single island in the original design.

The increased width of the central reservation affords a safe harbourage for vehicles to await a suitable gap in traffic on the through road.

If the minor roads are staggered and cannot readily be re-aligned, the islands should all be increased in length by the distance of the stagger.

It may sometimes be convenient to construct a lay-by for omnibuses in the back of the islands facing the minor roads.

Most of the features incorporated in *Diagram 3* are repeated in *Diagram 4*, but it is necessary to modify the position of the footpaths in order to avoid the cycle tracks.

Diagram 5 is a modification of *Diagram 4*, suitable for a T junction. For the convenience of turning traffic the shape of the island in the central reservation has been slightly modified, and to avoid unnecessary interference with frontages all the widening of the major road has been arranged on one side.

A safety strip eight feet wide has been shown alongside the central island for vehicles which have weaved across the first carriageway and are awaiting an opportunity to cross the second carriageway.

Diagram 6. At any intersection of roads carrying moderate traffic at which it is not proposed to provide traffic control signals the junction should be either a roundabout or a fly-over. For single carriageway roads without cycle tracks a suitable lay-out is shown in Diagram 6. The traffic capacity of the junction increases as the diameter of the central island is increased, and, if possible, this should be at least 180 ft.

Diagram 7. Where one or both of the intersecting routes is of such importance as to justify dual carriageways and cycle tracks, the lay-out shown in Diagram 7 is recommended. For the carriageways the lay-out in plan is similar to that shown in Diagram 6 but the volume of traffic at the junction calls for special provision for cyclists and pedestrians. It will be seen that this is effected by the construction of separate concentric roundabouts for these two classes of traffic.

The level of the cycle track and footpath relative to that of the carriageway will depend on local conditions but on level ground it will generally be best to keep the footpaths and cycle tracks at approximately the original ground level and carry the carriageways over the subways by means of embankments. This will eliminate gradients for pedestrians and cyclists, avoid drainage difficulties in the subways and give better facilities for lighting and policing.

The height of the embankment will normally be about ten feet. The gradients will thus assist braking of vehicles approaching the roundabout and acceleration when leaving it.

Diagram 8 is an alternative design to Diagram 7 but is recommended for adoption only in those cases where it is impracticable to construct a two-level roundabout. The desirable course is to segregate cyclists from other traffic at a junction of such importance, but if this cannot be done, the risk of accident can best be minimised by disposing the cycle tracks as shown in Diagram 8. This is a departure from the arrangement shown in Diagrams 4, 5 and 6 of Memorandum No. 483 (Roads), where cyclists are led into the carriageway before entering the roundabout.

Diagram 9 shows the application of the fly-over principle to a Y junction. It is particularly suited to the junction at the ends of a by-pass, as it involves minimum risk of collision and minimum delay to the streams of traffic. It will be seen that no provision is made for vehicles turning from one arm of the Y to the other; if they are few they should take an alternative route, if they are numerous a different design should be adopted.

The Diagram illustrates a right-hand fork. The appropriate design for a left-hand fork is similar except that the ramp furthest from the junction should be extended to 1,314 ft. from the crest to allow for a vertical curve which will give a sight distance of 500 ft. Some adjustment of the cycle track can then be made if desired, as its downward gradient may conveniently be made steeper than its upward gradient. On level ground drainage under the subway may present some difficulty.

(c) *Improvement of Existing Junctions.* In the improvement of existing road junctions where traffic is considerable and sufficient space is available a modified form of roundabout or central island may be introduced with advantage. As mentioned in the note on Diagram 6, the diameter of the

Footnote.—The Committee prepared a number of other designs of junctions incorporating the fly-over principle. Owing to their high cost and the large area of land required such junctions are not suitable for general application. Drawings of them will be deposited at the offices of all Divisional Road Engineers, who will be glad to supply detailed information and consider with Highway Authorities the applicability of these more complex designs to particular schemes.

central island should be as large as is consistent with the space which can be made available, and in any case should be sufficient to ensure easy and safe negotiation by commercial and public service vehicles.

Experience has shown that large areas of paved carriageway with wide sweeping curb lines encourage speed at road junctions and may be a source of danger to both vehicular and pedestrian traffic. Where there is insufficient room for a roundabout much can be done to improve traffic conditions by carefully designed refuges and re-alignment of the kerbs, the chief object in this case being to bring intersections between traffic streams to right angles as nearly as possible and to prevent turning traffic from taking the corners at high speed.

14. REFUGES

Refuges, if carefully sited, are a means of increasing the safety of pedestrians when crossing the carriageway. It is desirable to leave a space or spaces across the refuge in the direction of the pedestrian crossing, level with the carriageway. The distance between the edge of the refuge and the kerb on the nearside should normally be not less than 20 ft., but in built-up areas a smaller width may have to be used in special circumstances. Refuges at junctions should be so sited that the inside wheels of turning traffic are not forced to describe arcs of less than 30 ft. radius.

A bollard or guard post should be provided at each end of a refuge, so designed and illuminated that it is readily identified as such and is clearly visible to road users. The height of the bollards should be not less than four feet above road level but they should not be so large as to obscure pedestrians making use of the refuge. Bollards should be made visible at night by white internal illumination, or where this is impracticable by white flood-lighting. The sign "KEEP LEFT" may be fixed on the top of the guard post; these words should be in white letters upon a blue background and of the dimensions described in The Traffic Signs (Size, Colour and Type) Provisional Regulations, 1933.

In addition to the two guard posts there should be a post fitted with a light source surrounded by a diffusing globe at a height of about 16 ft. This post should be as near as possible to the centre of the refuge without obstructing the level space referred to above. The kerb of the refuge should be of a material which is naturally light in colour or should be painted white periodically, whilst the light from the posts should illuminate the kerb and preferably throw the vertical sides into sharp relief.

More detailed guidance regarding the illumination of guard posts is given in the Final Report of the Departmental Committee on Street Lighting (August, 1937) which includes a review of recommendations made by previous Committees.

15. PEDESTRIAN CROSSINGS

In planning a system of pedestrian crossings, the general principles set out in Appendix I to Circular No. 414 (Roads) dated 14th January, 1935, should be followed. Kerbs at pedestrian crossings should be sloped at a suitable angle to facilitate the passage of perambulators or bath chairs.

Wherever practicable guard rails should be erected in conjunction with pedestrian crossings whether at street junctions, footbridges, subways, or elsewhere, in order to induce persons crossing the street to do so only at the pedestrian crossings. It is important to ensure that the footpaths connected by the crossings are of adequate width.

16. STREET NAME-PLATES

Street names should be marked with clear and dignified lettering such as is recommended in Circular No. 340 (Roads) 1940.

Section 19 (1) of the Public Health Act, 1925, requires Local Authorities to cause the name of every street to be painted or otherwise marked in a conspicuous position on some house, building or erection in or near the street, and the appendix to Circular No. 340 suggests the principles to be adopted in connection with the display of street names. Through routes in towns and built-up areas should be clearly indicated by means of suitable signs.

17. DUAL CARRIAGEWAYS

Dual carriageways should be constructed where an existing road carries, or a proposed road is expected to carry, 400 vehicles at the peak hour, and will often be justified on less heavily trafficked roads solely on grounds of public safety. Where it is necessary to provide more than two traffic lanes the construction of dual carriageways, if practicable, is preferable to widening a single carriageway.

The separation of dual carriageways should be effected by a reservation of the greatest width practicable. Endeavour should be made to secure a width of 26 ft. between dual carriageways of 22 ft. and not less than 10 ft. between dual carriageways of 30 ft. in order to provide a dimension of 70 ft. between the outer kerbs, which would enable large vehicles to turn from one carriageway to the other without reversing. Reservations should be planted with low trees or shrubs with the object of avoiding glare from head-lights. Where the central reservation is broken to allow of communication from one carriageway to another complete visibility across the ends of the reservation should be maintained for at least 50 ft. back from each end of the opening.

In rural areas the connections necessary between dual carriageways across the central reservation should be kept to the minimum and in no case should be less than 440 yards apart. In built-up areas and particularly in shopping centres this dimension may have to be reduced. The connections should be sited opposite to the exits from the side roads.

Each carriageway should be treated as a "one-way" street.

18. LAY-BYS

On important roads it may occasionally be desirable to form lay-bys in which vehicles may stand to permit adjustments or repairs to the vehicles without obstructing the main carriageway.

For convenience in cases of the breakdown of vehicles the lay-bys should be situated at or near the lowest points of gradients. Whenever possible advantage should be taken of short sections of disused or abandoned carriageway to serve as lay-bys. Lay-bys are not intended for omnibus stopping places, though in certain places it may be desirable to construct stopping places off the main carriageway specifically for omnibus traffic.

The length of a lay-by will be determined by the volume and character of the traffic on the road but the normal length should be approximately 100 ft. Suitable connections should be made at each end to enable vehicles to leave and rejoin the main carriageway with ease and safety. The width of a lay-by should normally be ten feet and in no case should it be less than eight feet. The width should not be obtained by reducing the width of the cycle track or the footpath. An intermittent white line with three feet markings and three

feet gaps should be provided at the junctions of the lay-by with the carriageway. It may also be advantageous to make the surface of the lay-by a different colour from that of the adjacent carriageway. Generally a channel should be formed in continuation of the kerb line of the carriageway to carry rain water past the lay-by. Lay-bys on opposite sides of the road should be staggered.

In the case of dual carriageways lay-bys should always be constructed on the near side of the carriageway and never in the central reservation.

19. PARKING PLACES

The parking of cars on the highway should be discouraged and provision for the purpose made on land which does not form part of a highway. Attention is drawn to the extension of powers of local authorities provided under Sections 16 and 17 of the Restriction of Ribbon Development Act, 1935.

Public parking places in built-up areas should be easy of access from main business and shopping districts.

20. SERVICE ROADS

The Restriction of Ribbon Development Act, 1935, is designed to enable Highway Authorities to prevent undesirable development along roads and to encourage grouped development. This course should be followed wherever practicable, but if the circumstances in any particular case are such as to require that consent shall be given to buildings fronting the highway, the Highway Authority should exercise their powers under the Act to secure the provision of service roads, either immediately or in the future, as may be necessary. Service roads, elsewhere than in shopping areas, should be effectively fenced from the highway, and permanent access thereto should be limited, if practicable, to intervals of not less than 440 yards.

21. CYCLE TRACKS

The provision of separate tracks for pedal cyclists on important roads can generally be justified on the grounds of public safety; their construction will sometimes secure substantial economies by avoiding the necessity for widening an existing carriageway.

Save in exceptional circumstances cycle tracks should be unidirectional and separated by verges from the carriageway and footpath. The width should normally be nine feet and should in no case be reduced to less than six feet. If the traffic warrants a width in excess of nine feet, the increase should be by units of three feet. Should it not be practicable, in the case of an existing road in a built-up area, to obtain sufficient space for the verges, the cycle track may be separated from the carriageway and footpath by kerbs or fencing.

Cycle tracks should be kept at a uniform level across garage and similar entrances, which should be graded accordingly.

CONSTRUCTION

22. CARRIAGEWAYS

(a) **Subsoil.** The design of the foundation is largely governed by the nature and bearing capacity of the subsoil. A thorough investigation of subsoil conditions along the route, including the possibility of the presence of salts injurious to concrete, should be undertaken before the alignment of a new road is fixed.

The stability of the road is dependent upon careful preparation, adequate drainage and consolidation of the sub-grade.

The volume changes of clay subsoils arising from changes in the moisture content may be reduced by the incorporation of granular material such as gravel, sand or clinker, either by harrowing or by rolling the material into the clay. Care should be taken to prevent direct contact between the clay subsoil and the road foundation proper, and for this purpose a layer of granular material, waterproof paper, clinker concrete or ballast concrete of lean mix, have been used successfully to meet varying conditions. It is also important that the ingress of water to clay subsoil should be prevented; the road surface should be well sealed and, particularly in cuttings, intercepting drains should be laid along the edges of the road.

(b) **Foundations.** Pitched and hardcore foundations should be fully compacted before the application of the wearing surface; where circumstances permit this may be achieved by allowing traffic to run on a temporary surface.

Save in exceptional circumstances concrete used in road construction for the full width of the carriageway should be finished and used as a wearing surface.

(c) **Surfaces.** (i) *Uniformity.* The provision and maintenance of an adequate non-skid surface is of primary importance and this quality need not be sacrificed to obtain durability. Both are attainable.

Changes in the type of material may be necessary to meet varying conditions occurring on long routes, but care should be taken to provide and maintain a uniform surface texture as frequent changes in the character of the surface of a road constitute a potential source of danger. Where a road crosses an administrative boundary the highway authorities concerned should arrange to ensure uniformity in the laying and subsequent treatment of the adjacent road surfaces.

(ii) *Surfacing Materials.* In determining the material to be used for surfacing, Highway Authorities should consider which material will be the most economical for the particular circumstances, having regard to resistance to skidding, initial cost, probable economic life and cost of maintenance. Subject to these considerations efforts should be made to secure the use of road surfacing materials which are light in colour, in the interests of visibility at night.

Footpaths and cycle tracks should be provided and maintained with a surface finish which is at least equal to that of the adjacent carriageway.

(iii) *Surface Conditions.* It is essential that road surfaces should be maintained in a clean condition. A road surface covered with a film of dirt will tend to be slippery particularly at the onset of rain after a spell of fine weather.

(d) **Surface Treatment.** Surface dressing of roads should not be regarded as routine work. Highway Authorities should consider, in each particular case, whether surface dressing is necessary to prevent disintegration or to provide a non-skid surface. Where there is an excess of binder, rendering the surface sticky or irregular, it should be burned off.

For a road surface which has become uneven consideration should be given to the application of a thin carpet of which several types are available which have proved satisfactory under traffic for five years or longer. If the existing road surface is waterproof and the site is in open country an open textured type of thin carpet will be suitable, but if the road surface is crazed or the sealing coat has been worn away a denser or more nearly waterproof (but still non-skid) thin carpet will be preferable, particularly on sites which remain moist for long periods.

(e) **Camber.** Excessive camber tends to the uneconomic use of the highway, induces drivers to keep near the crown of the road and may be a source of danger. A cross-fall which is excessive increases the tendency to side-slip, and in towns the overhang of high vehicles may cause collisions with erections on

the footpath. All resurfacing works should therefore include the elimination of any excessive camber.

Where it has become necessary to increase the width of dual carriageways expenditure will be minimised if the original carriageway has been constructed with a straight cross-fall. In normal cases dual carriageways on straight lengths of road should be constructed with the cross-fall from the central reservation outwards.

On a straight length of road the appropriate fall of the finished surface from the crown of the road to the channel suitable for close jointed stone setts, asphalt, wood paving and concrete, is 1 in 48 and for ordinary stone setts, tarmacadam and grouted surfacings, including surface dressings, 1 in 40, but local conditions may necessitate some modification.

23. FOOTPATHS

Attention is drawn to Section 58 of the Road Traffic Act, 1930, which requires proper and sufficient footpaths to be provided on all roads for the safety and accommodation of foot passengers wherever it is deemed necessary or desirable to do so. The width of a footpath will be determined by the volume of pedestrian traffic anticipated but should not be less than five feet even in rural areas. In shopping streets widths up to 20 feet may well be justified. In order to facilitate the provisions of suitable cross-fall to footpaths, local authorities should ensure that step and sill levels of buildings are fixed in relation to the ultimate crown of the carriageway.

The widening of the carriageways of narrow country roads should not be effected by encroaching upon the grass verge or footpath unless adequate space can be left for pedestrians.

Means of access which are essential to enable vehicles to cross footpaths and cycle tracks should be suitably paved and graded to the channel. As pointed out in Section 22 (c) (ii) a surface finish should be provided and maintained at least equal to that of the adjacent carriageway.

24. KERBING

Kerbs should always be provided in built-up areas, over bridges, at the foot of retaining walls when they abut on the carriageway and where necessary for the protection of pedestrians. Regard should be had to the advisability of using local materials. In the open country where a kerb is necessary roughly dressed stone may be appropriate or, if a raised kerb is not required for safety or other reasons, a pleasing result may be obtained by the use of sunken kerbs in conjunction with grass edging.

On country roads the kerbs on the central reservation between dual carriageways should be designed to minimise danger and avoid unnecessary resistance to vehicles in emergencies. Sharp arrises to kerbs should be avoided and the introduction of a chamfer from the vertical, a rounded section, or the provision of a splayed front edge are recommended. Attention is drawn to the British Standard Specification No. 340 (including the Addendum dated 13th October, 1938), and to Specification No. 435 which give detailed sections of suitable kerbing.

Under normal conditions in built-up areas the height of the kerb above the surface of the carriageway should approximate to four inches, but where the gradient of the road is small this dimension may vary from three inches to five inches. In rural areas the height of the kerb should not exceed four inches.

An important function of the kerb is to indicate the limits of the carriageway; lightness of colour whether natural or obtained by painting is very desirable. At road junctions and sharp bends the painting of kerbs in lengths

of one foot with a one foot gap is recommended. Where the line of the kerb or verge is interrupted by a road junction or wide vehicular entrance it should be continued by an intermittent line with three feet marks and three feet gaps.

Small isolated spur stones at the edge of the carriageway even if whitened for better visibility, may constitute a source of danger, particularly in fog. It is often helpful to provide black and white posts to indicate the directions and approximate limits of the carriageway. These should be fitted with red reflectors facing a driver on the nearside and white reflectors on the offside. They should be not less than three feet in height and not less than 18 inches from the edge of the carriageway.

Kerbs are not generally required for cycle tracks but where they are considered necessary the height should not exceed $1\frac{1}{2}$ ins. and the edge should be chamfered.

See Section 15, paragraph 1, for kerbs at pedestrian crossings.

25. DRAINAGE

Adequate provision should be made in all cuttings for the collection and disposal of surface water. As a precaution against slip in clay and other unstable types of soil it may be necessary to form steps in the slopes of steep cuttings to facilitate the construction of lateral drains for the collection of the surface water, in addition to rubble drains on the face of the slope.

On soils which do not afford natural drainage consideration should be given to the provision of sub-soil drainage. Where the cross section of a road is in cutting or partly in cutting and partly on embankment, it will often be desirable to provide a longitudinal drain to intercept surface and sub-soil water, which may flow from the higher ground towards the road foundations.

The siting of surface water drains, gully connections, etc., should be undertaken with due regard to future developments, the duplication of carriageways and the ultimate use of central reservations, etc. It is preferable that surface water drains should be duplicated on each side of a single carriageway and usually on the outer sides of dual carriageways.

Gullies should be placed in the verge or at the back of the kerb with appropriate side entrance gratings.

26. GRASS VERGES AND TREE-PLANTING

Wherever possible verges of ample width should be interposed between paved areas. Cycle tracks should be separated from the carriageway and footpaths by verges of not less than six feet and three feet respectively. Consideration should be given to the use of verges for equestrians where the provision of such facilities is justifiable. In cases where verges are intended to fulfil the function of a footpath or a track for horsemen it is necessary to ensure that the use of the verge for this purpose is not precluded by inadequate maintenance or by the deposit of loose material.

The type of trees for roadside planting should be carefully selected with particular regard to their environment, habit, safety and suitability for planting in public roads. Trees which are liable to become dangerous by reason of falling branches should not be selected and it is desirable to avoid those which shed large leaves on the carriageway in the Autumn.

In addition to their decorative value, trees and shrubs may be useful in supporting the soil of cuttings.

Soil 18 ins. below the surface is almost sterile of the organisms which are necessary to assist the growth of trees and shrubs. On a new cutting, it is, therefore, essential to import good top spit soil in which the trees and shrubs

can be planted. The organisms from these patches of imported soil will spread in a few years all over the bank. The scattering of seed is useless on sterile sub-soil.

The surface of chalk cuttings weathers with frost the first year after the cutting has been made, and it is doubtful whether in view of this crumbling of the surface, it is worth while trying to grow anything on them until their slopes have become stabilised.

On clay banks attempts should be made to grow trees and shrubs as rapidly as possible, in a dense formation.

In planting in clay it is important to introduce some top spit soil, and to put in trees and shrubs as small as possible, and not to plant them too deep. It is essential that a small area around the shrub should be kept weeded during the first few years of life.

Verges are often formed with soil unsuitable for tree growth. Suitable soil can be obtained from the site of the road, when it is first cut, by stacking the turfs then available at convenient intervals throughout the whole road, ready for tree planting. Where it is necessary to import soil, one and a half cubic yards of soil will be required for each tree; otherwise one cubic yard should ordinarily suffice.

It is not always desirable to plant in avenue form and this practice may with advantage be varied by the formation of clumps suitably sited.

The treatment of the roadside margin should not be confined to tree planting, but should include the carefully considered use of shrubs, plants, etc., where such treatment is appropriate to the environment. In selecting the sites for planting, care should be taken to ensure that vision of drivers or pedestrians may not in the future be obstructed when the trees have attained maturity; for example, shrubs and trees should not be planted in the central reservation near the openings connecting dual carriageways. A continuous row of shrubs of even level may become monotonous. Small trees should not be planted in a straight line along the central reservation, but staggered irregularly. Where trees are planted as an avenue, regard should be had to the ultimate lay-out of the road, future alignment of mains, surface water drains, etc., as the laying of these may cause damage to the roots; conversely, where a defective joint in a water main or surface water drain occurs, damage may be caused by the roots of the trees.

The importance of the care of trees cannot be too strongly emphasised. Harm can be done to newly planted trees and shrubs by neglect as well as by wilful damage. Arrangements should be made for their efficient protection and maintenance. The latter should include not only pruning, attention to the soil, and the replacement of dead trees, but also frequent inspection so that loose or broken stakes or broken ties may be remedied before the defect results in serious damage to the tree. The heaping of soil from excavations round the stems of young trees is detrimental to their life; particularly in the spring.

The Roads Beautifying Association, 7, Buckingham Palace Gardens, London, S.W.1, is prepared to advise Highway Authorities, where desired, on the treatment of verges and slopes and the choice of trees and shrubs, and has done valuable work in this connection.

27. FENCING, HEDGES, AND GUARD-RAILS

In general it is desirable that boundary fencing should be supplemented by the planting of hedges. Care should be taken that existing hedges should be preserved wherever possible as they materially contribute to the amenities of the countryside.

DIAGRAM 1

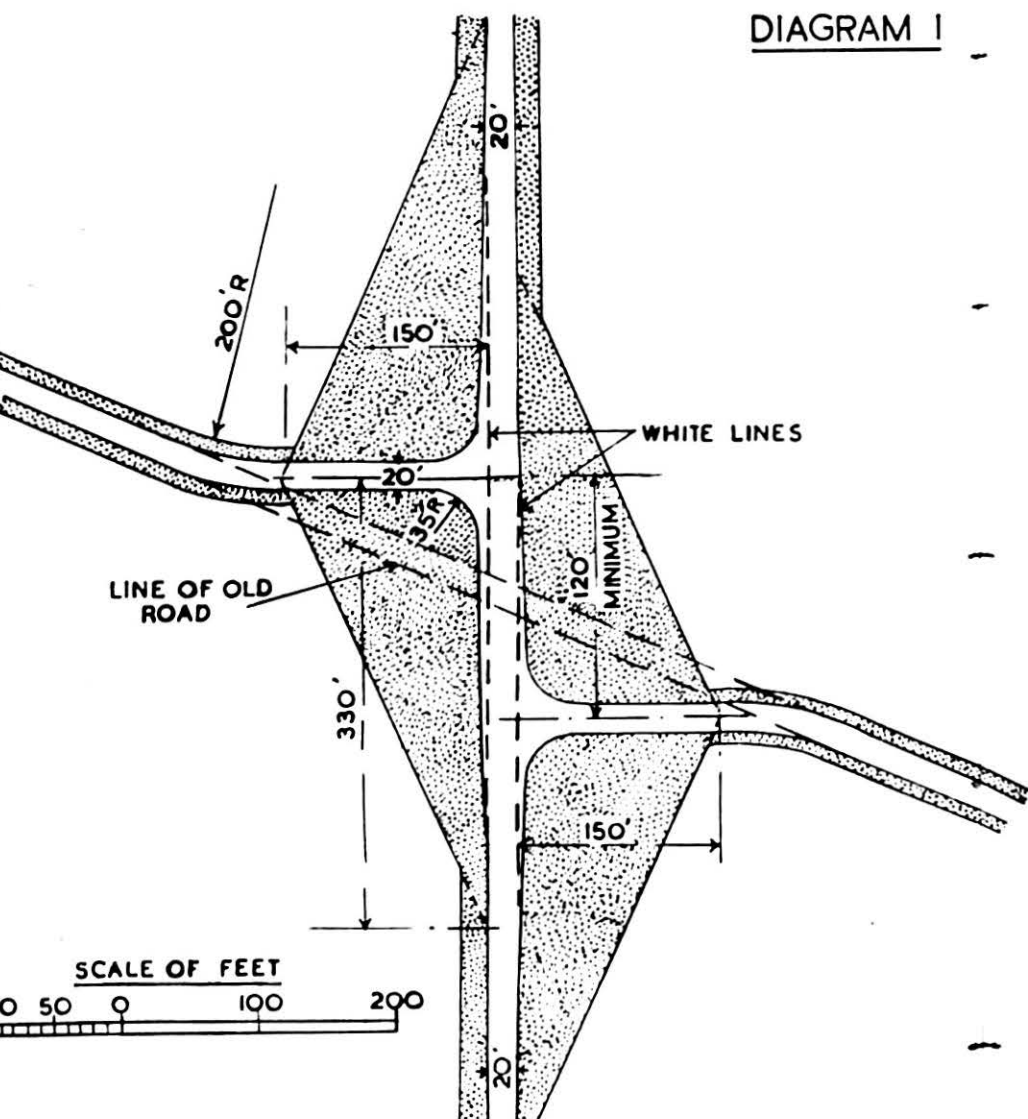


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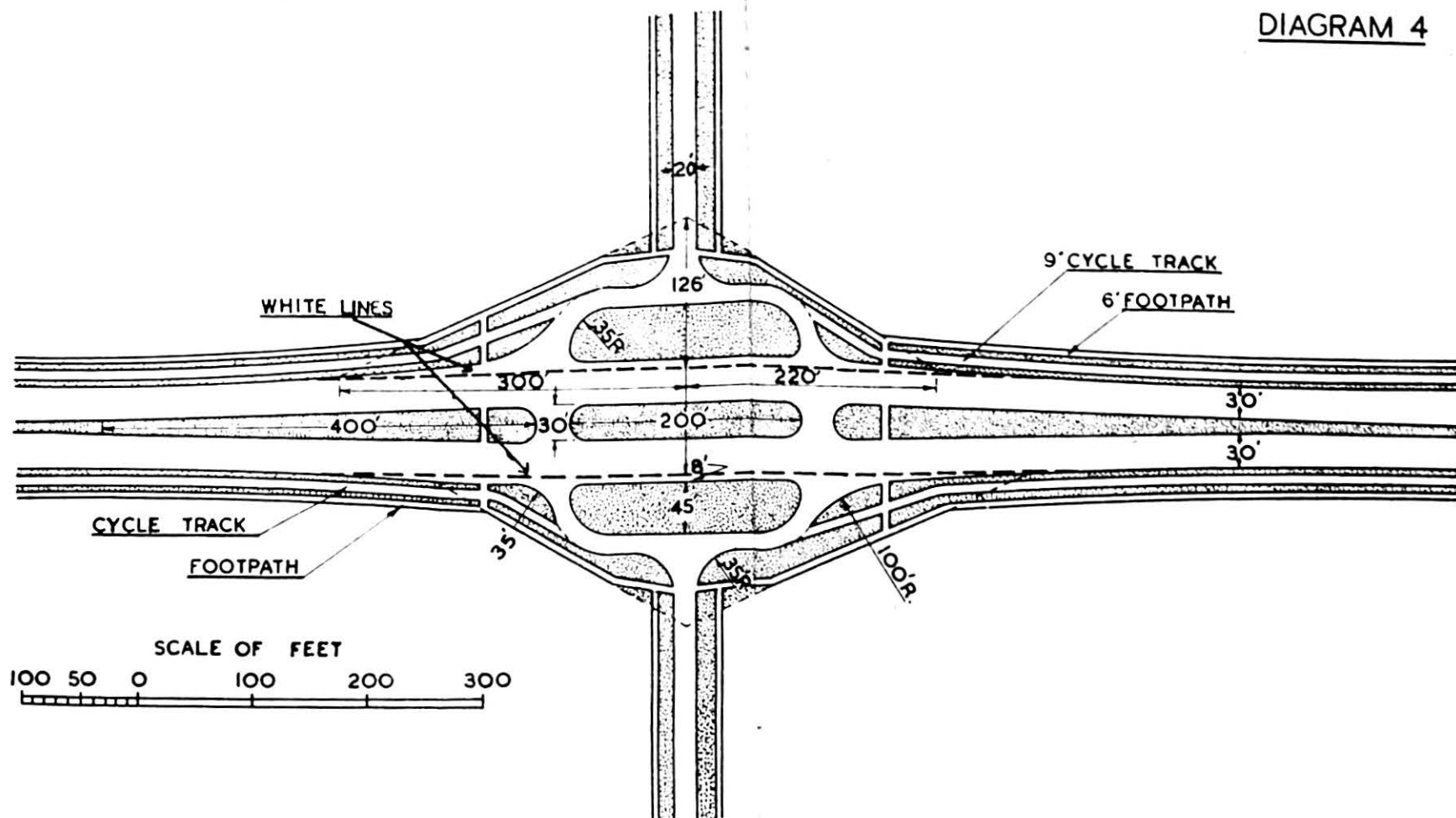


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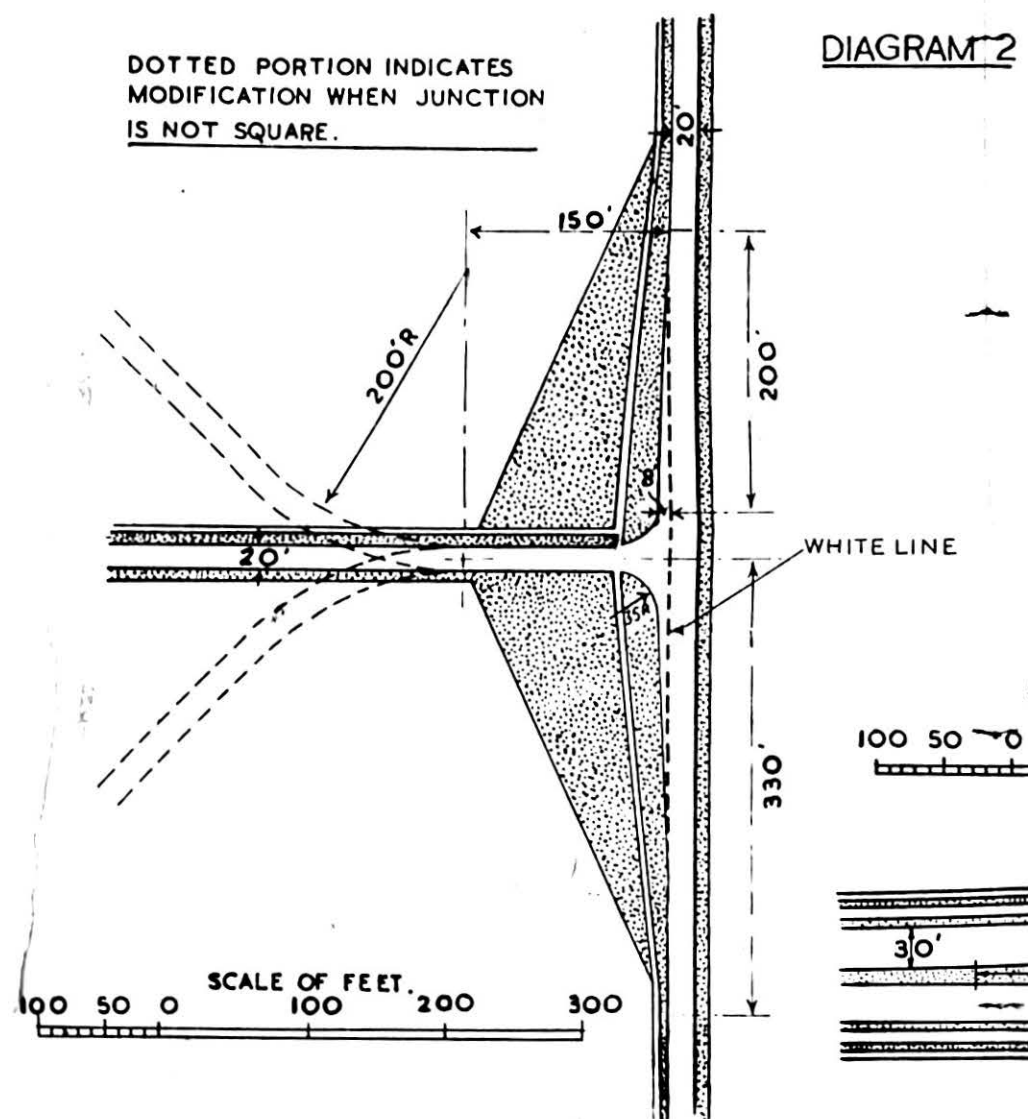


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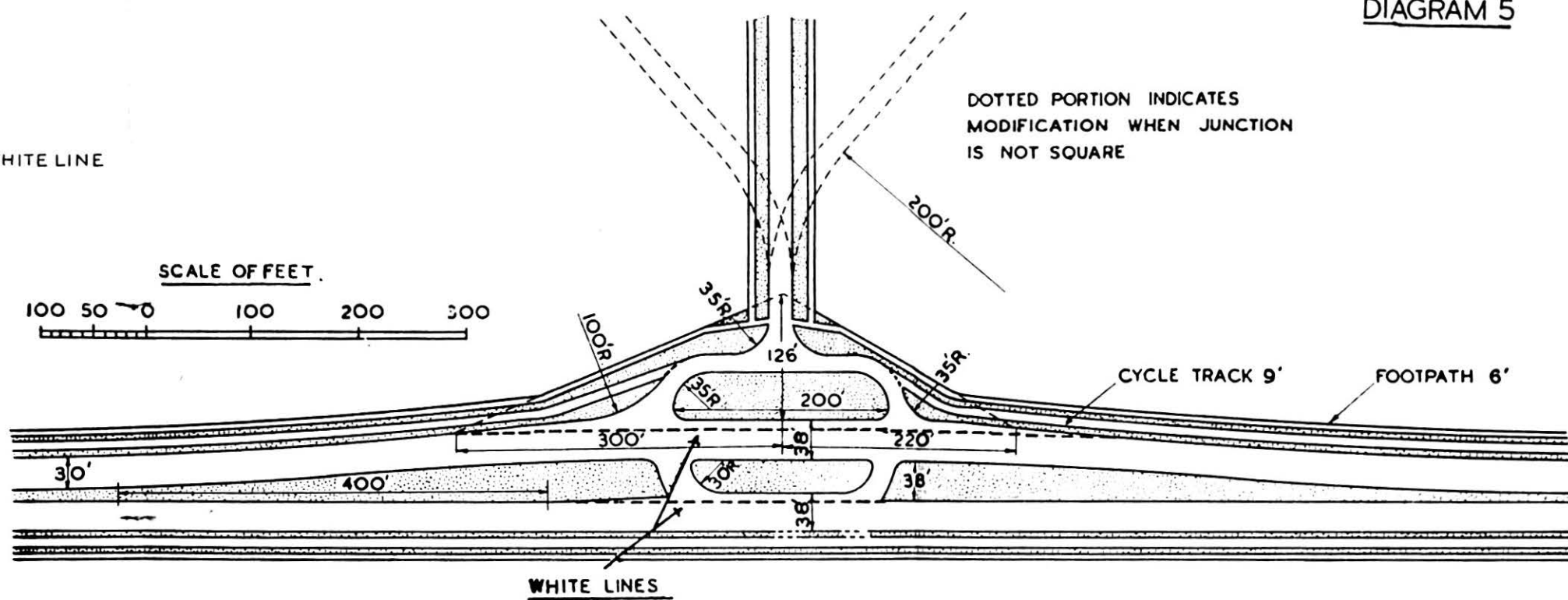


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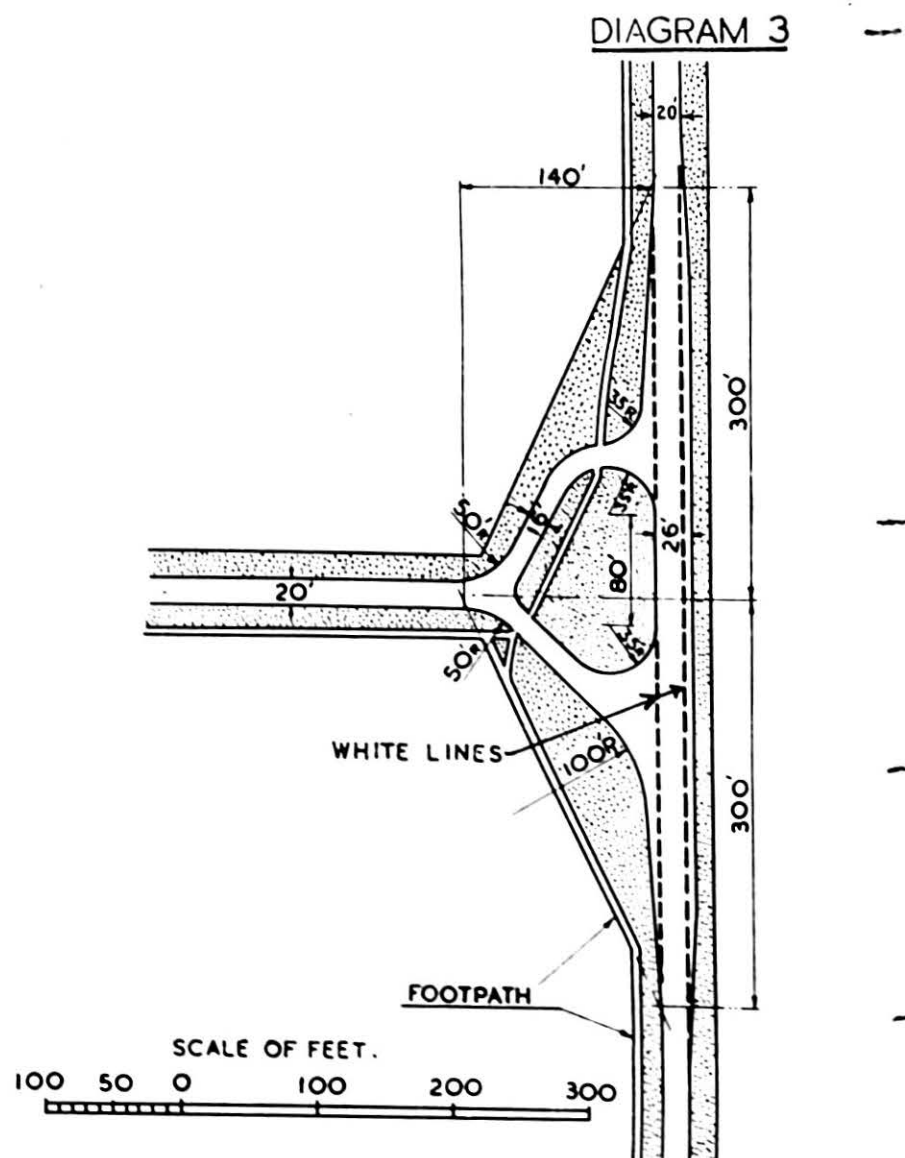


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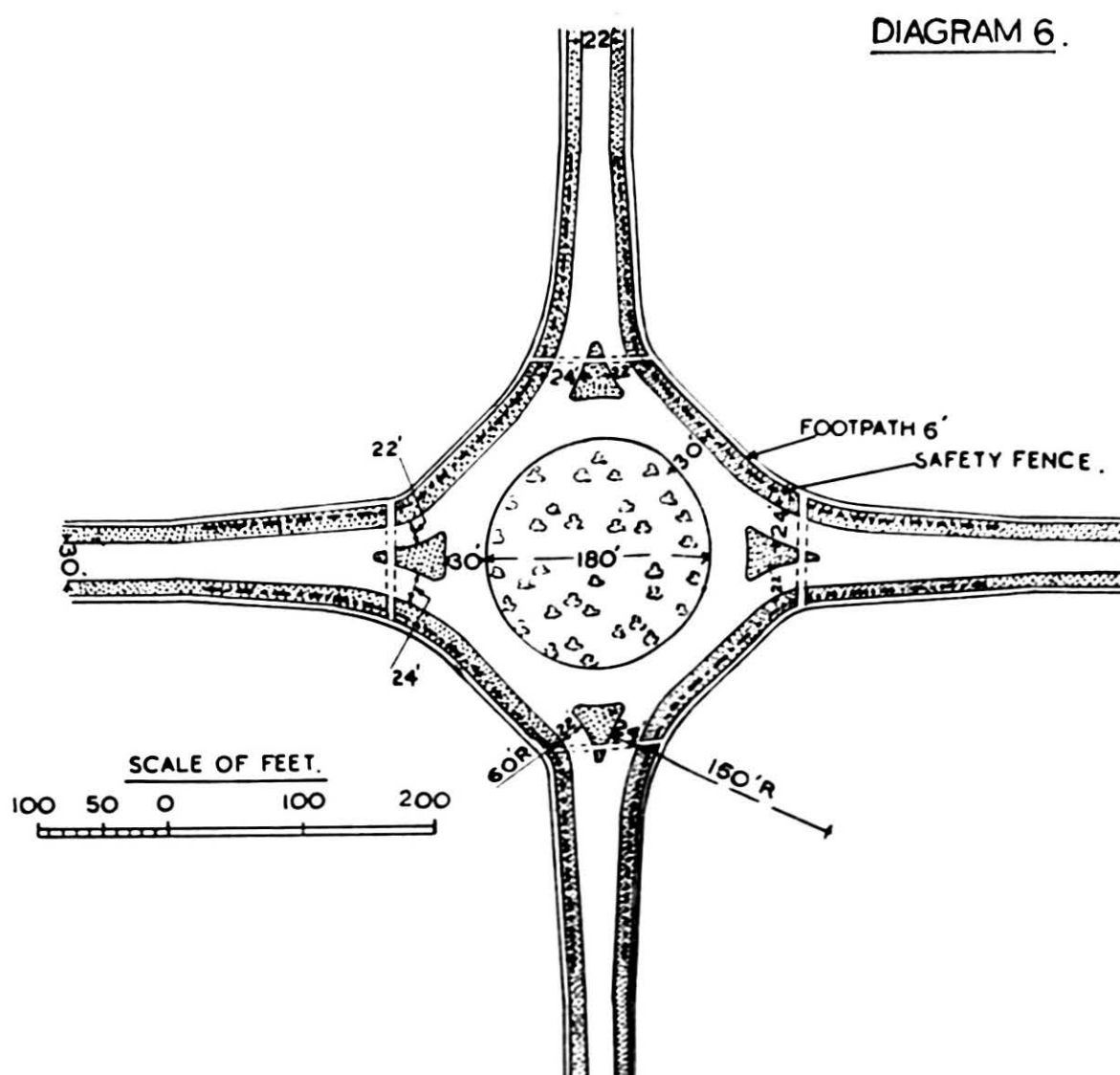


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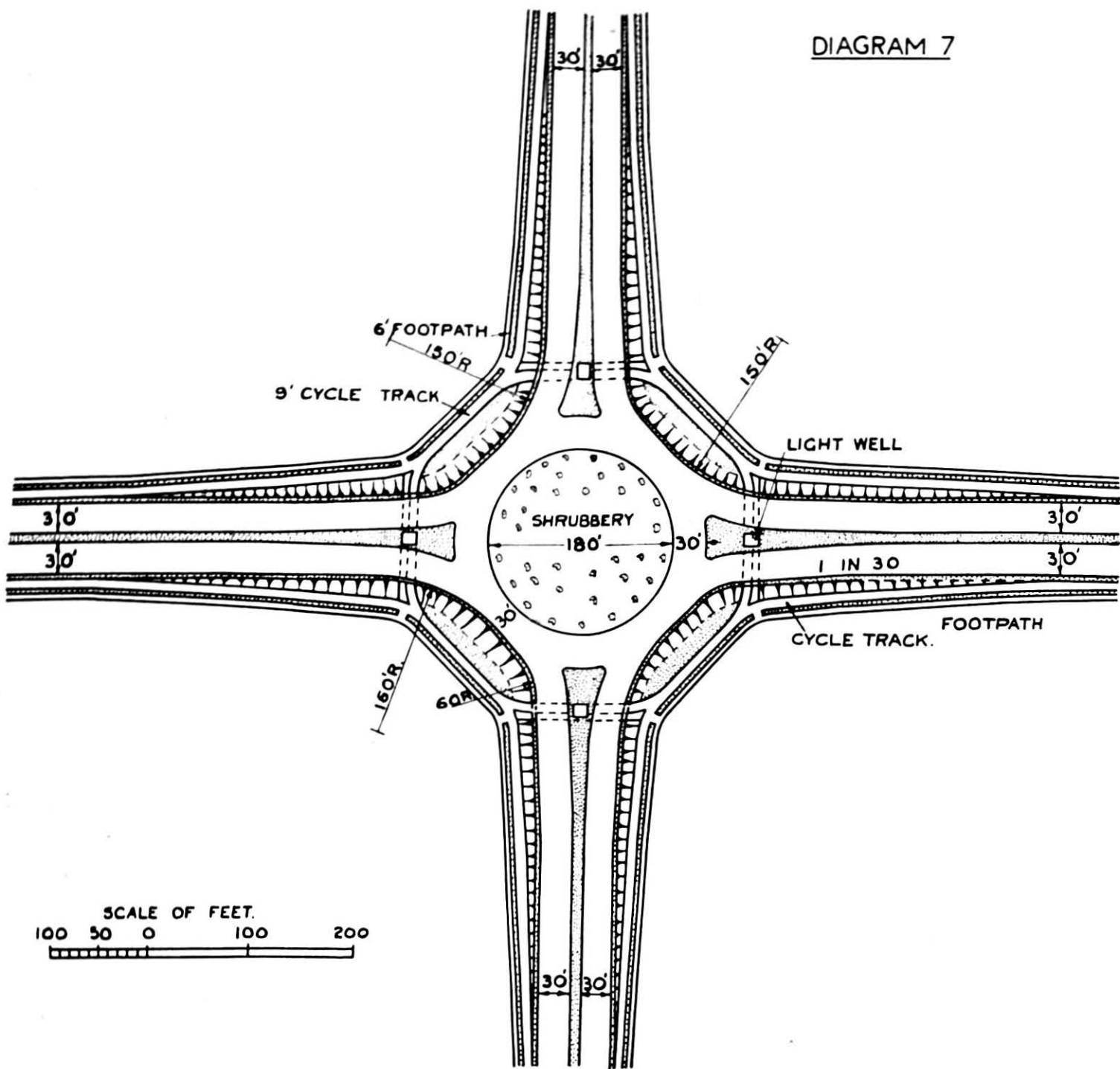


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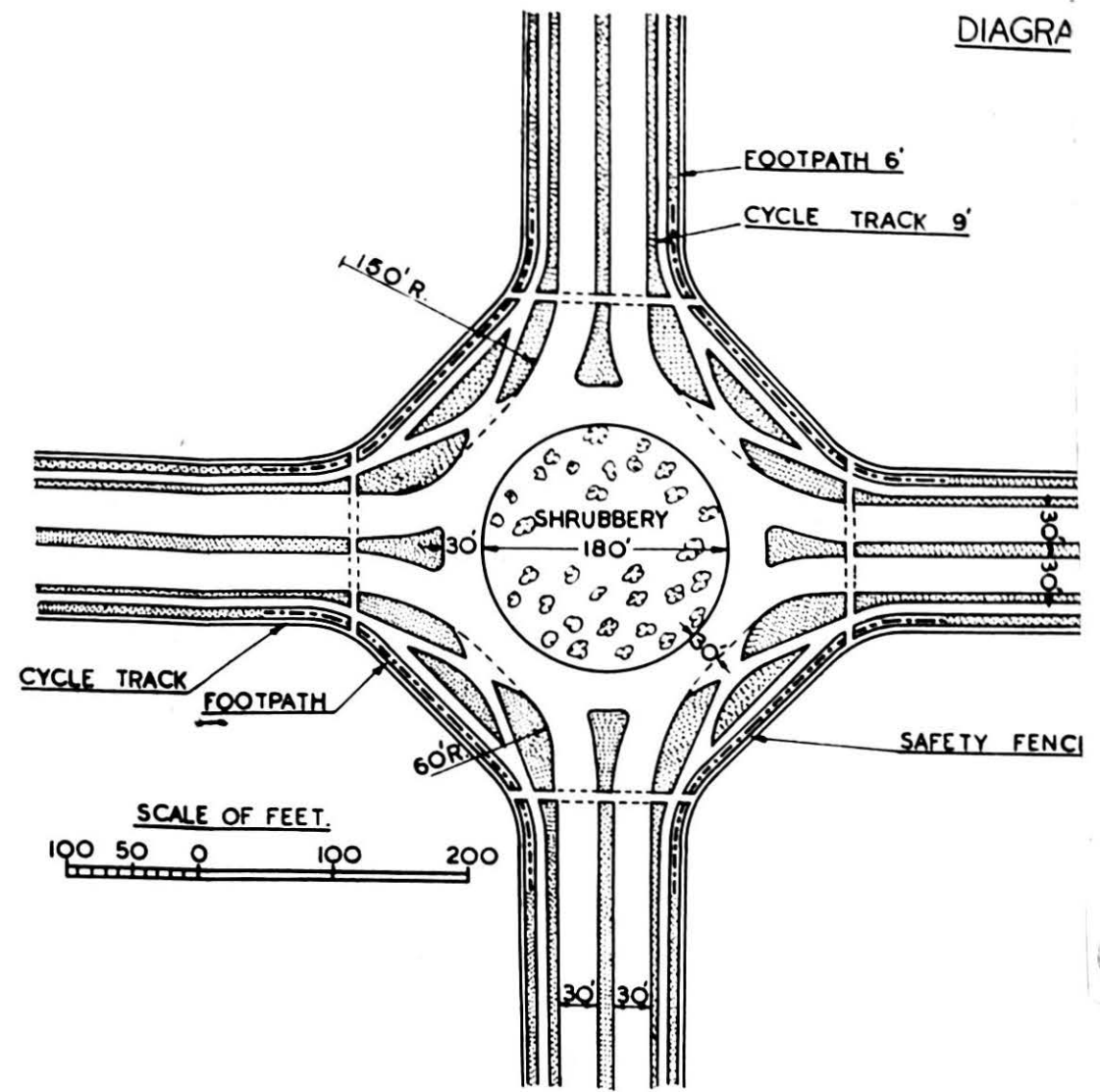
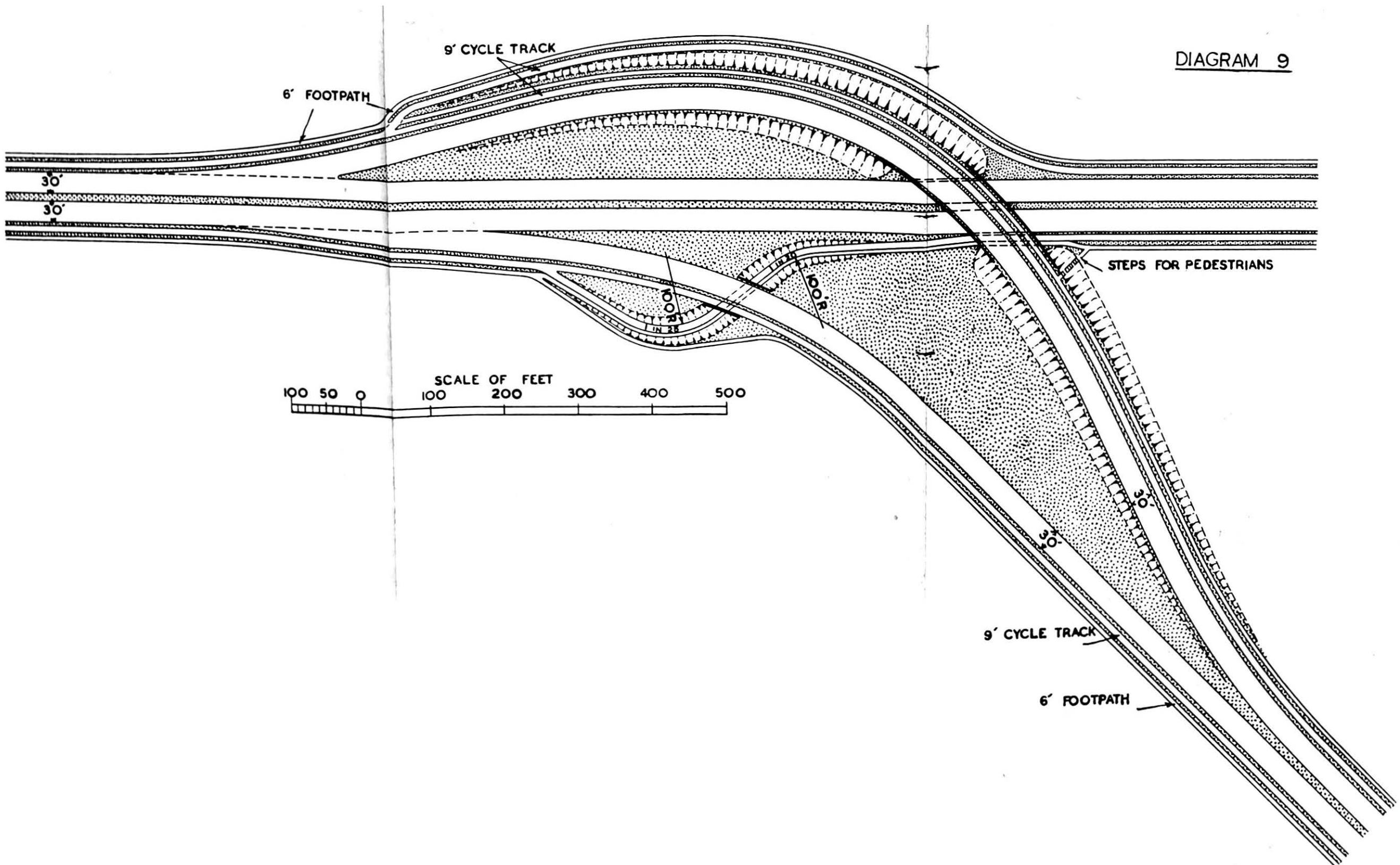


DIAGRAM 9



Where open fencing is erected at road junctions pending improvement of lay-out it should extend sufficiently in either direction from the apex of the junction so that ample visibility is obtained. Hedges not more than three feet high may be used with advantage between footpaths and the carriageway at road junctions. Attention should be given to the risk attendant upon the provision of openings in hedges and fences between carriageways and footpaths, cycle tracks, etc., and precautions should be taken to ensure clear visibility at such points. Guard rails should be erected on the footpa outside exits from schools, factories, cinemas, etc., where pedestrians prone to cross carriageways without regard to vehicular traffic.

On embankments and at the outer edge on hillsides roads need protection at the limits of their effective widths; in some instances this may be provided by turf or earth banks, rather than by a fence or guard posts which may not be strong enough to withstand the impact of a heavy vehicle.

Provision should also be made for the protection of pedestrians, where the footpath is adjacent to the upper edge of an embankment, or cutting.

28. SITING OF UNDERGROUND MAINS AND SERVICES

For the purpose of preventing interference with the carriageway adequate verge accommodation should be provided on all new roads for the laying of drains, underground mains, cables, etc., and their relative positions should be determined at the outset. When grass verges have to be disturbed, turf and top-soil should be cut, stacked and reinstated.

Consideration should be given to the desirability of duplicating service mains and drains on each side of a single carriageway or on the outer sides of dual carriageways in order to avoid the subsequent breaking up of the carriageway for service connections. Where it is anticipated that subsequent development will necessitate mains or services crossing the carriageways, inconvenience and expense can often be reduced by laying short lengths of transverse mains or services before the carriageway is constructed. Boring machines can also be used to avoid disturbance of the carriageways. The adequate and prompt reinstatement of trenches in carriageways is of prime importance. To restore as far as possible the monolithic character of the concrete foundations, the exposed edges should be prepared with a bevelled face and cut back to at least four inches beyond the width of the trench before reinstatement takes place.

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