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PAMPHLET No. 10
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FORESTERS'
MANUAL

FOREST ENGINEERING

ROADS AND BRIDGES
TOPOGRAPHICAL SURVEYING AND SUBDIVISION
DEPARTMENTAL BUILDINGS

FORESTS DEPARTMENT
PERTH
WESTERN AUSTRALIA

10/3/61—500

FORESTS DEPARTMENT OF
WESTERN AUSTRALIA

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FOREST ENGINEERING

SECTION 1.—ROADS AND BRIDGES
SECTION 2.—TOPOGRAPHICAL SURVEYING AND SUBDIVISION
SECTION 3.—DEPARTMENTAL BUILDINGS

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Issued under the authority of the
Hon. W. S. BOVELL, M.L.A., Minister for Forests

PERTH: 1961

SECTION 1.—ROADS AND BRIDGES

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FOREWORD

(1) The attention of officers receiving this pamphlet is drawn to the introduction in Pamphlet No. 1 which is applicable to the Manual as a whole.

(2) It is to be noted that each section as issued will override the instructions contained in circulars on subjects covered by the section and such circulars will automatically be cancelled.

(3) It is intended that Forest Engineering will contain four sections, Roads and Bridges, Topographical Surveying and Subdivision, Departmental Buildings and Sawmilling. The last section, however, will not be published until a later date.

ROADS AND BRIDGES

INTRODUCTION

Introduction.

1. Construction and maintenance of roads and tracks for forest protection, management and utilisation absorbs a major part of forest revenue. Selection of good road alignment, together with careful costing, close conformity with specifications and effective supervision of roading operations enables limited funds to be used to the best advantage.

ROAD PLANNING

Road planning.

2. Road planning is a function of the Divisional Officer. The location and standard of road depends on the nature and frequency of traffic, or finance available and on the nature of the area to be roaded. A sensible balance must be sought between costly cartage over cheap roads and cheaper transport over expensive roads.

Estimates.

3. The annual road programme is considered and presented in conjunction with the annual financial estimates. Proposals for major roads, including those constructed under Federal Aid Road Grants, must be covered by details of estimated costs for each phase of construction and supported by plans showing alignment and curves. A plan of the annual road programme is required to support the estimates.

ROAD LOCATION AND SELECTION

Road location.

4. The sequence for road location is as follows:—

Obligatory points.

(a) Examine air photos if available, otherwise type maps or up to date topographic maps of the area. Mark

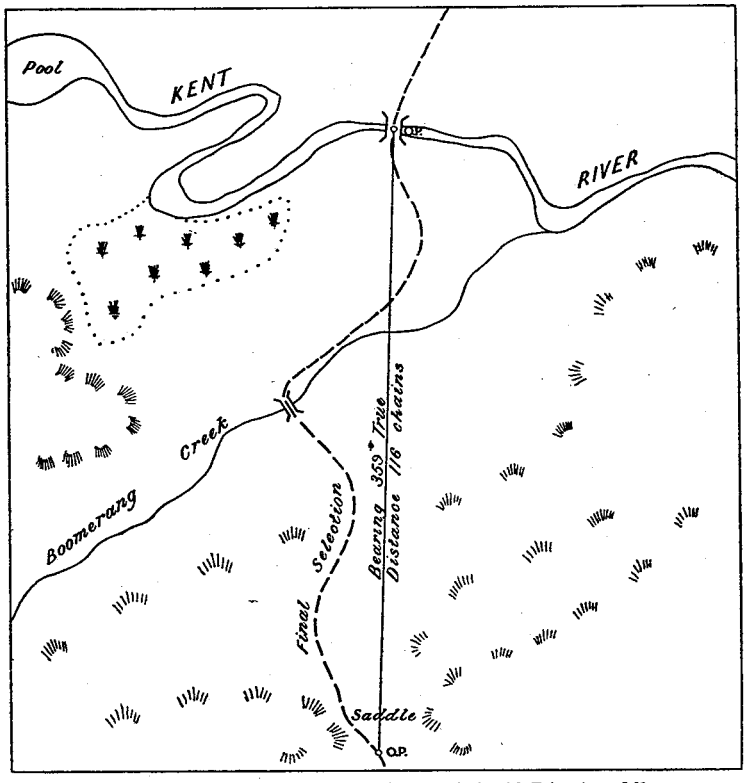


Fig. 1.—Sketch illustrating obligatory points (O.P.) at saddle and river crossing.

obligatory or key points through which the road **must** pass (e.g. suitable stream crossings, saddles between ridges, narrow necks through swamps). Stereoscopic examination of aerial photos can be of value where the route lies through difficult country.

(b) Join obligatory points and note the bearing and distance of each 'leg'.

Care in selection.

(c) Blaze the straights in the field, at the same time noting any limiting factors such as steep grade, rock, swamp or heavy siding. Having done this, select and peg or blaze the final centre line to be as straight as possible and within specified limits for curves and grades. Keep in mind the necessity for low cost construction by avoiding heavy clearing or earth movement, expensive bridging and unsatisfactory road foundations. In general the route should follow high ground. Careful selection is an essential pre-requisite for good roading.

SPECIFICATIONS

General.

5. It is necessary for D.F.O.'s to ensure that all roads, tracks and firelines conform to the approved specifications, as there may be a tendency on the part of officers and overseers to produce a road which is too costly for a forest track but below the specifications for a sub-arterial road.

Arterial Roads

Arterial roads.

6. These roads are to be selected with a view to carrying fast inter-divisional traffic.

Demarcation.

7. Centre line is to be marked with waddies, and chip blazes cut not more than 4 ft. off centre line. At intersection points, 4" x 4" flat topped pegs 2'6" long with 15" above the ground should be numbered, trenched or stoned. Reference trees as required should be marked at the time of original pegging. Straights are to be waddied every 5 chains. Tangent points are to be marked by cross sticks. Curves should be waddied at T.P.'s and each 1 chain chord.

Location.

8. Keep as straight as possible on original survey but when doing the final pegging straights and curves are to be "swung" to reduce clearing cost of stone, stumps and the larger trees. Long straights for this purpose may be broken into 10 chain lengths by offsetting the original straights up to 1 chain (i.e. by creating a bend giving angles not greater than 168°).

Avoid following gullies. Keep up on the gravel slopes or ridge tops if free of stone. Other things being equal, an endeavour should be made to keep all roads on leeside slopes in relation to prevailing winds as an aid to fire control. With arterial roads high cross slope is undesirable as it entails heavy side cutting for an 18 ft. road width.

Curves are to be laid out by the tangent offset method but, after placing preliminary waddies, final waddies are to be adjusted to save clearing costs. Adjustment may be made by moving the whole curve, by deviating from a point prior to the tangent point to hit the first or second curve peg, or by adjusting individual pegs up to 6 ft. inwards towards the curve centre.

Selection must give attention to natural surface as it is not intended to surface arterial roads except at special points, or when the volume of traffic makes is necessary.

Width of clearing.

9. The width of clearing shall be 18 ft. with a road surface of 12 ft. In Karri country the width of clearing is to be increased to 20 ft. Clearing will include the removal of trees likely to fall across the road at restricted points, such as sidlings, cuttings and bridges, but not on level areas where quick deviations could be made.

Grade.

10. Ruling grade is to be 1 in 15. 1 in 12 will be permitted for short distances to avoid detours from the most direct route, but all roads requiring grades steeper than 1 in 12 will

be referred to the Regional Superintendent or Senior D.F.O. before clearing is commenced.

Curves.

11. Curves are to be kept to a 1,000 ft. radius wherever possible, but may be reduced to 500 ft. if necessary. All curves of less than 500 ft. radius to be referred to a Senior D.F.O. or a Regional Superintendent before clearing. In order to turn a spur, a smaller radius may be necessary, but, where this occurs it is better, if possible, to avoid the curve by crossing the spur on a steeper grade. Angles of 160° to 180° will not require curves to be pegged.

Bridges and culverts.

12. Bridges will be built to 13 ft. width only, but all culverts will be built to the full width of the clearing to facilitate the use of graders on the shoulder of the road. Approaches to bridges and culverts to have a minimum straight of 3 chains. Concrete pipes will be used wherever practicable.

Cutting and filling.

13. Cutting and filling will seldom be necessary but where the crossing of a flat is unavoidable, the amount of filling required will be referred to a Senior D.F.O. or Regional Superintendent before the road is commenced.

Heavy Haulage Roads

Heavy haulage roads.

14. These roads are constructed to carry heavy log traffic. Specifications read as for arterial roads, however particular attention must be paid to grade, especially that against the load. Only short pinches steeper than 1 in 15 can be permitted and then only if a straight flat or downhill run can be provided.

F.A.R.G. Roads for which a Specific Grant has been made

F.A.R.G. Roads.

15. These are roads built with special funds provided by the Main Roads Department. The specification to which they will be built will be decided after consultation between the District Engineer (M.R.D.) and the Regional Superintendent or Senior D.F.O. concerned.

16. Generally the standard will be that of the arterial road, but in some cases the M.R.D. may require width of clearing from 22 ft. to 30 ft. and stricter limits on grade, radii of curves, etc. The M.R.D. may also specify particulars of drainage, bridges, culverts, gravelling, etc., and the District Engineer should be consulted by the D.F.O. should any doubts arise as to specifications or requirements.

17. When estimates are submitted for F.A.R.G. funds, a plan of the selected route must be sent to head office. Before construction is commenced the D.F.O. will advise the District Engineer and invite his inspection and approval.

Sub-arterial Roads

Sub-arterial roads.

18. These roads should be selected with a view to carrying fast traffic from the fire gang centres, and, where practicable, around forest boundaries. Specifications closely follow those required for an arterial road, but the width of clearing is reduced:—

(a) **Demarcation.**—As for arterial roads, but curves need be pegged only every 2 chains.

(b) **Location.**—The same care in original locations will be practised as with arterial roads, but greater latitude will be allowed in swinging straights and curves to reduce construction costs. Angles of less than 160° are to be avoided.

(c) **Width.**—The width of clearing shall be 14 ft. with a 12 ft. roadway. In Karri country the width of clearing shall be increased to 16 ft.

(d) **Grade.**—As for arterial roads, but 1 in 10 may be permitted for short distances.

(e) **Curves.**—As for arterial roads, but a 4 chain curve may be used without reference to a Regional Superintendent.

(f) **Bridges and Culverts.**—As for arterial roads.

(g) **Cutting and Filling.**—As for arterial roads.

Forest Tracks

Forest tracks and trafficable firelines —selection.

19. Selection is done by field officers, but it is the responsibility of the D.F.O. to ensure that the alignment is satisfactory before authorising work to be done on it. No trees further than 4 ft. from the centre line should be blazed. A direct route is required with straights of 10 chains or more, certainly not less than 5 chains, and sharp bends and turns to dodge big trees must be avoided. However, the road may be 'swung' to avoid large trees. Selection should aim to avoid removing trees over 50 inch g.b.h.

Avoid sharp bends.

Width of clearing.

20. Tracks are cleared to a width of 12 ft. in Jarrah forest and 15 ft. in Karri country.

Grade.

21. A maximum of 1 in 12 is desirable, however it will at times be necessary to accept 1 in 8. Where steep grades are unavoidable, straight approaches are desirable. A combination of steep grade and 'dog legs' is most undesirable.

Curves.

22. Curves are not surveyed, but where country permits, all bends of angular measure less than 150° should approximate to a true curve. On right angle bends, such as occur in following around private property with outer firelines, the aim should be to ease the corner with a curve of approximately 6 chains radius. The inner break will, of course follow the fence closely and require a curve of only 1 chain radius.

Bridges and culverts.

23. These should follow the specification for 9 ft. width as shown in F.D. blueprints. Approaches are required to be straight for 3 chains on each side. Concrete pipes should be used wherever practicable.

Bridge and Culvert Blueprints

Blueprints.

24. Bridge and culvert blueprints are as follows and are available on request from head office:—

13 ft. pile bridge for spans over 20ft.—Plan 858a.

13ft. bed log bridge 8 ft.-20 ft. span.—Plan 858b.

9 ft. bed log bridge 8 ft.-20 ft. span.—Plan 858c.

9 ft. pile bridge for spans over 20 ft.—Plan 858d.

Varying span log culverts—Plan 858e.

SURVEY

Survey.

25. (a) Although the importance of good road selection is stressed for all types of road and track, expenditure on careful topo survey of the road before clearing is to be kept to a minimum.

(b) Under our system of theodolite survey of a control framework, certain roads are selected for survey after clearing and these surveys form the framework on which A.P.I. and topo work depend. (See under Survey section of Manual).

ROAD CONSTRUCTION

Clearing

Road clearing.

26. Most road clearing is today performed by heavy bulldozers which carry out the same work as was formerly done by hand at greater cost and effort, i.e. removal of all trees, shrubs, logs and stone on the selected alignment to the full width as specified. Supervising officers should ensure that stone and large roots and the rootstocks of persistent shrubs and palms are removed to adequate depth, i.e. to at least 6 inches and preferably to 12 inches on major roads. It is important also that the blade be angled and used to cut large roots which, if left, would foul the grader blade in forming the table drain.

Side falling.

27. Where road clearing is carried out within a sawmilling permit arrangements should be made where practical for trade cutting of any mature trees within approximately 2 chains of the proposed road, which, on account of lean, could not normally be felled clear of the road.

Debris disposal and log salvage.

28. All clearing debris should be pushed at the low side of the road to enable the grader to draw spoil from the high side and operators should be clearly briefed **to avoid heaping debris against roadside trees.** Arrangements should be made in advance for salvage of millable logs and such logs should be left in an accessible position for crowning off and loading onto trucks. Salvage of logs should be carried out prior to gravelling and final grading to avoid damage by trucks and tractors to the finished road surface. As clearing proceeds excavation is carried out for bridges and culverts so that installation may proceed while the machine is within easy distance for filling. Detours are made as necessary to enable materials, etc. to go forward behind the machine.

Avoid damage to survey posts.

29. The D.F.O. must ensure that every effort is made to avoid damage to survey posts.

Survey posts offset from instrument point.

In the past, the head office party carrying out Controlled Surveys has offset survey pegs from the instrument point by the half-angle method so that they are parallel to the line of traverse and 50 links or 100 links away. In future, all such survey pegs will be offset to be a standard 100 links from the line of traverse, to allow for any later straightening or widening of the road.

For detailed information of the method see the Foresters' Manual on Topographical Surveying and Subdivision.

Roading of flats.

30. The construction of access roads across the extensive poorly drained flats of the far south can be effected either by clearing extra width to enable a heavy grader to cut deep table drains and crown the centre high, or by leaving the root mat intact and gravelling the wheel ruts. Lack of gravel may preclude the latter in which case the vegetation, including root mat, is rolled to the sides to leave a sandy track which will carry normal summer traffic and also 4 wheel drive vehicles in winter.

Contract specifications and supervision.

31. Specifications for contract clearing should indicate clearly the type of machine required, e.g. 'bulldozer of at least 85HP with angle and tilt blade and a tree pushing arm.' Whether the tender should be on an hourly or a mileage basis should also be stated. Selection should be well advanced when clearing commences and it is very often desirable that the officer responsible for the selection should also supervise the construction, he being familiar with the alignment and usually best able to get maximum value from the machines. He is required to keep a record of the hours that contract machines work and certify the operator's daily time sheets as correct. The time sheets, with detail of work performed, e.g. mileage of clearing, yardage of filling, etc., should be furnished each fortnight to the Divisional Office where authority is given for Treasury payment to the contractor. Contract road clearing may not be carried out on weekends unless special circumstances exist and written approval is obtained from the Regional Superintendent or Senior D.F.O.

Forming

Road forming.

32. Initial forming of major roads may be done by the bulldozer, but it is more usual and desirable to use a heavy grader, provided that the surface is left in the right condition by the bulldozer. No stone or large roots should remain which could foul the blade and side cutting must be completed and cut to adequate depth, especially on sidlings. The bulldozer is better equipped to cut rock-hard clay.

All culverts should be completed before grading commences. The form-grading determines the profile of the finished road

hence care is necessary to secure the right camber, curvature, super-elevation and drainage. Guide pegs and careful supervision will be necessary where the operator lacks experience.

Grading

Grading.

33. Forest tracks are frequently graded flat with a slight fall to the low side so that seepage and drainage is across rather than along the road to limit scouring. Where at one grading, the blade displaces the surface material to one side, it is desirable at the next grading to pick up any gravel or soil accumulation and redistribute it across the road to the other side. It is the swamper's job, in addition to removing roots and stones, to open drainage channels through mounds of spoil left by the grader. The grader should be used to divert water to the low side of the road wherever possible. It is usually desirable to crown steep sections of track, again diverting water with the machine.

Draining

Table drainage.

34. As water is the most destructive agent on gravel roads, proper drainage is essential. The road surface is commonly cambered or crowned to shed water into surface or table drains at the side. On forest roads a surface drain is required on one side or on both sides except where flat grading is practised (see under Grading). The surface drains channel surface water away from the road and through culverts under the road as necessary. They are usually formed by the grader and collect also the run off from the hillside.

Culvert spacing.

35. The spacing between culverts depends on the grade of the road and the amount of water which reaches the road from the hillside. On steep grades culverts must be closely spaced to keep the volume of water low and prevent erosion of the drain. There must be a culvert at the bottom of every grade. The number of culverts required per mile will generally vary from 4 to 20. Where an even grade of 1 in 15 applies, relieving drains (15 inch diameter pipes) are commonly required at intervals of 500 ft. There should be a catchpit or sump hole at the junction between drain and culvert.

Size of waterway.

36. The size of culvert required depends on the area of the catchment, on run-off conditions, and on the maximum incidence of rainfall. Various formulae can be used, however, for the conditions which apply in the main area of Jarrah and Karri forest, a useful guide is given by the following table showing maximum watersheds for a range of pipe sizes:—

	Acres.
12 inch diameter	90
15 inch diameter	140
18 inch diameter	200
24 inch diameter	360
30 inch diameter	560
36 inch diameter	810

Observations of streams in full flood and inspection for debris stranded at high water mark often give a useful lead on the size of waterway to be provided.

Pipe installation.

37. Culverts accommodating a stream should have the same alignment as that of the stream and care should be taken to ensure that pipes are not set too low, otherwise silt or water rests in the pipe, reducing the effective waterway. Culvert pipes must be placed on a firm foundation, preferably a longitudinal sill, and firmly packed in position. The pipes should be laid on a uniform grade. Joints may be sealed with cement mortar to a depth of 3 inches and reinforced with wire netting. However it has been found that provided the pipes are level and fit closely at the joint, no sealing is required. The depth of soil required over the pipe should roughly equal the diameter of the pipe.

When a dozer is used to push the filling, first pack the underside of the pipe firmly by hand and then ensure that the machine does not move or damage the pipes.

Sump holes.

38. Sump holes or catchpits at the entrance to relieving drains should be a little bigger than the diameter of the pipes and should drop 12 inches below the bottom of the pipe to form a silt trap.

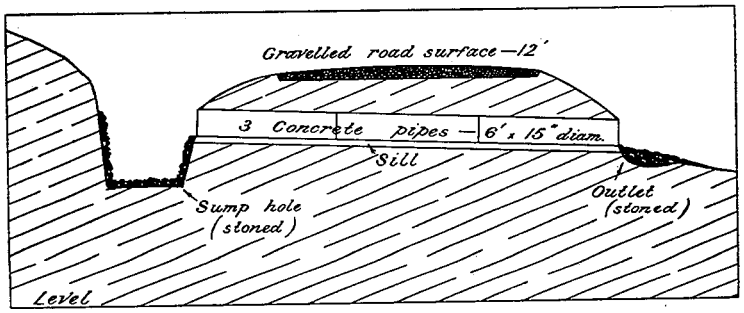


Fig. 2.—Diagrammatic cross-section of a pipe culvert.

Stone facing.

39. The entrance and often the exit of the pipe culvert will require stoning to prevent water from eroding under and around the pipe. Stone is packed carefully in position on a suitable slope or batter to form wings which channel the full flow of the stream into the pipe.

Box culverts.

40. Box culverts are virtually bridges on a small scale, with bedlog abutments and decking secured at right angles to the direction of stream flow (see culvert blueprint No. 858C).

Natural fords.

41. Both natural and artificial ford crossings over major streams in the Karri forest have saved expensive bridging. However, the combination of satisfactory approaches and a suitable ford crossing is generally rare. A rock base for the crossing is desirable but gravel or beds of small stone may be used. Concreting is usually necessary to smooth irregularities in the road bed, the water passing through clefts in the rock surface, or, in some cases, through concrete pipes cemented in position. A disadvantage is that the winter flow of most of our streams renders a ford crossing unusable in winter.

Stony crossings.

42. Stony crossings over minor streams are common where the track or fireline carries little traffic and stone is plentiful close at hand. Ironstone is knapped or broken and compacted in the stream bed and road approaches.

Bridges

Bridges.

43. Bridges on forest roads are invariably of timber construction and most usually of the bedlog and round stringer type. Spans will rarely exceed 20 ft. and where wider crossings are necessary multiple spans will be used. Where decking height will be such that more than 5 bedlogs are necessary it will usually be desirable to use the trestle on sill type of construction. The design for major bridges such as on F.A.R.G. roads should be referred to Main Roads Department bridge engineers.

Bridge planning.

44. It is esential in bridge planning to give careful consideration to the size of waterway, the nature of foundations and the size of timbers necessary.

Waterway.

The waterway should be large enough to carry the run-off expected in a flood year. Existing records should be checked, local residents consulted and the banks examined for debris stranded by floods in the past.

Approaches.

45. In choosing the site, look for straight approaches on acceptable grade. A 3 chain flat approach is the desirable minimum. If necessary, in order to secure satisfactory approaches, the bridge may be placed on an angle to the line

of stream flow provided that the abutments are parallel to stream direction.

Channel.

46. The stream channel at the bridge site should be straight with uniform profile and free flow. Obstructions on the down stream side should be removed if they will impede flow so as to flood the bridge or approaches. Look for stable banks with no possibility of scouring.

Profile and clearance.

47. In order to effectively consider bridge clearance above high water level and continuity with approach roads, it is useful, on major crossings at least, to plot a profile of the centre line of the road and bridge, including the stream bed, and to superimpose the high water level. The bottom of the stringers should be preferably 2 ft. above maximum high water. Mark on the profile the position of piers and abutments, ascertain the amount of filling required and decide the location of the borrow pit.

Construction of bedlog bridge.

48. Marker pegs should be positioned at each end of the bridge with tops set at the proposed level of decking. Allowing for 4 inch decking and specified stringer thickness, the number of bedlogs and the thickness between faces can be ascertained.

Bedlog sills.

49. The base of the bottom bedlog should be positioned approximately 1 ft. below the level of the stream bed to obviate any tendency to scouring or undermining by water. Where the foundations are soft it will be necessary to first position sills (approximately 10 ft. long and 18 inch diameter) beneath the bedlogs at right angles to them and at approximately 8 to 10 ft. centres. Once in position the bedlog is packed with stone and the upper side faced to give a level bearing surface approximately 15 inches wide. Other bedlogs are faced in advance according to specification (see plan below) and secured in position with 24 inch drift bolts. The standard plan from this stage is self explanatory, but it is necessary to warn against removing more than 20 per cent of stringer thickness in facing the underside of the ends where they seat on the upper bedlogs or corbels. Apart from end trimming the underside of stringers is not faced.

Suitable timbers.

50. Jarrah, Wandoo, Blackbutt and Marri are commonly used for bridge timbers, the species used depending largely on availability in relation to bridge site. Karri is not used and Marri, whilst of satisfactory strength and durability, ignites and burns more readily than other species hence it is not used where Jarrah or Wandoo are readily available. Application of creosote where fungal development is likely, i.e. where timber is comonly exposed to air and moisture, will extend bridge life considerably.

Full stringer bridge.

51. Several experimental bridges of up to 45 ft. span have been constructed in karri forest using a 'full stringer' technique in which stringers (usually marri) have been faced on two sides and spiked together with lateral drift bolts at approximately 3 ft. centres. The upper surface has then to be dozed flat to carry traffic. A variation on this technique entails pouring a concrete deck on the stringer base, to which it is effectively keyed by closely spaced nails or spikes. Neither of these methods of bridging is adopted as standard practice.

Gravelling

Gravelling.

52. Gravelling specifications vary with the class of country, the class of road and the amount of traffic it is to carry. Forest tracks are not usually surfaced, but sections of track carrying winter traffic, especially in the karri forest region, do require reinforcing. Arterial roads are frequently surfaced to a width of 12 ft. and a depth of up to 6 inches depending on the nature of natural surfaces.

Selection of gravel pits.

53. Where gravelling is anticipated it is good planning to select suitable gravel pits in advance and open them up with bulldozers, pushing up an adequate reserve of gravel as clearing progresses, keeping in mind the necessity for short cartage,

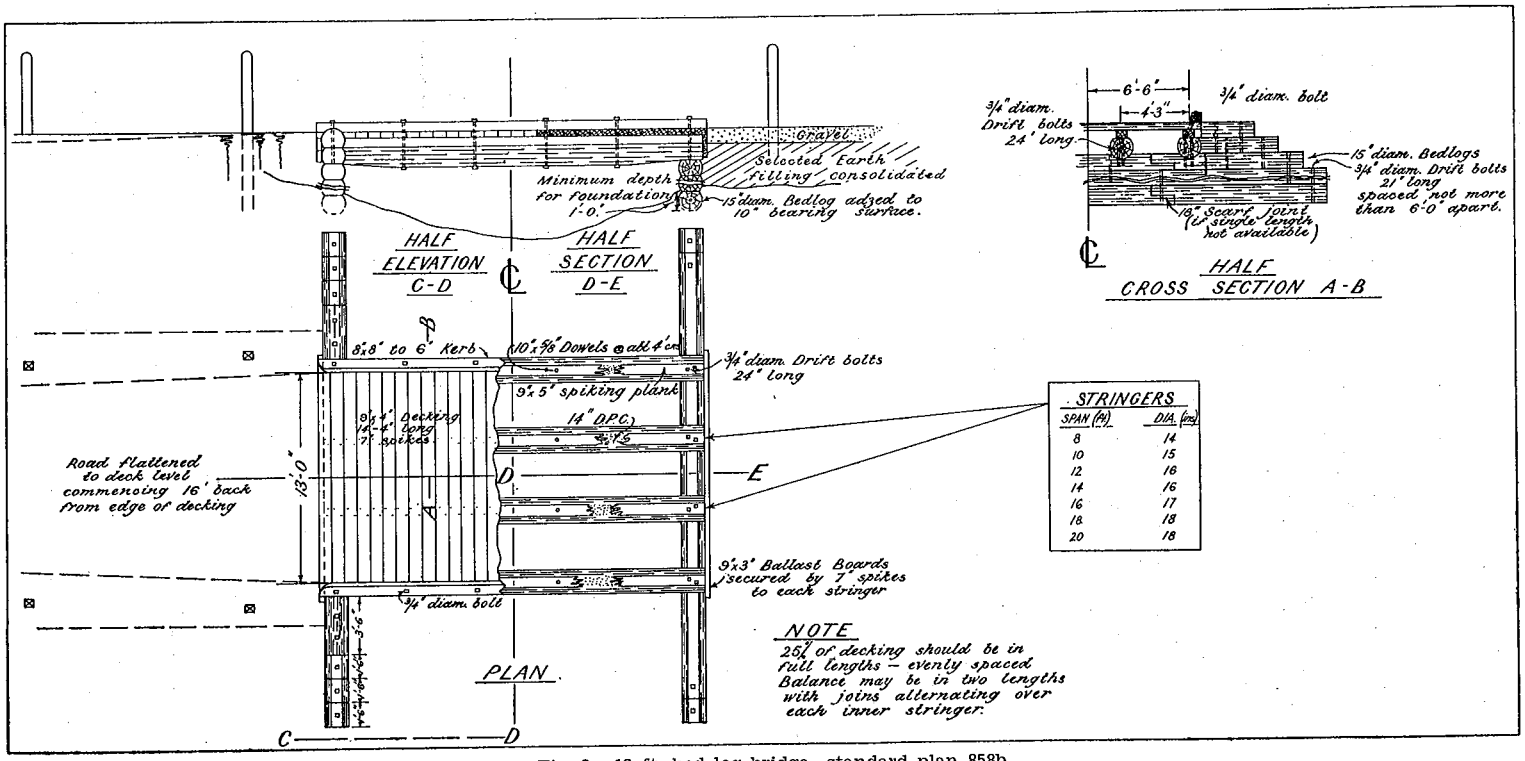


Fig. 3.—13 ft. bed log bridge—standard plan 858b.

i.e. for spacing pits no more than two miles apart. It is important to place gravel pits several chains away from the roadway to screen them from view. Where possible pits should be located in openings or in poorer class timber. It is unfortunate that much of the best gravel supports the better stands of timber.

Gravel quality.

54. The best class of gravel has a graduation in pebble size to a maximum of approximately one inch in diameter and a sufficient clay content in the matrix to give good binding qualities. Cohesion of particles can be tested by moistening and rubbing between the thumb and forefinger. Lack of effective binding material produces a loose road surface prone to potholing and corrugation.

Gravel loading.

55. In organisation of a programme of gravelling it is desirable that sufficient trucks be used to keep the loading equipment in reasonably continuous operation. Advance preparation of pits, with heaping of gravel by bulldozer is necessary for effective operation of a front end loader. The common side-loading ramp is constructed high enough to allow trucks to pass beneath the spilling mouth. Floor logs are set at an incline and should project far enough past the sill logs to place the load in the centre of the tip truck tray but not so far that the tractor has to ride on the projecting platform. The remainder of the platform should be sufficiently long and embedded in the gravel to ensure stability and the side walls of the chute should be about 2 ft. high to confine the gravel pushed by the bulldozer.

Explosives

Explosives.

56. Gelignite is frequently used in the removal of stumps, trees, and stone. Regulations under the Explosives Act govern the use and storage of explosive materials. Whenever possible it is preferable to purchase fuse, gelignite and detonators as required from local stores to avoid the necessity for providing special storage facilities.

Transport of explosives.

57. Explosives must not be carried on trucks which are carrying men and should be in a padded and strongly made wooden box.

Blasting of stumps.

58. Removal of stumps and roots from the ground solely with explosives is difficult and costly, hence normal practice is to loosen and shatter with explosive so that stump roots or stone may be dragged or pushed out using hand winch, tractor or bulldozer. A 1 inch hand auger is used to bore into the stump at a downward angle of 30 to 45 degrees. The deeper the holes are the better, but a depth of 12 to 18 inches is usually sufficient. A detonator is carefully crimped to the end of a length of fuse and inserted in a hole made in the end of a plug of gelignite which is placed deep in the hole, sealed with lightly tamped earth or tightly wadded paper and fired.

Additional plugs to the limit required may have been gently rammed into position before insertion of the fused plug. A single plug is commonly used to open up a hole large enough to take a main charge of 1 lb. of gelignite.

Blasting stone. Rock drilling.

59. When blasting stone, particularly if a straight horizontal or vertical face is required, holes should be bored and fired in groups. A double explosion will more than double the effect of a single 'shot.' Most rock drilling is carried out with a petrol driven pneumatic drill. Drills of 2 to 4 ft. in length are used and longer lengths can be obtained if required (up to 16 ft.). The cutting tip, or bit, is screwed onto the end of the drill and requires constant sharpening or renewal. As a general rule, boreholes should be one and a half times their depth apart and the distance of the holes from the edge should be half to three-quarters of the depth.

Quantity of explosive.

60. The quantity of explosive to be used in each hole is largely a matter of trial and error, but as a guide it is suggested that $\frac{3}{4}$ lb. of gelignite per foot depth of bore should be

used, provided that the top of the charge is at least 8 inches below the surface.

Safety precautions. Use of instantaneous fuse.

61. All persons within range should take cover at the time of firing. Traffic should be halted where necessary and precautions taken to protect buildings and livestock. Tools, bars, etc., should all be removed from the site of the explosion. Once all precautions have been taken the fuse may be lit. If more than one fuse is to be lit use a progressively longer fuse for each charge, lighting the longest fuse first.

Safety fuse.

62. Safety fuse burns at the rate of 2 ft. per minute but this should be tested with each consignment and with old stock. When firing is done separately the number of charges should be tallied and a count of the explosions made to ensure that all charges have fired.

'Misfire' action.

63. If a misfire occurs—

Do not approach the site for at least 20 minutes.

Do not touch the explosive or the safety fuse in it.

Fill the hole with water.

Bore a new hole and charge it.

Fire the new hole.

Instantaneous fuse.

64. "Cordtex," an instantaneous high explosive fuse is not to be normally used or stored, on account of danger in untrained hands. However, because of its special value for simultaneous firing of a number of charges, it may be used for certain projects, but only after the D.F.O. has satisfied his Regional Superintendent or Senior D.F.O. that it will be used only by one man trained in its testing, uses, and the danger of misuse. On completion of the approved project, surplus instantaneous fuse is to be destroyed. "Cordtex" (or FID-fuse, instantaneous detonating) will not explode by lighting, i.e., it must be detonated. The detonator is bound to the "Cordtex" with adhesive tape and the end of the "Cordtex" can be made merely by joining with tape. The detonator is fused with ordinary safety fuse, which, when fired, triggers the simultaneous detonation of all charges.

COSTING

Costing.

65. All construction expenditure on roads, firelines, bridges and culverts, is to be allocated against Items II (A) and II (B), except in the case of F.A.R.G. Roads, which, being recoupable projects, are to be shown under Item 13. Each particular road under Item 13 will be given a distinguishing letter and cost allocated accordingly.

66. Quarterly reports for road construction will provide information as follows:—

Item II (A)—Chainage, wages cost and unit cost for *clearing only,* plus vehicle loading.

A new road is deemed "cleared" as soon as it is trafficable by a 4-wheel drive vehicle.

Item II (B)—Costs of other construction such as selection, initial grading, culverts, bridges, etc., plus vehicle loading. The unit cost is not required at head office but should be recorded locally as a check on operational efficiency.

Particular care is necessary to ensure that chainage of construction appears in the Quarterly Report only once, i.e., that additional work, such as gravelling carried out later, is shown under Item 12 (A)—road maintenance, to avoid duplication of mileage already shown.

Overheads.

These costs are incomplete, as 25 per cent. overheads must be added to cover leave, payroll tax, workers' compensation, hand tools and supervision. Costs for mechanical plant are not included in the report.

Recoupable projects.

67. When accounts are to be rendered for work performed under recoupable projects, an additional 5 per cent. is added to the total cost (including vehicle and plant hire), to cover local and head office administration expenses.

ROAD MAINTENANCE

68. Regular maintenance of all roads and tracks by means of grading, drainage and removal of encroaching scrub and fallen trees, is essential to preserve the net-work in good trafficable condition. The aim over a long period should be an upgrading of road quality by surface improvement, widening where necessary and relocating and improving drainage as experience dictates.

Grading.

69. Graders of approximately 40, 60 and 100 horsepower are used respectively for maintenance grading, heavier maintenance plus initial grading, and for the forming and grading of major roads.

Maintenance completed before fire season.

70. The maintenance programme on District track networks should be completed before the end of October, in readiness for the fire season. Removal of logs is carried out by a tractor-dragsaw combination or by truck and dragsaw using block and tackle in the latter case to avoid strain on the truck transmission or chassis.

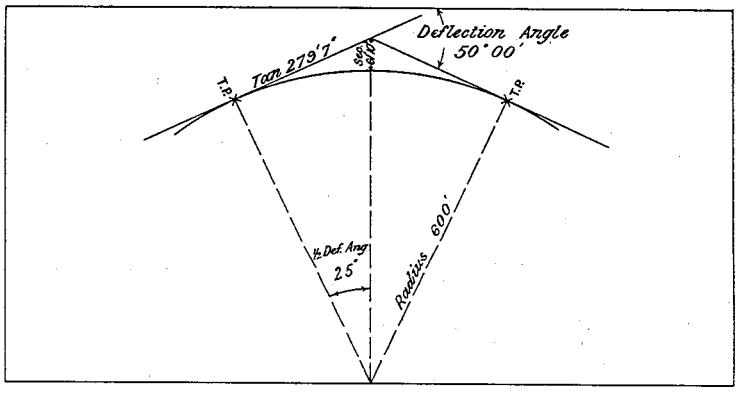
Slashing.

71. Removal of overhanging scrub is carried out by hand slashing, but investigations are being made into the economics and techniques of control by chemical hormone weedicides and by mechanical shears and flails.

APPENDIX 1

EXPLANATION OF CURVE DATA.

To obtain measurement of Tangent and Secant of a curve when the Deflection Angle and Radius are given, using Table of Curve Data.



Example: To find Tan. and Sec. lengths for a Deflection Angle of 50° and a curve Radius of 600'.

From Table—25° (½ Def. Angle) gives Tan. .466, Sec. .103.

These are distances for a Radius of 1 foot.

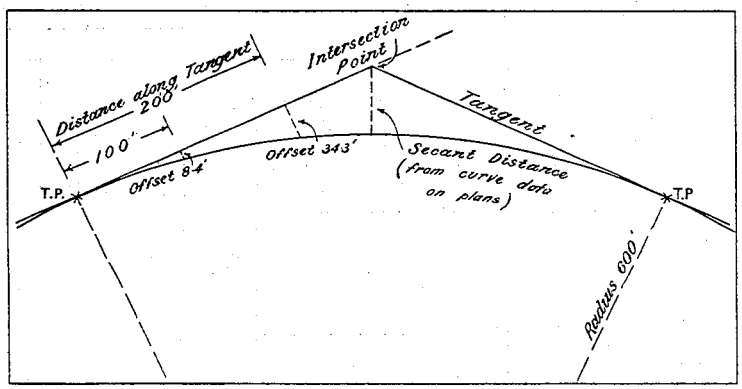
Therefore for a Radius of 600' multiply by 600 thus—

Tan. .466	Sec. .103
600	600
279.6 or 279'7"	61.8 or 61'10"

To set out a curve by offsets from Tangent Line, using Table of Curve Data.

Example: To set out a 600′ Radius Curve.

From Table (under column R. 600′)—
offset at 100′ (distance along Tangent) = 8.4′
offset at 200′ (distance along Tangent) = 34.3′
and so on, setting out at each required distance up to the Intersection point.



Set out similar offsets for the other half of the curve back from the other T.P. towards the Intersection point. The Secant distance at the centre of the curve is *not* offset but is measured along the half angle.

For curves over 1000′ radius offsets should be calculated from the following formula:

$$\text{Offset} = R - \sqrt{R^2 - G^2}$$

where R = Radius
G = Distance along Tangent Line from T.P.

CURVE DATA

COMPASS ANGLES, TANGENTS AND SECANTS

½ Def. Ang.	Tan.	Sec.	½ Def. Ang.	Tan.	Sec.	½ Def. Ang.	Tan.	Sec.	½ Def. Ang.	Tan.	Sec.
10	·176	·015	26	·488	·113	42	·900	·346	58	1·60	·890
11	·194	·019	27	·510	·121	43	·933	·367	59	1·66	·941
12	·213	·022	28	·532	·132	44	·966	·390	60	1·73	1·000
13	·231	·026	29	·554	·143	45	1·00	·414	61	1·80	1·063
14	·250	·031	30	·577	·155	46	1·04	·440	62	1·88	1·130
15	·268	·035	31	·601	·167	47	1·07	·466	63	1·96	1·202
16	·287	·040	32	·625	·179	48	1·11	·494	64	2·05	1·281
17	·306	·046	33	·649	·192	49	1·15	·524	65	2·14	1·366
18	·325	·051	34	·676	·206	50	1·19	·557	66	2·25	1·458
19	·344	·059	35	·700	·221	51	1·23	·589	67	2·36	1·559
20	·364	·064	36	·727	·236	52	1·28	·626	68	2·48	1·669
21	·384	·071	37	·754	·252	53	1·33	·663	69	2·61	1·790
22	·404	·079	38	·781	·269	54	1·38	·703	70	2·75	1·924
23	·425	·086	39	·810	·287	55	1·43	·745	71	2·90	2·072
24	·445	·095	40	·840	·305	56	1·48	·788	72	3·08	2·236
25	·466	·105	41	·869	·325	57	1·54	·838	73	3·27	2·420

OFFSETS TO CURVE FROM TANGENT LINE

Dist. along Tang.	R 100	R 150	R 200	R 250	R 300	R 350	R 400	R 450	R 500	R 600	R 700	R 800	R 900	R 1000
25	3·2	2·1	1·5											
50	13·4	8·6	6·4	5·0	4·2	3·6	3·1	2·8	2·5	2	1·8	1·6	1·4	1·2
75	33	20·1	14·6	11·5										
100		38	27	21	17	15	13	11	10	8	7	6	6	5
125			44	34										
150			68	50·0	40	34	29	26	23	19	16	14	12	11
200				100·0	76	63	54	47	42	34	29	25	23	20
250					132	105	88	76	67	55	46	40	35	32
300							135	115	100	80	67	58	52	46
350								167	143	113	94	80	71	63
400									200	153	125	107	94	84
450											164	139	121	108
500											210	175	152	134
550												219	188	165
600													229	200
650														240

APPENDIX 2

SUPER ELEVATION

	10 m.p.h.		20 m.p.h.		30 m.p.h.		40 m.p.h.	
Curve Radius	⊖	16 ft.	⊖	16 ft.	⊖	16 ft.	⊖	16 ft.
100								
200								
300	·72							
400	·54	8·6						
500	·43	6·9						
600	·36	5·8						
700	·30	4·8						
800	·27	4·3	1·06					
900	·24	3·8	·95					
1,000	·21	3·4	·85	13·6				
2,000	·11	1·8	·42	6·7	·96			
3,000	·07	1·1	·28	4·5	·64	10·3		
4,000			·21	3·4	·48	7·7	·86	
5,000			·17	2·7	·38	6·1	·68	10·9
6,000			·14	2·2	·32	5·1	·57	9·1
7,000			·12	1·9	·27	4·3	·49	7·8
8,000			·10	1·6	·24	3·8	·43	6·9
9,000					·21	3·4	·28	6·1
10,000					·19	3·0	·34	5·4

Note.—These figures apply to a 16 ft. road surface.

ALL measures in inches unless otherwise stated.

Super elevation is the amount of banking necessary on a curve.

To determine the difference in level between the inside and the outside edge of the road surface, multiply $\ominus$ by the width of the road surface.

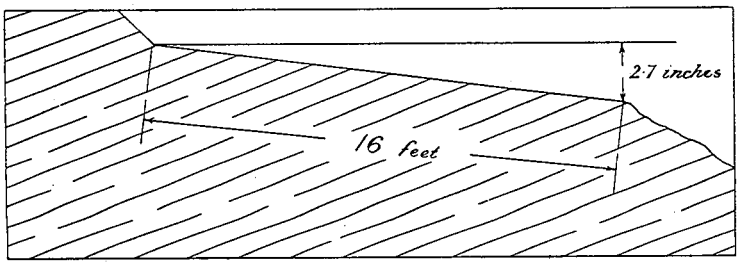
For example :

On a 20 m.p.h. road 16 ft. wide, a curve with a radius of 5,000 feet will need to be

$= 16 \times \ominus$

$= 16 \times \cdot 17$

$= 2 \cdot 7$ higher on the outside edge of the curve than the inside.



Appendix 2.—Explanation of super elevation.

SECTION 2.—TOPOGRAPHICAL SURVEYING AND SUBDIVISION

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TOPOGRAPHICAL SURVEYING AND SUBDIVISION

INTRODUCTION

1. Topographical surveys of forest land and the collection of field data is required for the preparation of maps, the compilation of Working Plans and the systematic control and recording of all forest operations.

For the purposes of administration the forest areas of Western Australia, over which the Forests Department exercises control, are divided into:—

Divisions.

2. These range from a quarter of a million to over one million acres in area but include varying patterns of land for which the tenure is farming, mining, national parks, fauna and flora reserves and others.

It is vitally important that the forest lands under the control of the Forests Department be clearly defined—in other words those boundaries involved must be clearly indicated not only on a map but in the field.

Districts.

3. These are smaller units of administration within a Division and are controlled by the local forest officer. Here, the detailed knowledge of private property boundaries, timber reserves and existing roads, tracks, firelines and topographical features such as ridges, rivers, creeks, rock outcrops, swamps, forest types and other natural features are of paramount importance to the Officer in Charge of a District. Such information enables him to record trade cutting operations, regeneration work and the various phases of controlled burning etc. and to submit proposals for future work.

Blocks.

4. These are smaller administration units within the District usually 7,500 to 15,000 acres in extent and bounded by known road and tracks or natural features. They are given an appropriate name—e.g. Mack Block after Mt. Mack.

Compartments.

5. The smallest working units within a block are compartments. These are numbered and are nearly always bounded by roads, tracks, tramway formations or creeks, etc. They vary in size according to forest types, being 25 to 150 acres in Karri and 350 to 650 acres in Jarrah.

Extent of requirements.

6. Normally the survey of the foregoing subdivision is carried out by survey camps supervised by trained men, but the Forester will, in the course of his work, find it necessary to use the prismatic compass in locating access roads and in the demarcation of lease and permit boundaries.

SURVEY INSTRUMENTS AND WHEN TO USE THEM

Theodolite.

7. This is used to provide accurate general mapping control including ground control for aerial mapping. Permanent marks—e.g. survey posts—are placed in the ground at every angle to provide ties for further subdivision either by theodolite or prismatic compass.

It is anticipated that theodolite subdivision will eventually reach the stage where traverses by compass and chain need not exceed 3 to 5 miles.

Theodolite projects must be referred to head office and are not to be undertaken without their approval.

Compass work.

8. The compass and 5 chain steel band is used on traverses over a mile in length, where reasonably accurate work is required.

Oil Float Type or Forester's Compass.

9. These are used for general survey work, including compass and pacing traverses, opening old theodolite surveys, etc. It is not proposed to supply Forester's Compasses but where they are still available they may be used.

Dry card type.

10. These prismatic compasses are gradually being replaced by the oil float type. Unless in first class condition it is not advisable to use them on traverses requiring a fair degree of accuracy. They are best used for surrounds of trade cutting operations and temporary assessment lines, etc.

Plane Table and Alidale.

11. Plane tabling is a method of surveying the peculiar feature of which is that the field observations and plotting are done simultaneously. It is commonly used by the Forester to locate the positions of buildings and fences in a settlement. It may also be used for short traverses of tracks in reasonably level and open country.

12. **Examples of Instrument Use:**

(a) **Sub-arterial Roads.**—Use prismatic compass (oil float type) together with 5 chain steel band, plumbobs and arrows.

(b) **Forest Tracks and Firelines.**—Use prismatic compass and 5 chain steel band—plumbobs and arrows not needed.

(c) **Boundaries of Trade Cutting Operations.**—Use prismatic compass and pace distances.

Degree of Accuracy Required

13. **Theodolite Framework Control Surveys:**

TA Surveys closed by calculation to within 2 links per mile.

TB Surveys closed by calculation to within 10 links per mile.

TC Surveys showing a misclose by calculation of 10-20 links per mile.
Reference trees marked on A.B. and C. traverses to be shown with a double circle.

14. **Compass and Chain Surveys:**

CD Compass surveys closed by plot to within 25 links per mile and tied to other Lands Department surveys or F.D. theodolite surveys at not more than 3 mile intervals.

CE Compass surveys closed by plot to within 50 links per mile and tied to other surveys as above at not more than 3 mile intervals.
Reference trees marked on CD and CE traverses to be shown with a single circle.

CF Compass surveys showing a misclose of more than 50 links per mile, or tied to other surveys as above at more than 3 mile intervals.
Reference trees marked on F traverses will be shown with a broken circle to indicate that position is doubtful.

CG Surveys by compass and pacing. Misclose 5 chains per mile.
No reference trees are to be marked along these unreliable traverses.

15. Where it is considered necessary to reduce the error of close in TC (Theodolite surveys) and CF (Compass surveys) by field check or ties to other surveys, the field books will be returned to the field officer for this purpose.

A schedule will be marked on the foot of each compilation sheet for important surveys likely to be used for control showing error of closure, whether by calculation in the case of theodolite surveys or by scale for acceptable compass surveys as follows:—

EXAMPLE OF SCHEDULE ON COMPILATION SHEETS

Road	Square Ref.	Distance	Class	Error		Remarks
				By Calculation	By Scale	
Mackay	Ax84–BK83	72,000	TB	+N45+E11	....	Cal Book P.2
Mackay	BK83–BP84	48,000	TA	—N8+E2	....	Cal Book P.4
Old Willies....	BJ85–BM87	24,000	CD	....	–S25–E50	

DESCRIPTION OF INSTRUMENTS

Forester's Compass

16. The Forester's compass consists essentially of a magnetic needle supported by an agate and moving freely on a steel point at the centre of a horizontal graduated circle

enclosed in an aluminium case having a glass cover. To the case is attached a pair of sights. The compass rests on a tripod by means of an attachment containing a ball and socket joint for convenience in levelling the compass. The base of the 3" diameter compass is square, and could be used for plotting as it contains a scale and protractor while the 5" diameter compass has a circular base without external markings for plotting purposes. The levelling bubbles are set at right angles on the base.

The magnetic needle.

17. This is a slender bar of steel strongly magnetised and supported on a fine pointed pivot on which it turns freely. By means of the small thumb screw or plunger the needle may be steadied, or, when not in use, it can be lifted from the pivot and held against the glass of the compass box, so that it will not wear the pivot by oscillating when the compass is being moved.

The sights.

18. Attached to two diametrically opposite ends of the compass case are the sights, called sighting slot and vane respectively, by means of which the compass is aligned to any object. The sighting slot is at the south end. This is the end from which the sight is taken; the sighting vane is at the north end. The sights have joints near the base, so as to fold down on the needle box.

The graduated needle circle.

19. Within the circular box containing the needle is a graduated circle having a diameter slightly greater than the length of the needle, and at the centre of which is the pivot supporting the needle. This circle is graduated in half degrees from 0 deg. to 360 deg. The markings run anti-clockwise for convenience when reading the instrument.

Plate levels.

20. For the purpose of indicating when the compass is in a horizontal position, two small spirit levels are attached to the compass. Each level consists of a glass tube curved slightly upwards at the middle. The greater part of the tube is filled with alcohol, the remaining space being occupied by a small bubble of air. The tube is mounted in a brass tube, or case, and attached to the compass plate by screws. One tube is parallel to the line of sight and the other one is at right angles to it. When these levels are in proper adjustment, the compass can be brought to a perfectly horigontal position by so moving or tilting it as to bring the air bubbles to the centre of the tubes.

The tripod.

21. Consists of three wooden folding legs about 4 ft. 6 in. in height shod with steel and connected to a metal tripod head.

Ball and socket joint.

22. Attached to the underside of the compass case is a projecting piece or centre having in its lower end a vertical **socket,** by means of which the compass is connected with its support. This socket is slightly conical in form and fits on a **spindle,** on which it turns freely, permitting the compass to be revolved in a horizontal plane. On the lower end of the spindle is a ball turned perfectly spherical and held in the spherical socket, the upper part of which screws on its lower part in such a manner that its pressure on the ball can be regulated by tightening or loosening the screw. This ball and socket joint permits the compass to be moved or tilted in any direction in the operation of levelling it, the screw being at the same time sufficiently tight so that the compass will remain in position when levelled. The lower part of the ball and socket joint is attached to the top of the tripod head.

Care of instrument.

23. Compasses are in adjustment when issued. Every reasonable care should be taken to keep them so. Handle carefully, protect from weather and see that the needle is clamped when not in use.

If a compass is inadvertently damaged or gets out of adjustment, it should be returned to head officer for repair. On no account should repairs be attempted locally except the replacement of horsehair in the sighting vane.

Prismatic Compass (Dry Card Type)

24. The standard prismatic compass used for this work is 3" diameter. It consists of a flat circular brass or gunmetal box containing a green card circle divided into half degrees. Underneath and across the diameter of this circle a flat permanent magnet is fixed having an agate screwed into its centre. The green card is supported at the agate on a pivot point screwed precisely in the centre of the bottom of the brass case. The card is accurately balanced about this centre by the addition of sealing wax at the northern end to counteract the dip to the south. In the front of the box a magnifying right angle prism is fitted and held in a small dove-tailed slide which allows this prism to be raised or lowered in order to bring the divided circle accurately into focus. The prism box is hinged so that it may be folded back when replacing the cover to protect the glass of the compass. Above the peephole of the prism, a slit is cut so that the user can bring the vertical wire, opposite the prism, into line with the object sighted to the prism, and at the same time read the divided circle. The vane carrying the vertical wire can be folded down on the glass before replacing the cover. In this position, it engaged with a small vertical pin which, acting on a lever, lifts the magnet off its pivot and locks the card against the glass cover. A small finger piece is fitted in the side of the case, which operates a friction brake, thus allowing the user to stop and steady the oscillations of the green card when about to take his readings. A leather case and strap are provided to protect the compass when not in use.

25. As a compass leaves head office, it should be in good adjustment and the user is seldom, if ever, called upon to make any alterations to the original settings. In fact there is hardly anything he can do to correct any apparent errors, and the whole instrument is so simple that the only adjustments likely to be required are those due to serious damage which would necessitate its return to head office for repairs. There are only two tests that the user need make:—

(a) to determine the index error, and

(b) the accuracy with which the needle comes to rest.

An index error (a) is caused through an incorrect setting, mainly of the compass card and pivoting point and is apparent when bearing to known points are taken, e.g. bearings taken from a corner of a location in two of the cardinal directions would show this error, and (b) by repetition of readings on the same mark. If the needle does not always take up the same position, it shows that either the pivot point has become blunt or that the agate has been damaged. The blunting of the point is the only damage that is likely to occur but occasionally agates do require replacing. Care should be taken that the sighting vane is folded down and the needle lifted off its point whenever the instrument is being carried from place to place.

Prismatic Compass (Oil Float Type)

27. This is similar in principle to the dry card type but the protractor is immersed in a fluid—either kerosene or alcohol.

When a persistent air bubble occurs they must be sent to head office for repairs. A hypodermic syringe is needed to force out the air bubble through a small aperture and the correct fluid must be injected.

28. The standard pattern five chain steel band with carrying reel is used. **Chain.**

The band is usually graduated as follows:—

First 10 links at each end are marked in links and 1/10ths links; first and fifth chains are marked in links; the intervening second, third and fourth chains are marked at 10 link intervals.

29. In the event of a chain being broken while on the job, the broken ends should be carefully cleaned with carborundum stone or sandpaper to remove all trace of rust, etc., and a brass sleeve carefully fitted and soldered to make a firm neat joint. (Repair outfits are obtainable on requisition to Head Office).

The repaired 10 link section should then be checked with a sound section.

Chains should be examined and checked at intervals.

Magnetic Variation or Declination.

30. The magnetic variation or deviation, better referred to as declination, is the horizontal angle between the magnetic north and true north and should always be taken into account when mapping by compass.

As the magnetic poles do not coincide with the geographic poles, the magnetic meridian does not coincide with true meridian except in certain localities.

The direction and amount of variation between the two alters at different localities on the earth's surface and is not constant but is subject to some periodic fluctuations.

Testing Compass for Magnetic variation.

31. The magnetic variation may be ascertained by setting up and checking by fore and back sighting between any two survey pegs fixed by theodolite, the true bearing of which being known. Care must be taken that local magnetic attraction does not exist when the compass is being tested. The backsight indicates this.

Conversion of magnetic to true bearing.

32. All bearings (or readings) taken with a compass are "magnetic bearings," and plotting is always done in relation to a true north and south line. Before plotting therefore, magnetic bearings must first be converted to true bearings. In the case of 5° westerly, the true bearing is obtained by subtracting 5° from the magnetic bearings.

The method of plotting adopted by the Department automatically adjusts compass to true bearings.

Local magnetic attraction.

33. The compass needle may be deflected from its natural direction by the attraction of any magnetic substance near it, such as iron ore, the rails of a railway, wire fence, etc. Local attraction is very often met with, and special pains must be taken to avoid the errors and loss of time to which it may give rise. When the bearing determined by a foresight does not agree with the reverse bearing of a backsight, the usual cause of the variation is local magnetic attraction, and is often found to be confined to a comparatively small area. By selecting some other turning point on the traverse (shortening or prolonging the 'shot' affected) the local attraction may usually be reduced to within negligible limits, if not altogether avoided. The method of adjusting compass readings is set out in paragraph 44.

SURVEYING PROCEDURE—COMPASS AND CHAIN

Starting point.

34. The survey should be commenced from some known point shown on the topo sheet, e.g. the survey pegs at a reference tree, the corner of a location, a road survey or the survey pegs along a survey line from which the magnetic variation plus any small individual variation in the compass may be ascertained. Survey may also be commenced from a reference tree fixed by compass, but a point fixed by theodolite survey is preferable. In any case, reliably established ties should be made as often as possible to a point during any traverse in order to ensure all possible accuracy.

In the past, the head office party carrying out Controlled Surveys has offset survey pegs from the instrument point by the half-angle method so that they are parallel to the line of traverse and 50 links or 100 links away. In future, all such survey pegs will be offset to be a standard 100 links from the line of traverse, to allow for any later straightening or widening of the road.

Fig. 1 shows the method employed for these offsets. If required, detailed information is obtainable from head office of the position of pegs.

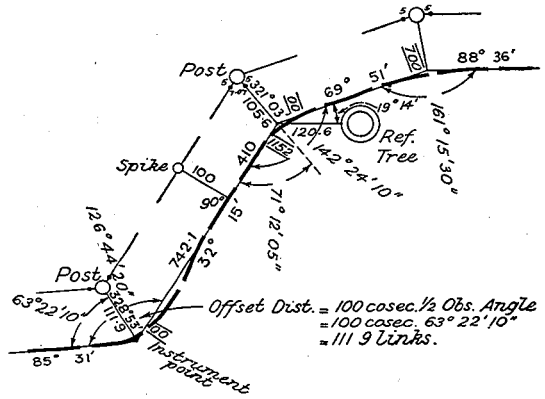


Fig. 1.—Controlled Surveys—method of offsetting pegs from instrument point.

35. Do not interfere with existing survey pegs.

36. Having established the magnetic variation and determined the starting point, the survey may be commenced. The field notes should be entered in a field book.

Field Book.

37. The field books should be identified by the user's name and a consecutive number, e.g. Smith No. 1; Smith No. 2, etc. Description of survey, type of instrument and magnetic variation should be clearly stated in the field book, together with the registered F.D. number of compass and chain.

Each traverse entered in field book should be initialled and dated.

As the traverse continues the following points in booking should be noted:—

(a) Where "shots" are longer than 5 chains, each 500 links and the broken chainage is to be noted in the field book (see Appendix 2) to avoid the common error of dropping 5 chains in the total distance.

(b) Calculations of correction for slope are to be shown in the margin and the corrected figure shown in the "Distance" column.

(c) The distance between stations shall be shown between parallel lines. The figures OO should be shown in the same way at each instrument station—see Appendix 2.

(d) At the end of the traverse the total distance of the traverse shall be shown.

(e) As each field book is completed or submitted for despatch to head office, the index shall be filled in.

(f) Care and accuracy in recording readings, sketching features and establishing ties is more important to the final result than demanding a minimum chainage of work per day.

Traversing.

38. The compass is set up at the starting point (entered as O in the field book of Traverse A, or an alphabetical designation, and A/O on the waddy). The compass is then directed to the first waddy in the traverse, read, then turned to the reverse bearing and clamped; this saves excessive swinging and wearing of the compass agate and pivoting point. The waddies should be so placed as to give the longest possible shots. The five chain band is run out and the distance chained to the nearest link. Where the 'slope' of the ground exceeds 4°, allowance should be made when chaining the shot, the degree of slope being measured with an Abney Level or other

clinometer and the measured chainage adjusted in accordance with directions and table in Appendix 1. The chainage along a traverse line to any feature contacted, such as the edge of a flat, stream, culvert, track formation etc., should be noted. Features off the traverse line should also be noted, and chainage ascertained by pacing offsets, i.e. pacing at right angles from the traverse line to the feature. The compass is then set up at Waddy A/1 on which the chainage has been inserted in crayon and directed to A/O, the clamp screw released and the back sight noted which should read ± 180° of foresight if not subject to local attraction. The compass should then be turned to Waddy A/2 and proceed as before. Ties should be made as often as possible including to own work, thus localising any errors.

Reference trees.

39. Reference trees should be marked in the field not less than 40 chains and not more than one mile apart, unless otherwise directed by the D.F.O.

They are best placed at the intersection of roads, or, where no branch roads exist, on the tops of ridges, in saddles, or near creek crossings.

Selection of reference trees.

40. Reference trees should be selected for permanency and should be reasonably windfirm and healthy. Avoid any trees, especially hollow-butts, subject to damage or destruction by fire, but do not mark vigorous growing stock of the A, B, or C type.

41. **Lightly** blaze the tree in the form of a shield and chalk on it a letter corresponding with that of the traverse and a number. For example, the first reference tree along traverse 'E' would be E_1, the second E_2, and so on.

42. If the traverse plots to satisfaction, and after discussion with the D.F.O., reference trees may be cut where they are well inside a particular reference square. Where, however, there is any doubt as to which square they are in, they are not to be cut until head office advises the correct square and number. Keep a separate notebook to record trees cut and to be cut.

For the size of the shield, letters and numbers, see Appendix 3. A surveyor's gouge is used to cut the letters and numbers.

43. A foresight only and the distance from the nearest instrument station is all that is required to tie in the tree.

Adjusting field notes for local magnetic attraction.

44. Field notes are entered in columns providing for compass readings, for foresights and backsights: Variations ±: Progressive Variation ±: Corrected Bearing: chained distance.

The first, second and last columns record actual readings on the traverse, intervening columns are used for adjustment of bearings when required.

The Forester's compass is read to only ¼° and therefore small adjustments may be made by halving the variation ± 180° between foresight and backsight of a traverse line to a difference of 1°. If the difference is greater than this, correction should be made in accordance with the following method, which actually is an adjustment of the included angle at each turning point on the traverse:—

(i) Convert backsight to read as a foresight by adding or subtracting 180° to backsight when foresight is under or over 180°.

(ii) Compare these bearings and enter the ± angle required to make backsight equal foresight under '± variations.'

(iii) Ascertain the total differences ± over a group of bearings. If the totals do not balance within 1° the compass bearings have been either incorrectly read or entered and need check.

(iv) Add ± variation progressively and enter results opposite the next succeeding bearing under '± progressive variation.'

(v) Add or subtract to or from foresights and enter under 'corrected bearing'.

The following is an example met with in the jarrah forest:—

Compass Bearing F.S.	B.S.	Variation		Progressive Variation		Corrected Bearing	Distance
		+	—	+	—		
304 °	124°	....	....	....	....	304 °	943
322 °	138 °	4 °	....	0	0	322 °	1,087
329¾°	156¼°	....	6½°	4 °	....	333¾°	432
315 °	125 °	10 °	....	....	2½°	321½°	764
347 °	173¼°	....	6¼°	7½°	....	354¼°	898
6¼°	186 °	¼°	....	1¼°	....	7½°	642
71 °	254¼°	....	3¼°	1½°	....	72½°	1,531
88½°	262¼°	6 °	....	....	1¾°	86½°	1,047
46 °	232 °	....	6 °	4¼°	....	50½°	639
71 °	249¾°	1¼°	....	....	1¾°	68½°	543
168¾°	349¼°	....	½°	0	½°	168¼°	751
181 °	1 °	....	....	....	....	181 °	832
		21¼°	22½°				

45. In the course of traversing, particularly in the south-west, ironstone formations having magnetic properties are frequently passed over or approached. In practice it will be found that this local attraction occurs on a short section of the traverse and rights itself on leaving the source of the disturbance. Under these circumstances each 'group' of variable readings requires adjustment which should not be carried on over fore and backsights which agree ± 180°.

Note.—There are other methods of adjusting bearings for local attraction, but the above has proved satisfactory.

Plotting field notes.

46. True to scale topo sheets are supplied by head office. These sheets show all existing surveys and compass survey work previously carried out. Upon these sheets the traverse line should be plotted.

The compass work is plotted direct onto the topo sheets by means of a parallel ruler, etc., and protractor, which is an imprint on a sheet of cardboard, the middle of which is cut out. The work is plotted in the following manner: The magnetic variation plus any variation of the compass being established at, say 5½ to the west, and the true bearings of the North-South grid reference lines 1½° to the east. The magnetic bearing of the grid lines would be 7°, hence the 7° mark on the protractor is set on the grid line and the 187° mark at the south end. The centre of the protractor is ascertained by placing the parallel ruler magnetically east and west, i.e. to lie across 97° on the eastern side and across 277° on the western side of the protractor; a short line is drawn cutting the grid line at the intersection which is the centre of the protractor. Care should be taken when plotting a bearing to see that the parallel ruler cuts this intersection. The protractor is pinned or weighted onto the plan and the field notes can now be plotted. All the existing work on the topo sheets is plotted to true bearings. As the protractor has been swung 7° to the west, the 7° is taken off any line plotted without calculation, i.e. when a magnetic line is plotted it becomes a true bearing. The starting point being established (not necessarily at the centre of the protractor) the first bearing, say 73° of the traverse is plotted. The parallel ruler is placed across the protractor, the edge coinciding with 73° and 253° and as a check it should be seen that the parallel ruler also cuts the intersection point at the centre of the protractor. The parallel ruler is then rolled into position until the edge is directly over the starting point and a line is drawn with a 5H drawing pencil in the direction 73°, i.e. to the right. The distance is scaled and noted and the next bearing plotted, and so on to the end of the traverse. All work should be tied in correctly, i.e. traverses should be checked as often as possible by running ties to existing surveys. These traverse lines should be drawn in a thin pencil line and the work sketched in, in accordance with the conventional signs.

Each page of the field book should be dated and indexed with the topo sheet.

47. Upon completion of the work or a section of it, the topo sheet and field book should be forwarded per **registered post** to head office through the Divisional Forest Officer. If required at any future date locally they may be obtained on application. Original notes, not copies, should be submitted. D.F.O.'s are required to sign all topo sheets submitted and make notes re miscloses.

Prismatic Compass and Pacing Without Backsights

48. This type of survey work is sufficient for ascertaining the extent of top disposal areas, tree marking areas, etc. The accuracy required is to a five chain misclose.

49. In this work no sight sticks or pickets more commonly known as waddies, are necessary, but in their stead trees are used. The person carrying out the survey commences work from some known point indicated on the topo sheets, not necessarily a survey peg or reference tree, but intersections of tracks or features would be sufficient for this work. A tree bole is sighted to in the direction it is desired to proceed with the traverse. The bearing noted to the nearest degree, the compass card locked against the glass cover and the distance paced and noted. Upon arrival at the tree sighted to, another tree is selected in the required direction and the traverse continued as before until completion, tying to a known point shown on the topo sheet even if extra traversing is required.

50. When reading the bearing through the prism, care should be taken in raising or lowering the prism to bring the compass card graduations into proper focus and the compass held in a horizontal position to allow the card to swing freely. The card is then steadied by the friction brake until it swings over about three degrees of arc and the mean of the swing noted as the required bearing. A little practice will enable the user to read bearings with accuracy in this manner without waiting for the compass card to come to complete rest, thus saving time. The field notes should be noted in the field book specially kept for the purpose by the person carrying out the work.

SPECIMEN PAGE OF FIELD BOOK

Traverse of Top Disposal Area Boundary Within S.M.P. 834
Topo Sheet D4

Pacing Standard for five chains Equals 126 Paces.

Sight No.	Bearing	Distance		Remarks
		Paces	Chains	
1	89°	98	4	Ref. sq. DF70 tracks intersect
2	225°	216	8·6	
3	117°	158	6·3	
4	109°	139	5·5	
5	227°	181	7·2	
6	258°	87	3·5	
18	247°	175	6·9	Track
19	319°	284	11·3	Track crosses formation

Note.—The entry in the column headed 'chains' is made after returning to camp or office and is worked out as follows:—

For each traverse line multiply the number of paces taken by five and divide by your standard. This figure should be a constant for each officer but must be given at the top of each page used of the field book, so that calculations can be checked if required. Thus 216 paces multiplied by five and divided by 126 equals 8.6 chains.

Pacing.

51. To obtain satisfactory results from compass and pacing, the pacer must calibrate his steps. This should be done before starting each compass survey job, unless an officer is frequently engaged in this class of work, in which case he should check his pacing at least once every month. The method to be followed will be to walk naturally along a surveyed line for a distance of five or ten chains and count the paces taken. Between 1929 and 1955, where reference trees have been established by theodolite, two survey pegs have been put in at these trees, five chains apart in one of the cardinal directions. One peg would be near the reference tree and trenched giving the direction of the second peg—also base lines have been run through the major axes of compartments and pegs put in five chains apart. The number of paces taken by an officer may be ascertained or checked between these pegs.

When running a traverse the paces taken between each angle should be noted in the field book and converted later to chains when back at camp or office. A sample page of the field book and method of calculation appears above.

Prismatic Compass and Pacing With Backsight

52. This type of survey should be carried out when surveying permanent tracks and improvements within compartments. The accuracy required is to a two chain misclose.

In this work more care is taken and waddies are placed at the traverse turning points.

53. A point being selected which is shown on the topo sheet, a waddy is placed upright at it. Waddies are then placed at all the turning points and at the last point which like the commencing point must be tied to a known point preferably a survey peg or reference tree. The survey now really begins at the last waddy put in and is numbered 1. A foresight is taken to the previously established waddy No. 2, and the bearing read and noted; the distance is then paced and also noted in the notebook, specially kept for the purpose. At waddy No. 2 a backsight is read to waddy No. 1 and a foresight read to waddy No. 3 and noted in each case, the distance paced and proceed as before taking backsights and foresights from every waddy.

A backsight should agree with a foresight ± 180° but if not local magnetic attraction would be the cause. If fore and backsights ± 180° disagree up to 5° the difference may be halved and the mean accepted as the correct bearing.

If, however, the difference exceeds 5° the notes should be forwarded or referred to the Divisional Forest Officer who will be able, if the compass bearings have been read correctly, to correct them for local magnetic attraction by a method set out in Notes on Compass Survey by Forester's Compass and five chain band.

SPECIMEN PAGE OF FIELD BOOK

Traverse of Track in Windsor Block Compt. 5 Topo Sheet D4
Pacing Standard for Five chains Equals 123 paces

Sight No.	Fore-sight	Back-sight	Corrected Bearing	Distance		Remarks
				Paces	Chains	
1	310°	130°	....	181	7·4	Ref. Tree DF 75/1
2	253°	77°	225°	198	8	
3	291°	106°	288½°	136	5·5	
4	274°	91°	272½°	112	4·6	
5	268°	93°	270½°	229	9·3	
14	259°	75°	257°	130	5·3	Fire line
15	194°	16°	195°	385	15·7	Formation crosses fire line

Note.—The entry in the column headed 'chains' is made after returning to camp or office and is worked out as follows:—

For each traverse line multiply the number of paces taken by five and divide by your standard. This figure should be a constant for each officer but must be given at the top of each page used of the field book, so that calculations can be checked if required. Thus 181 paces multiplied by five and divided by 123 equals 7.4 chains.

The foresights should be corrected to give the bearing to be used in plotting, thus at waddy No. 2 180° added to the backsight read at No. 3 77° = 257° and the foresight read at No. 2 = 253°, therefore the mean = 255°.

The field notes, using the corrected foresights, should now be plotted and transferred to 20 chain scale topo sheets in the same manner as described under paragraph 6 (d) of these notes.

54. No reference trees are to be established on traverses run by compass and pacing methods.

Plane Table and Alidade

Plane table.

55. The plane table consists essentially of a drawing board, which carries the sheet of paper, and is mounted on a tripod in such a way that the board can be levelled and rotated about the vertical axis and clamped in any position.

The board ranges in size from 15" x 15" to 30" x 24" and must be of thoroughly seasoned wood constructed in such a manner as to counteract the effects of warping.

Alidade.

56. The alidade consists of a wooden graduated ruler equal in length to the smaller dimension of the board and finished with a pair of sights. One of the vanes is provided with a narrow slit, while the other is open and carries a hair or wire. To permit proper sighting in undulating country, a strong thread is stretched tightly between the centres of the tops of the vanes. A spirit level is usually fitted to the alidade, but if not a small spirit level will suffice to level the board—two readings being made at right angles.

A trough compass about six inches long is used when it is necessary to orient the table to magnetic meridian.

Finally a waterproof cover is provided to prevent the wetting of the board and the paper fastened to it.

57. The paper used should be of good quality and fastened tightly over the board to prevent the possibility of displacement by the friction of the alidade. By using a sheet of paper larger than the board and pasting or pinning it to the underside of the board a smooth taut surface is obtained. If drawing pins are used, care should be taken to see they do not work loose.

Method of use.

58. There are several methods of using the plane table and alidade but only three methods are likely to be used by the Forester. They are:

(i) Radiation.
(ii) Traversing.
(iii) Intersection or Triangulation.

Radiation.

59. Select an instrument station, O, from which all points to be surveyed are visible. Set up and level the table and clamp the horizontal movement. Select a point O on the sheet to represent the instrument station, and, with the alidade touching O, sight the various points A, B, etc. to be located, drawing radial lines towards them. Measure distances OA, OB, etc., set them off to scale, and join the points a, b, etc., so obtained.

Traversing.

60. This method is used for laying down the survey lines of a closed or unclosed traverse, and corresponds to theodolite traversing. The detail may be located by offsets in the usual manner. Having selected a system of stations, A, B, C, D, E, set up over one of them, say A, and, having selected a. on the paper, bring it over A. Clamp the board, and, with the alidade

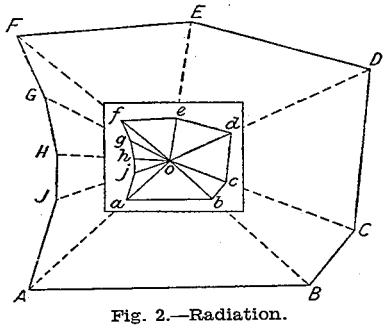


Fig. 2.—Radiation.

touching a, sight E and B and draw rays ae and ab. Measure AE and AB, and scale off ae and ab. Set up B, with b over B, and orient by laying the alidade along ba, turning the table until the line of sight strikes A, and then clamping. With the ruler against b, sight C, and draw bc to scale. Proceed in this manner at other stations, in each case orienting by a backsight before taking the forward sight.

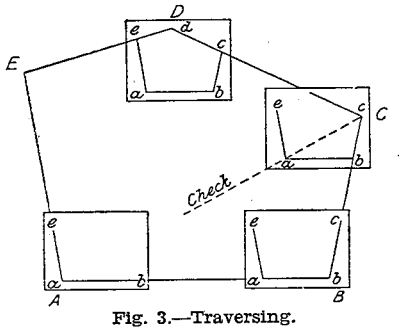


Fig. 3.—Traversing.

Intersection of triangulation.

61. This method is largely used for mapping detail, but is also available for plotting the positions of points to be used as subsequent instrument station. The only linear measurement required is that of a base line.

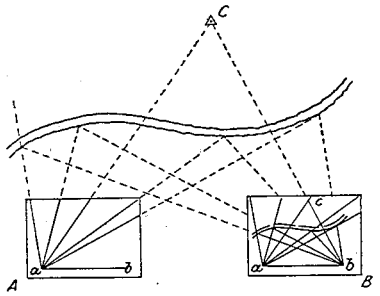


Fig. 4.—Intersection or Triangulation.

Lay out and measure a base line AB. Plot ab in a convenient position on the sheet. Set up as A with a. over A, and orient by laying the alidade along ab. and turning the table until the line of sight cuts B. Clamp, and, with the ruler touching a, sight the various points defining the surrounding detail and points selected as future instrument stations, drawing a ray from a. towards each. Proceed to B, set up with b. over B, and orient by backsighting on A. Through b. draw rays towards the points previously sighted. Each point

is located by the intersection of the two rays drawn towards it. Before leaving B, draw a series of first rays towards other points not sighted from A, and then proceed to C, orient on A or B, and obtain a new series of intersections.

GENERAL INSTRUCTIONS

62. Survey information for incorporation in Forests Department Plans, must be clearly shown in Field Books and **original** notes submited to Head Office together with a plot on Topo Sheets. Errors should be crossed out, not erased.

63. All surveyors should have copies of F.D. Plan 1050 for guidance.

64. Description of Feature Surveyed, i.e. Existing or proposed Main Forest Road, Road, Track, etc., together with name (if any) should be noted at start of traverse.

65. Ties should be made to two or more original survey posts or pickets (not fence posts) and position of tie shown by sketch in Field Book with number of location or road post and number of Topo Sheet. Do not interfere with survey posts.

Unfenced surveys are usually best suited for obtaining good ties.

Distances are required between original survey marks found.

66. An index of field notes signed and dated should be shown on last page of Field Book, i.e. page number, feature traversed and number of Topo Sheet.

Theodolite surveys.

67. Angles at Traverse Stations and Ties to and along original Surveys should be read by doubling the angle, face left and face right, second angle being turned from reading noted in Field Book.

Angles should be read to the nearest minute.

68. An angular close is required to original surveys tied to.

69. Each broken distance chained should be noted with angle of rise or fall and adjusted total distance noted at the end of each traverse line.

Adjustments should be made to chained distances for slopes of one or more degrees.

70. Position of reference trees should be fixed by angle and distance from traverse to broad arrow cut on tree.

71. Compass check posts when established at reference trees should be placed true North and South or East and West.

72. Survey data should be noted along traverse lines and other surveys in Field Book as illustrated on F.D. Plan 1050.

Compass surveys.

73. Fore and backsight bearings are required along traverse lines and original surveys to which traverse is tied.

74. A difference in readings of not more than one degree can be accepted without correction for local attraction.

75. Each broken distance chained should be noted and adjustment made for slopes of four degrees or more. An Abney Level or Clinometer should be used for this purpose.

76. Fore and Back bearing and adjusted total distance of each traverse line should be noted at the top of page. Distances should also be shown at the end of each traverse line (see F.D. Plan 1050).

77. Magnetic Variation of each compass used and position where checked, should be noted in Field Book.

78. For compass work, use F pencils or if not available an H pencil—HB is too soft, 2H too hard.

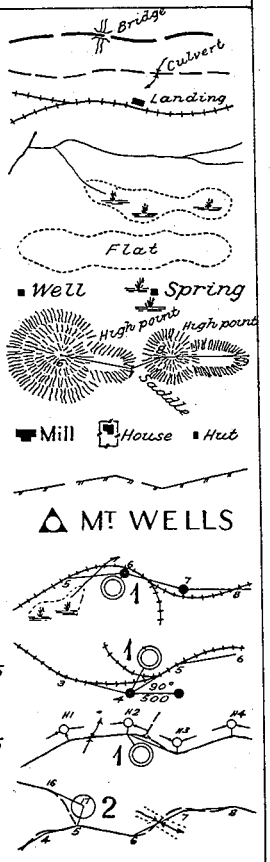
79. Care and accuracy in recording readings, sketching features and establishing ties is more important to the final result than demanding a minimum chainage of work per day.

80. Take care of your equipment—clean and oil the five chain steel band when not in use—place the compass in its case and see the case and leather straps are in good condition.

A prismatic compass (oil float) costs about £16.

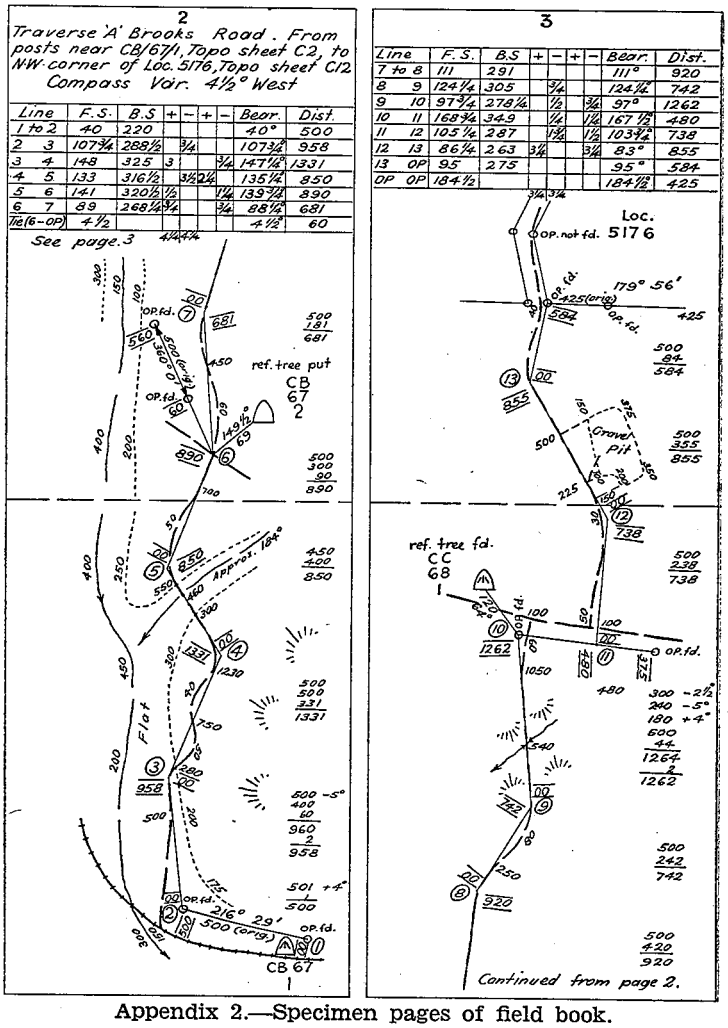
A five chain steel band costs about £10.

CONVENTIONAL SIGNS
AS USED ON TOPOGRAPHICAL SURVEY SHEETS

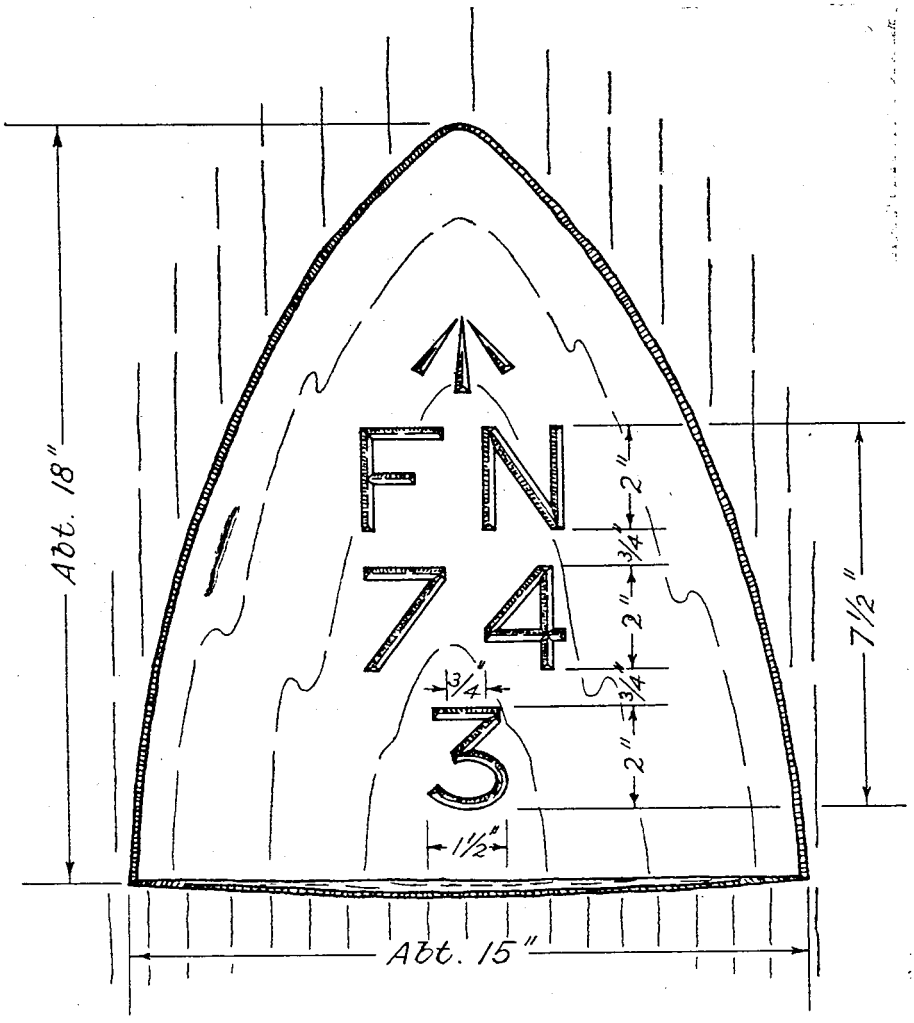


For A.P.I. conventional signs see the legend on each sheet

Appendix 1.



Appendix 2.—Specimen pages of field book.



Appendix 3.—Marking a Reference Tree.

Dimensions of letters approximate only; a matchbox may be used to determine the size of the letters, the thickness of the box being used to determine the spacing between the letters.

APPENDIX 4

TABLE OF VERSED SINES

CORRECTION FOR SLOPE FOR EACH 100 LINKS

Deg.	Min.	Versed Sines	Deg.	Min.	Versed Sines	Deg.	Min.	Versed Sines
	30	·004	9	....	1·23	17	....	4·37
	45	·009		10	1·28		10	4·45
1	....	·015		20	1·32		20	4·54
1	15	·024		30	1·37		30	4·63
1	30	·034		40	1·42		40	4·72
1	45	·047		50	1·47		50	4·80
2	....	·06	10	....	1·52	18	....	4·89
	10	·07		10	1·57		10	4·98
	20	·08		20	1·62		20	5·07
	30	·09		30	1·67		30	5·17
	40	·11		40	1·73		40	5·26
	50	·12		50	1·78		50	5·35
3	....	·14	11	....	1·84	19	....	5·45
	10	·15		10	1·89		10	5·54
	20	·17		20	1·95		20	5·64
	30	·19		30	2·01		30	5·74
	40	·20		40	2·07		40	5·83
	50	·22		50	2·12		50	5·93
4	....	·24	12	....	2·18	20	....	6·03
	10	·26		10	2·25		10	6·13
	20	·29		20	2·30		20	6·23
	30	·31		30	2·37		30	6·33
	40	·33		40	2·43		40	6·43
	50	·36		50	2·50		50	6·54
5	....	·38	13	....	2·56	21	....	6·64
	10	·41		10	2·63		10	6·75
	20	·43		20	2·69		20	6·85
	30	·46		30	2·76		30	6·96
	40	·49		40	2·83		40	7·06
	50	·52		50	2·90		50	7·17
6	....	·55	14	....	2·97	22	....	7·28
	10	·58		10	3·04		10	7·39
	20	·61		20	3·11		20	7·50
	30	·64		30	3·18		30	7·61
	40	·68		40	3·26		40	7·72
	50	·71		50	3·33		50	7·83
7	....	·74	15	....	3·41	23	....	7·95
	10	·78		10	3·48		10	8·06
	20	·82		20	3·56		20	8·18
	30	·86		30	3·64		30	8·29
	40	·89		40	3·71		40	8·41
	50	·93		50	3·79		50	8·53
8	....	·97	16	....	3·87	24	....	8·64
	10	1·01		10	3·95		10	8·76
	20	1·06		20	4·04		20	8·88
	30	1·10		30	4·12		30	9·00
	40	1·14		40	4·20		40	9·12
	50	1·19		50	4·28		50	9·25

SECTION 3.—DEPARTMENTAL BUILDINGS

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DEPARTMENTAL BUILDINGS

GENERAL PROVISIONS

1. The Forests Department has found it necessary to acquire by construction or purchase an increasing number of buildings including dwellings, offices, workshops, garages, store sheds, lookout towers, etc. Any works connected with buildings will be subject to the conditions set out hereafter.

Permission to be first obtained.

2. Before any buildings, additions or alterations are undertaken the approval of the Conservator must first be obtained.

Provision in Estimates.

3. Officers must anticipate their requirements in buildings to the extent that provision for funds must be made in the estimates each year.

Local building by-laws to be examined.

4. Before commencing a building programme, officers should contact the local authority to ensure as far as possible that local by-laws are not being infringed. This is particularly important if such buildings are within or adjoin a townsite boundary.

Questions likely to be involved are:

(1) Construction generally.
(2) Stormwater drainage.
(3) Separation between buildings.
(4) Roads and footpaths.
(5) Cold water plumbing if connected to a local reticulation service.
(6) Sewerage or septic installations.

Ownership to site must be proved.

5. The D.F.O. concerned must check to see that the site selected is under the control of the Forests Department and that the rights of any other authority are not involved.

Selection of the site.

6. Before any building proposal is submitted for approval a survey of available areas must be made to select the site best suited for the purpose.

The main points to be considered in the selection of a site are:

(1) Access and proximity to the work.
(2) Slope.
(3) Aspect.
(4) Location and height in relation to water reticulation service.
(5) Location in relation to electricity supply.
(6) Drainage.
(7) In the case of dwellings, availability of essential services and amenities.

FOREST SETTLEMENT LAYOUT

7. Where future development of an area of forest will require a concentration of labour, the D.F.O. must prepare a plan showing the proposed settlement layout.

This plan which will be prepared on a scale of two chains to the inch, must be submitted to Head Office and approved in writing before any works are undertaken.

The settlement plan should clearly show:

(1) Contour form lines at five feet vertical intervals.
(2) The position of each house and the direction it will face.
(3) The position of office, workshop, storerooms, garages.
(4) The position of single men's camps.
(5) Water supply reticulation pipelines giving location of well or dam, pump house, storage tank.
(6) Access roads.
(7) Provision for recreation, tennis courts, children's playground, etc.
(8) Community hall.

Positioning of individual houses.

8. Where possible the fronts of houses should face downhill, thus avoiding high steps or ramps at the rear of the house.

The fronts of houses facing a surveyed road must be set back not less than 25 ft. nor more than 35 ft. from such road survey.

The plan should allow sufficient room for a garden, a few fruit trees and/or ornamental trees around each house but in no case should this area exceed ¼ acre.

Design of buildings.

9. Departmental buildings will conform to standard designs as approved by the Conservator. The standard designs now in use by the Department are available from Head Office and no departure from these designs will be permitted except with the approval of the Conservator.

Selection of the type of house.

10. In selecting the type of house to be built, consideration must be given to the following points:—

(a) Person for whom it is required, whether officer or workman.
(b) Slope of ground must be considered in selecting type of house.
(c) Aspect (avoid hot afternoon sun on kitchen).

Avoid monotony.

11. Where a number of houses are to be built in a settlement, it is desirable to mix the types to avoid monotony.

Decision on type.

12. After considering all the factors involved, the D.F.O. will make a recommendation to head office as to the type of building to be erected, the site, method of building (day labour or contract), but the final decision as to type will be made by the Conservator.

CONTRACTS AND SUPERVISION

Building by contract.

13. Most houses, offices, large workshops and garages are built by contract after tenders have been called through the press, but sometimes contracts are let following the submission of quotes obtained by the D.F.O. or Forester in Charge.

Specifications.

14. Head office will prepare and supply detailed specifications of houses and offices, for the erection of which, contracts are to be let. Where the Department is to supply material and the contract is for labour only, head office will also supply a materials' list.

Supervision of erection.

15. To ensure that the specifications are being complied with by the building contractor arrangements are made for a supervisor from the P.W.D. to supervise the work.

The D.F.O. must advise head office of the anticipated commencing date for any contract and then of the actual date of commencement so that adequate warning can be given to the supervisor concerned.

16. Although the P.W.D. supervisor does supervise the work, his visits are usually at infrequent intervals so that the local officer of the Department must also keep a check on the work and contact the supervisor if he considers that the work is not up to specification. Local officer to supervise.

17. In the case of the erection of other buildings, whether by contract or day labour, it shall be the responsibility of the officer in charge to see that the specifications are fully complied with. Supervision of other buildings.

18. To assist officers with the interpretation of specifications and supervision of building operations, the usual order of procedure is set out hereunder and a glossary of terms commonly used in the building trade is included in the appendix. Interpretation of specifications.

ORDER OF WORK

19. All tree stumps, roots and superficial rock must be removed from the site which should be roughly levelled, though extensive cutting and filling should be avoided, except in the case of workshops and garages where surface level is approximately floor level. Any large or overhanging trees should also be removed before the building is commenced. Clearing of the site.

The above work should be carried out by Departmental labour.

20. The general orientation of the building should have been decided during the selection of the site. Setting out the site.

Normally the long axis of the building should follow the contour as closely as possible. Firstly set out the front of the building and the one side by pegs, set back from the corners. The datum will be taken from an adjoining building, road or other survey.

In laying off a building, the tape, preferably steel, must be held taut and level.

To ensure that the building is square, the diagonals (across corners) must be checked and if not equal, must be adjusted.

21. Where the building is to be built on stumps, a minimum of 12″ must be allowed from the ground level to the ant cap. This height will be fixed for the stump at the highest point of the site. Stump height.

22. Stumps for most buildings will not be less than 4″ x 4″ in section and set not less than 20″ in the ground and on sole plates 18″ x 8″ x 1½″. Stumps.

Where solid rock occurs a tapered masonry or concrete pier may be substituted for the wooden stump. Such a pier should have a minimum top dimension of 6″ x 6″ with a taper of 1″ to the foot. Such a pier must be provided with an ant stop similar to the wooden stump.

The lower portion of the stump to a point 6″ above the ground level must be brush treated with creosote.

Stumps should be of durable timber such as jarrah, wandoo, blackbutt.

They are installed at a maximum distance of 6′ apart. All stumps under walls and partitions that are 3′ or more out of ground, shall be braced with 4″ x 2″ carried over three stumps and checked out ½″ and bolted to the stumps with ½″ bolts.

23. When the stumps are all in position, the ant caps must be placed on top of each stump. Ant caps.

24. Where used in conjunction with stumps they shall consist of galvanised iron or copper 24 or 26 gauge. The edge shall extend 2″ beyond the edge of the stump and be turned down at an angle of 45°. Ant stops should preferably be stamped out but if cut from sheet metal, all joints should be mitred and soldered. Ant stops.

In the case of any masonry foundations such as for a chimney, a plain sheet of 24 or 26 gauge galvanised iron must be installed below the level of the bearers, and projecting out 6″ on all sides. This projecting edge must be turned down to an angle of 45°.

If the foundation cannot be covered by the one sheet, then two sheets may be joined with 1" lap but in this case the joint must be rivetted at 6" intervals and well soldered throughout.

Bearers.

25. The bearers (usually of 4" x 3" section) are now installed on top of the stumps with the narrow edge uppermost and not more than 6' apart. The bearers shall be nailed to each stump with one 6" nail.

Floor joists.

26. The floor joists (of 4" x 2") are positioned across the bearers at 18" centres. Two joists are positioned to carry each wall, thus allowing the ends of the floorboards to be nailed to them.

Frames.

27. All bottom wall plates are set in position and corners and joints marked and halved joints cut out.

Stud positions for doors and widow openings are marked and then other stud positions are marked at a maximum spacing of 18" centres.

Top plates are now placed on the bottom plates, joins marked and cut out and stud positions transferred.

Rafter positions are marked on the outside top plates at this stage.

Studs.

28. Studs of 3" x 2" or 4" x 2" are all cut to the one length and gouging for stud joints is done from the top of the bottom plate and the bottom of the top plate.

The frame can then be assembled with the nogging head and sill trimmers in place and frame squared and braced with 2" x $\frac{3}{4}$". The frame can then be erected. A third stud should be placed at all corners and wall intersections or a single square stud can be used.

Ceiling joists.

29. Ceiling joists (of 4" x 2") are now nailed in place alongside the positions previously marked off on the top plate for the rafters.

Hangers are then tied to the ceiling joists.

Roof rafters.

30. The length of the rafters from the outside edge of the top wall plate to the near edge of the ridge board is found by accurately scaling off the plan. Provision must be made for the support of the guttering on the end of the rafters by faced board or step cut.

Cutting the birdsmouth.

31. Draw a scale plan of the roof pitch. The plumb and level cuts for the birdsmouth can be related to two levels set to the two angles.

Depth of birdsmouth.

32. The depth of birdsmouth normal to the edge of rafter is equal to a quarter of rafter depth, or usually 1".

Marking the ridge board.

33. The ridge board is marked with rafter positions by placing it on the ceiling joists over the previously marked wall plate.

Pitching the roof.

34. The roof is then pitched by abutting the two pairs of opposite rafters second from each end against the ridge board. The remaining rafters are then nailed into place.

Purlins.

35. Under purlins, struts and purlins can now be fixed into position and collar ties nailed into place.

Chimney.

36. The chimney complete with ant stopping, chimney tray and back flashing as necessary should now be erected.

Guttering and roofing.

37. The guttering followed by the roof covering should now be fixed into position.

Sheathing and frames.

38. The external sheathing, i.e. weatherboard or fibrolite, can now be installed.

Bottom wall plates in door openings are cut; thresholds laid and door frames fitted.

Flooring.

39. The flooring can now be laid, with butt jointed flooring o/o 4" x 1" for all exposed verandahs.

In cramping flooring, allowance must be made for the moisture content of the flooring, the time of the year, and the locality.

For instance, very dry flooring must not be cramped up tightly in the summer time, particularly in wet localities.

Window frames.

40. Window frames are set in place on galvanised iron flashing and flashings are also set over architraves and under weatherboards at the head of windows and external doors.

The flashings over external windows and doors should extend at least 4" beyond the outside edge of the frames to ensure that drips are carried out beyond such frames.

Electrical wiring, plumbing.

41. If electric power is available, electric wiring should now be installed. This wiring must only be carried out by a contractor holding a license issued by the State Electricity Commission. Where the electric power to be used is to be supplied by the S.E.C., the contractor must first apply to the nearest office of the S.E.C. for a permit to make an installation and on completion of the installation will notify the S.E.C., who will arrange for an inspection to be made before a meter is installed and a connection made to the power lines.

Water reticulation.

42. The installation of the water reticulation service to the kitchen and bathroom and any waste disposal piping should now be installed.

Interior trimmers.

43. Where a dado is required it will be necessary to install trimmers to take the top of the dado with another run in the centre.

Ceiling battens.

44. Ceiling battens are placed at a maximum spacing of 16" centres allowing for a manhole measuring 20" x 16".

Ceiling and lining.

45. Fibrous plaster sheeting can now be nailed, first to the ceiling and then to the walls, using galvanised clouts 1" long. In the angles of the walls, galvanised iron strips 4" wide bent at right angles should first be installed before the fibrous plaster. This will reduce the subsequent cracking and pulling away in the corners.

If flush jointing is not possible, the joint must be covered with cover batten, cornices preferably of plaster, but if wood is used it should be treated by staining or varnishing before erection.

Fixing out.

46. The stove is now installed and if necessary bricked in. Latest Insulheat type stoves where supplied should not be bricked in.

Any brickwork should be cleaned up with dilute hydrochloric acid (spirits of salts).

Doors and window sashes are hung after being stained, varnished, or prime coated for painting.

Bath, trough, sink, mantle shelf, cupboards, shelves are then installed.

Electrical fittings are added.

Fencing.

47. The front fence shall be of galvanised link mesh 42" wide attached to 4" x 2" rails supported on 6" x 4" posts at 8' spacing.

Side and back fences will be of split posts of jarrah blackbutt or other durable timber at 10' intervals, with 4 plain 10 gauge wires to which is attached 42" galvanised rabbit netting. The plain wire will be spaced to support the rabbit netting, one at the top and one in the centre, a third wire 3" from the top of the posts and a fourth wire between the top of the netting and top wire.

The rabbit netting will be attached to the plain wires by 12 gauge tie wire or special clips but must not have the plain wire threaded through the netting.

Barbed wire should not be used except where stock are troublesome.

Gate.

48. Allow for a gateway 10' wide of a cyclone gate in two sections of 3'6" and 6'6".

Where the vehicle entrance cannot be located in the front, a separate 3'6" cyclone gate will be installed in the front and a 10' single cyclone gate in one of the other fences, preferably the rear one.

Painting.

49. All exposed, dressed or wrot woodwork such as barge boards, fascia, window and door frames, verandah posts, front

fence posts and rails are to be given one primer coat followed by one oil based undercoat and a gloss finishing coat of an approved exterior paint.

Any necessary puttying of nail holes, etc. shall be carried out following the application of the primer coat.

Weatherboards will be given two coats of mixed raw and boiled linseed oil (50-50).

Painting of weatherboard.

50. The painting of weatherboard, whether dressed or rough sawn will not be undertaken except with the special approval of the Conservator.

FIRE TOWERS

51. Since the first fire lookout towers were erected at Mundaring and Collie in 1922 there has been considerable variation in design either to provide additional height or a more efficient use of materials.

The designs now in use by the Department are all constructed of timber and are as follows:—

(1) Round or squared jarrah legs, braced with sawn timber with cabin on top. Legs set directly in the soil ranging in height from 40′ to 120′.

(2) Same as the foregoing except that the tower legs are set on concrete blocks. Since 1938 all have been mounted on concrete foundations—height range from 30′ to 140′.

(3) Built entirely of sawn jarrah scantling using timber connectors, with a concrete foundation. One only tower of this design is 110′ high, situated at East Kirup and was built for experimental use of timber connectors.

(4) Tree towers consisting of a tall tree, usually karri, the bole of which is pegged to form a spiral staircase. The crown limbs are lopped back and a tower of sawn timber is built onto the stubs of the limbs. The total height of such tower ranges from 85′ to 200′.

(5) Pole tower, a new type tower in which a pole of the desired height is supported on a concrete base and stayed by six or more wire ropes into concrete anchor blocks. A ladder within a wire cage gives access to the cabin. This type, only one of which has been built to date, is still in the experimental stage.

Locating the tower site.

52. When it has been decided that a lookout tower is needed, proposals will be referred by the D.F.O. to the Superintendent for decision as to the best procedure to be followed.

DEPARTMENTAL WORKSHOPS, GARAGES AND LAUNDRIES

53. These buildings differ from those already dealt with in that the foundations are either of concrete bonded to the floor or else the main supports are of large sectional timber (often round) which are set in the ground after the lower portion has been brush treated with creosote or creosote oil mixture (50-50).

Levelling.

54. In the case of the above type buildings, the floor is levelled prior to the commencement of the building. The area levelled must extend sufficiently beyond the extremities of the building to permit of the construction of adequate drains to carry off drainwater and to permit of the easy movement of personnel around the building. If any considerable bank remains on the top side it must be given sufficient batter to prevent subsequent fretting away and blocking up of drainage ways and right of way.

Preparing foundations.

55. The most suitable foundation for a concrete slab floor is sand, rock, or a soil containing a high percentage of sand. A silt soil with a clay content not exceeding 30% would be satisfactory, but any soil with a higher clay content would

definitely be unsuitable unless the top 12" is removed and replaced with sand or other suitable filling.

Levelling the site.

56. When the site requires filling the material to be used should be clean (free from vegetable or animal matter) and hard. (Clay must be avoided.)

If the depth of the fill exceeds three inches it should be done in layers, each being consolidated before the next one is applied. Separate layers should not exceed 3" in thickness.

Footings.

57. Footings must be provided for external walls.

The footing recommended for an ordinary 9'-10' high timber frame wall is 15" wide by 8" deep. This would need to be proportionally increased in depth with increases in height and weight of the wall.

Floor thickness.

58. The thickness of concrete floors will normally be 4".

Concrete mixture.

59. The concrete mixture by volume shall be:

1 cement.
3 sharp clean sand.
4 parts ¾" blue metal or clean gravel.

Screed thickness.

60. The minimum thickness of the screed if applied before the concrete hardens shall be ¾".

Where the concrete has already hardened the screed thickness shall be not less than 1".

Screed mixture.

61. The mixture by volume should be:

1 part cement.
3 parts clean sand. The water-cement ratio should be 3½ gallons water to 1 bag (cub. ft.) of cement.

Laying the concrete floor.

62. If there is no solid external wall to work to, nail a piece of 4" x 2" or equivalent to the outside edges of the uprights with the top surface at the desired level for the concrete floor.

Garage and workshop floors should be laid level, but washhouse floors should have a fall of 1" to the open side, to allow for drainage.

Garage floor.

63. Excavate a 9" x 9" trench along the front under the garage doorway so that a piece of 4" x 2" nailed across the front corner posts runs level with the outside edge of the trench.

Lengths of 4" x 2" timber on edge are now laid on the fill along the length of the garage as screeds, the first are 12"-18" from the side and then at 3' intervals. Only two or three lengths are necessary as the timber is removed as the pouring of concrete progresses.

Concrete should be poured working from the back to the front between the 4" x 2" screeds. The work is screeded with a straight edge as it progresses.

It is desirable to pour the alternate strips of flooring and allow these to harden before pouring the intermediate strip.

Finally the front trench is filled to the top of the 4" x 2" screed.

A top coat of ¾" to 1" thickness, depending on condition of concrete, of 3 parts clean sand to 1 of cement is then trowelled over the concrete.

Finally neat cement is sprinkled over this damp surface and finished by floating with a wooden float or steel trowel.

Trowelling should not be excessive and the wood float finish is preferable to a trowelled surface as it is less likely to dust or craze.

Floor to be grooved.

64. With a jointing or grooving tool and a straight edge the floor is jointed into 3' expansion squares to conform to the edges of the concrete strips as originally poured.

In hot weather all concrete work shall be kept moist for seven days after depositing and all green work shall be kept protected as far as possible from both sun and rain.

AMENITIES

65. Under certain conditions additions will be made to Departmental housing units. These additions and the conditions under which they are installed are set out in the following paragraphs.

Extra rental payable.

66. Where any of these additions are made, extra rental as assessed by head office will be payable in respect of each addition and such extra rental shall be added to and paid along with the base rent.

SEPTIC SYSTEMS

67. Where there is an adequate reticulated water supply, septic tanks will be provided at all habitations owned by the Department.

Where drainage is bad.

68. If the site where the septic tank is required consists of heavy clay soil or suffers from bad drainage, details must be forwarded to head office before the installation is proceeded with.

French drains or soak wells.

69. The porosity of the soil in the locality will determine whether a soak well or a french drain should be specified.

In the deep sandy soils of the metropolitan area, the soak well is mostly favoured, but in the heavier soils a french drain should be used. If the country suffers from lack of drainage, the inverted french drain is recommended.

Specifications for a standard and inverted french drain and dry well are available from Head Office.

70. Before any septic installation is made, the occupant of the property must sign the Occupancy Agreement form F.D. 443.

Extra rental for septic systems.

71. Extra rental at the approved rate will be charged where septic systems are provided.

Plans required.

72. The D.F.O. must first submit to head office a plan in triplicate showing the layout of the proposed system in relation to nearby buildings, roadways, etc.

The following information should be shown on this plan:—

(a) Distance from house to W.C.
(b) Distance from W.C. to septic tank. This should be 6'.
(c) Distance from septic tank to the french drain or dry well should be 6'.
(d) Lot or location number.

To this should be attached a requisition for the necessary material for the installation. A standard list of materials is set out in the specifications.

Permit required.

73. Head office will obtain the necessary permit from the Health Department for each installation.

Local Health to approve.

74. The local health officer should be consulted before the installation commences to ensure that local requirements are being met as far as possible.

Concrete floor in W.C.

75. It is necessary to have a concrete floor several inches above ground level in the W.C. and therefore in the case of all earlier type Forest Department cottage designs, the W.C. will have to be external to the house.

Local health officer to inspect and pass.

76. Following the completion and passing by the local health officer of the installation, it may be brought into service.

Head office to be advised.

77. The D.F.O. will be responsible for advising head office of the date of inauguration of the service so that rent adjustments can be made.

Sewerage Systems

78. In cases where a Departmental house is connected to a sewerage system, the Department will pay all dues in connection therewith to the authority concerned while the occupier of the house will be required to pay the additional rent as fixed by Head Office.

GARAGES FOR PRIVATE VEHICLES

79. Subject to funds being available, garages may now be provided at Departmental cottages for the use of tenants.

Rent on garages.

80. Rent at the approved rate will be charged for these garages.

In cases where a subsequent tenant has no car he will still be required to pay rental on the garage.

Garage designs.

81. The design of the garages must conform to either one or two approved designs which are described by the letters "A" or "B".

Plans and specifications with a list of materials for these two types of garages are available from Head Office.

Type "B" garages may only be erected with the approval of the S.D.F.O. or more senior officer.

Type "A" garages may be erected with the approval of the D.F.O.

Location of garage.

82. Before the construction of any garage is commenced, the D.F.O. or more senior officer must inspect and approve of the site.

The garage should be erected at the back of the house and not closer than 20' to the house. This latter point is of importance in connection with the insurance of buildings.

As soon as the garage is completed the D.F.O. must notify head office of the house number, type of garage, occupant, date for commencement of rent increase.

ELECTRICITY SUPPLIES

Specifications for wiring.

83. Where electric power is available, Departmental houses will be wired and arrangements made for power service to be provided. Such wiring may only be carried out by a licensed electrician and must conform to the standards demanded by the S.E.C. even though they may not be the supplying authority.

Payment for power.

The tenant will be required to conform with any conditions or regulations imposed by the distributing company or organisation and will be responsible for payment of any dues, either for power consumed, meter rent, deposit, etc.

If the power supply is not restricted in any way, five power points in addition to the light points will be provided as follows:—

Power points.

1 for washhouse.
2 for kitchen.
1 for living room.
1 for dining room.

84. Light points will be provided in each room, including bathroom, wash house, lavatory, as well as front and back verandahs and hall or passage.

Additional points.

85. Additional lights and/or power points must not be installed, except with the approval of the S.D.F.O. or more senior officer.

Departmental electricity plants.

86. In the case of the larger settlements of 10 houses or more, the Department will, where possible, provide an electric power supply. This power supply will provide only for the lighting of houses and ironing of clothes during one or two afternoons each week and no other electrical appliance except an electrical radio set may be attached without the express permission of head office first being obtained.

Other conditions.

87. The conditions of the agreement whereby electricity is supplied to houses from a Departmental owned and operated plant are as follows:

Hours of operation.

88. **Lighting.**—Sunset to 10.30 p.m. daily. The officer in charge of each settlement may permit an extension of lighting times to 12 p.m. for communal social functions.

Ironing.—One afternoon per week except that in some large settlements to prevent overloading, it may be necessary to roster the ironing over two afternoons per week.

Payment for Electricity.—Payment for electricity supplied by the Department will be at a flat rate which will be subject to periodic revision.

This payment will be made as an addition to the rent.

Supply of lamps.

89. Houses are supplied with lamps in the first place, but each occupant will be responsible for any replacement needed.

The officer in Charge must ensure that on vacating premises that the last occupant leaves a serviceable lamp in each socket and that final payment for wages is not made until this matter has been attended to.

Number of lights and power points.

90. As provision is only made for the use of the electric iron, it will only be necessary to provide the one power point. The same electric light points will be provided as for other power supplies.

WATER SUPPLY

91. Where possible a reticulated water service is provided to each dwelling owned by the Department to serve the bathroom, wash house, septic system, kitchen sink and if sufficient water is available taps will be provided for watering a front and rear garden.

No rent on F.D. service.

92. In the case of water services provided by the Department, no charges have so far been made. However, where water consumption becomes excessively heavy consideration will be given to the installation of meters and a nominal charge for the water consumed.

Other services.

93. Where water is supplied by some other authority, the occupier of the house will be responsible for all charges due to that authority and for the observance of any conditions imposed by that authority.

SINKS, GREASE TRAPS AND HOT WATER SYSTEMS

Stainless steel sinks.

94. As funds become available and provided a satisfactory reticulated water service is available, consideration will be given to the installation of stainless steel sinks with cupboards, at all Departmental houses. Grease traps "P" traps and french drains or dry wells will in future be installed in conjunction with all sinks supplied by the Department.

Application to be made.

95. Following the receipt of an application for a stainless steel sink, the officer in Charge will submit same to head office with his recommendation. Before forwarding the application, the officer in charge must satisfy himself that the tenant clearly understands that he must clean and maintain the grease trap at regular intervals of about two weeks and will be held responsible for such cleaning. The officer in charge must also satisfy himself that the soil is sufficiently porous to permit of the effective operation of the french drain or dry well.

If the officer has any doubts as to the effective operation of the french drain or dry well, he should submit full details to head office for consideration.

Grease to be buried.

96. The grease that is skimmed from the top of the grease trap must be buried.

Increased rental.

97. Following the installation of a sink, an increased rental at the approved rate will be charged.

Hot water systems.

98. Subject to the approval of the Conservator and the availability of funds, a hot water system may be installed in a Departmental cottage.

Before forwarding an application to head office, for consideration, the D.F.O. must be satisfied that the necessary funds are available. The tenant concerned must be informed of and agree to pay the additional rental charged for this installation.

Standard installation.

99. The standard installation will consist of a copper tube installed in a No. 2 stove, a 30 gallon hot water storage tank, a four gallon cold water reservoir equipped with ball float valve.

The hot water service will be provided at the kitchen sink, to the bath and shower, to the hand basin where provided, but will not be supplied to an outside wash house.

A diagrammatic sketch plan of a standard hot water system together with a list of materials is available from Head Office.

The hot and cold storage tanks must not be installed between the ceiling and the roof owing to the possibility of damage to the ceiling by dripping water.

SLOW COMBUSTION STOVES—COOKING AND HEATING

Slow combustion cooking stoves.

100. Slow combustion stoves have been installed in several senior officers' homes, but owing to the high capital cost involved and consequently the high rate of rental that must be charged, any further installations will be carefully considered before approval is given.

Slow combustion heating stoves.

101. Slow combustion heating stoves such as "Wonderheat", "Heatmaster" have been installed in offices and homes.

Advantage of this class of stove are:—

(a) No chimney is needed which eliminates one common source of trouble with white ants.
(b) They allow for better control of draught and if properly handled are more efficient in heating a room than the open fireplace.
(c) If handled properly they are also more economical in fuel than the open fireplace.

Precautions in installation.

102. Certain precautions must be observed when these units are not installed in a chimney, as otherwise there is a danger of fire outbreak.

The correct method of installation is as follows:—

103. **Hearth.**—The hearth consists of a slab of dense concrete 3" thick or alternatively some material giving the same thermal resistance.

A sheet of 16 gauge galvanised iron should be placed between the slab and the floor.

Size of Hearth.—The hearth should extend—

(a) Not less than 12" beyond each side of the fire opening in the appliance.
(b) Not less than 14" in front of the appliance throughout its full length.
(c) Behind the appliance for the full width of the hearth to the backing wall or a distance of 12" whichever is the lesser distance.

Vent through hearth.

104. An opening must be provided in the hearth which during installation must correspond with the opening provided in the bottom of the appliance. A corresponding opening must be made in the floor to permit of the free passage of air from under the floor.

Method of heating.

105. During the operation of these heating appliances, fresh air is drawn in from under the floor, it passes around and is heated by the fire box, but does not come into contact with the fire or flue gases, and is then liberated into the room.

Positioning the stove.

106. The slow combustion heater should not be located closer than 12" from a timber frame or partition or combustible wallboard, unless a sheet of rigid incombustible material is fixed securely not less than ¾" clear of the walling and extending 12" above the top of the appliance down to the hearth and for the full width of the hearth.

The S.C. heater must be set at least 4" clear of the protective sheeting on the wall and this space must be kept clear of all combustible material.

A grill is supplied with some units to ensure that this space is kept clear.

Flue pipes.

107. The sheet metal used in the flue pipe should not be thinner than 18 S.W.G. Asbestos cement should not be submitted to temperatures in excess of 500°F and therefore should not be used within 6′ of the flue outlet from a slow combustion heater.

The flue pipe should be at least 6″ in diameter or if not circular, the minimum dimension should not be less than 4″ with a minimum cross sectional area of 28 square inches.

The flue pipe should be supported at intervals not more than 16 times its internal diameter or at the length of each section and it should rise at least 14′ above the appliance served.

Where the flue pipe rises through a ceiling or roof or through both, the space between should be encased in a sleeve of incombustible material spaced not less than 2″ from the flue pipe and extending at least 9″ above and below the roof and ceiling construction.

The flue pipe and shield should be suitably capped to prevent the entry of rain, but without interfering with the free escape of hot flue gases.

Where flue passes through a wall.

108. Where the flue is taken through a wall of wooden construction, it must be encased in a special insulating sleeve which consists of a 2″ layer of fibre glass or equivalent between steel or copper container and which must extend from the back of the appliance to 2″ beyond the surface of the far side of the wall.

GENERAL INFORMATION

Chimneys and fireplaces—dimensions of fireplaces

109. The principal dimension of fireplaces up to 42″ wide are as follows:—

Area of flue $\frac{1}{8}$ to 1/10th of the area of the fireplace opening for unlined flues.
Height of the throat—6″-8″.
Width of throat—approximately 4″.
Height of opening—28″-30″.
Depth of fireplace—16″-18″.

Projection of chimney above roof.

110. Where the chimney rises through the ridge, 2′ above ridge; where the chimney rises through roof slope, 2′6″ above ridge; where the chimney rises through flat roof 3′ above roof.

Fireplace.

111. In construction of a fireplace, it shall be so designed that the temperature of any nearby timber does not rise above 150°F.

Hearth should extend some 6″ beyond each side of the fireplace opening and at least 14″ from the face of the chimney breast.

Mortars

112. There are three types of mortar used in masonry work. They are:—

Cement mortar.
Cement-lime mortar.
Lime mortar.

Cement mortar

113. Is the strongest, but it shrinks and can cause moisture troubles. Usual mixture is 1 cement—3 sand.

The addition of a little lime as 1 cement—$\frac{1}{4}$ lime—3 sand does not appreciably reduce strength, but does reduce shrinkage and makes it more plastic and workable.

Cement lime mortar

114. There are considerable variations in mixes varying from 1 cement—1 lime—6 sand to 1 cement—4 lime—15 sand, but the first one is the one most commonly used.

Lime mortar

115. This mortar is weaker than the cement mortar in compression and shear, but has good adhesion to the bricks and low shrinkage and the walls are less liable to moisture penetration.

Has a tendency to fret in areas where there are severe frosts.

Common mix is 1 lime—3 sand.

For brickwork below ground level or above roof level recommended mix is 1 cement—$\frac{1}{4}$ lime—3 sand.

Window awnings.

116. In areas experiencing hot dry summers, shading of walls and windows, particularly those which face east or west, is very desirable.

The effect of shade is more marked with the wooden frame house. However the indoor temperature movement to be derived from external shade is not usually sufficiently great to justify expensive devices to provide it and shading of walls might reasonably be provided by trees, shrubs or creepers grown on a trellis and not on the wall of the house.

Windows are best shaded by external shutters or blinds. Internal blinds though less effective, are more economical and can make a significant contribution to improvement of indoor conditions.

Verandah.

117. The addition of verandahs provides shade and additional living area but are not particularly effective in intercepting the rays of low altitude sun in early morning or late afternoon but they do reduce glare on bright days, but at the same time do reduce daylight on overcast days.

Shrubs or trellis.

118. These can be very effective if due care is given to the selection of the right species and its correct positioning to provide shade at the right time and place without seriously interfering with air movement.

The use of deciduous species will overcome the problem of providing shade in summer whilst allowing any sunshine to penetrate through during the winter months.

PROTECTION OF BUILDINGS FROM DECAY AND INSECT ATTACK

Termites.

119. Termites or white ants constitute probably the biggest menace to a timber building apart from fire.

Protective measures.

120. Protective measures are better understood when it is appreciated that the termite species native to Western Australia are soil inhabiting and that if isolated from the soil they cannot exist.

This isolation from the ground is achieved by the installation of ant caps on all foundations.

Additional protection can be obtained by removing all stumps and roots from the ground on the building site and also by the poisoning of the ground with creosote or arsenic.

To eliminate white ants.

121. When termites have gained access to a building, the first step is to thoroughly examine the foundations to locate the means of entry.

Having located this means of entry, the following procedure should be adopted:—

First Method:

(1) Without destroying the termite galleries on the ground side of the ant stop, block the route of entry just below the ant stop.

(2) Obtain a small rubber bulb with small tube attached (infant's rectal syringe is ideal).

(3) Half fill the bulb with white arsenic. Make a small opening into the termite gallery below the obstruction, then puff a small quantity of the arsenic powder into the gallery and reseal the opening.

(4) The arsenic adheres to the ants and owing to their habit of grooming each other in their nests some of the ants will be poisoned. The ants, being cannibals, consume their dead members and in turn will die. In this way, the whole colony will be killed out.

Second Method:

Trace the termite galleries back to the nest and then break up the nest and thoroughly saturate it and the surrounding soil with creosote.

Lyctus borers.

122. With the use of marri in our buildings, it can be anticipated that some trouble from the Lyctus borers will develop.

However, these small borers confine their attention to the sapwood of certain species and hence attack can be completely prevented by ensuring that the sapwood is not included in timber used in houses.

Rarely will the attack have serious consequences, as usually the sapwood only occurs in small patches and its removal will not seriously affect the strength of the timber.

Evidence of attack.

123. Usually the first evidence of an attack will be the presence of a fine white dust in the vicinity. On closer examination small holes 1/16th" -$\frac{1}{8}$" in diameter (escape or exit holes) will be noted from which this dust is being ejected. In the process of escaping these borers will bore through fibrous plaster and pine lining but they do not normally attack pine.

Treatment.

124. As the extent of the attack is limited by the quantity of sapwood present, there is no justification for incurring much expense.

However, to discourage a reinfection in the same locality, it may be advisable to inject a small quantity of sodium pentachlorphenate or an equivalent insecticide into the escape holes.

Decay.

125. Rot or decay due to fungus growth will not develop in timber if the moisture content is kept below 25% or if it is kept saturated with water.

However, the temporary exposure of timber to moisture for periods of 4 to 6 weeks should not cause serious deterioration provided the timber dries out again.

For this reason it is necessary to provide good ventilation to sub floor areas, good drainage and if in a damp area, to raise the floor level.

The most favoured place for rot to develop, is in the joints and for this reason it is advisable to pre-treat the joints with paint or preservative before assembly and then to prevent moisture from lodging therein.

Discolouration of Timber by Nails

Discolouration of timber by nails.

126. Serious discolouration is caused by ordinary steel nails when used in some timbers, e.g. karri, blackbutt, pine.

For this reason, where timber structures are exposed to public view and are prone to suffer from nail staining, galvanised nails should be used.

INSURANCE OF BUILDINGS

127. Insurance to be effected:

(a) When any buildings are erected for, or purchased by, the department, head office should be immediately advised by the officer in charge of the District or Division. When such buildings are completed or taken over the following particulars must be supplied on form F.D. 181A:—

By whom occupied.
Purpose for which used.
Number of rooms.
Materials used in construction of walls (outside), partition walls, roof, lining and ceiling.
If supplied with electric light—number of points.
Telephones, switches, transformers (stating whether property of department or Commonwealth).
If departmental equipment is to be stored in the building, the report should indicate what this may consist of.

(b) A sketch should accompany the report indicating the position of the building referred to and the distance removed from any other building on either side.

(c) Insurance will be arranged from head office on receipt of this information.

(d) In order to provide a convenient means of reference to buildings, for fire insurance and other purposes, e.g. tenancy, alterations, repairs, renewals and painting, a number is allotted to each insured building owned by this department. Numbering of buildings.

(e) Number plates are affixed centrally on and near the top of the front doors of the respective buildings. In the case of new buildings the number plates will be sent out from head office after receipt of the sketch for insurances purposes.

MAINTENANCE OF BUILDINGS

128. To ensure that departmental buildings are maintained in a satisfactory condition, the D.F.O. or officer in charge must arrange for all buildings under his control to be inspected during the first week in January of each year. Particular care must be given to buildings in which such termite susceptible timber as karri or pine have been used to ensure that there is no sign of termite attack.

All buildings incorporating timbers other than jarrah, will have a metal plaque, naming the timber used, fixed to the right hand front corner of the building, 4' above floor level. Plaques will be supplied by head office on request.

129. Following the inspection a report on form F.D. 429 will be completed for each house and office. Report on building inspection.

Form F.D. 429 will be forwarded to the Divisional office, but a summary on form F.D. 436 covering the essential items of maintenance for houses and offices should reach head office not later than the 21st January. No returns are required for huts, garages, sheds, etc. although they should be inspected at the same time to ensure that any termite damage or undue deterioration is corrected.

Divisional officers are authorised to carry out any repairs and maintenance of a minor nature that might be required, such as broken windows, replacement of loose or broken boards, broken catches, handles and such other work of a minor nature and must ensure that termite precautions are fully maintained.

130. The external painting of dressed woodwoork, i.e. mouldings, barges, fascias, window frames, roofing, etc. should be done at not less than five year intervals and should be listed in the works programme with Divisional estimates each year, for the ensuing financial year. Maintenance painting.

131. The initial external painting of weatherboards and outer walls will be done only on head office approval. Subsequent repainting of external walls will be done at intervals of not less than four years. Painting of weatherboard exterior.

132. The oiling, varnishing or painting of internal joinery should only be required at long intervals and will only be done with the approval of the senior D.F.O. or more senior officer. Painting—internal.

133. The painting of interior walls will be the responsibility of the Department when it is considered necessary by the S.D.F.O. or more senior officer, either— Painting of interior walls.

(1) at the time of change of occupancy, or

(2) in cases where the house was occupied for a period of not less than eight years without inside maintenance.

In cases where the occupant is prepared to do the work himself in his own time, this may be arranged on the approval of the S.D.F.O. or more senior officer. Under these circumstances, the Department will supply paint and brushes.

Paint for interior use will be supplied in colours as near as possible to the tenants or local officer's request, provided that colours are restricted to pastel shades and that not more than four colours are used in any one house. Restriction on colour.

The paint to be used in bathrooms and kitchens will be oil based with a glossy finish, but for the remainder of the house other approved flat or matte finishes will be used.

The painting of freshly erected cement asbestos sheeting must be delayed for 12 months to allow the cement to mature and even then a neutralizing primer coat should be first applied.

Maintenance of Lookout Towers

134. This is covered in Pamphlet No. 7 (Fire Control), paragraphs 998-1,000.

RENTS

Cottage rents.

135. Rent at approved rates will be payable by all occupiers of Departmental cottages or huts.

Cottage rent collection from salaried officers.

136. When cottages are occupied by officers whose salaries are paid from head office rent will be deducted as it becomes due from such salary or wage.

Hut rent collections salaried officers.

137. All hut rent due by salaried officers, will be paid into the local office of the department. A receipt will be issued and the moneys collected, brought to account in the normal way.

The responsibility for the payment of such hut rent shall rest equally on both local officer in charge and the officer occupying the hut.

Rent collections from locally paid men.

138. When cottages or huts are occupied by departmental employees whose wages are paid locally by cash order, rent must be deducted fortnightly from the wages of the employee. The deduction column of the wages sheet headed "Conservator of Forests" is to be used for this purpose, and the number of the cottage or hut shown alongside the amount.

Rent collections where occupiers not employed by the Department.

139. Where occupiers of departmental huts or cottages are not employed by the Department, rent shall be collected weekly or fortnightly in advance by the forest officer in charge.

Under no circumstances shall rent be allowed to fall into arrears.

Official receipts must be issued for all such collections and the amount brought to account in the usual way.

Change of tenancy.

140. Change of tenancy of any departmental cottage must be notified to head office in order that records may be adjusted and the right person registered as occupier for the purpose of rent collection.

Occupants to supply own blinds.

141. All occupants of Departmental cottages are required to supply their own blinds, flywire doors and screens.

APPENDIX 1

GLOSSARY OF TERMS

Architrave. Mouldings mitred around a door, window, or other opening.

Arris. The sharp exterior angle formed at the intersection of two surfaces not in the same plane:—e.g., Arris Rail—a rail with a triangular cross-section fitted to posts for fences in such a manner as to show the arris in front.

Barge boards. Timber fixed on the gables of a building covering the ends of the purlins and ridge.

Battens. Narrow boards from 1" to 3" wide and ¾" and under 1½" thick used for fastening purposes—e.g., ceiling battens and tile battens.

Bearers. Main timber bases in wood frame buildings, usually 4" x 3" in section and laid along the top of the stumps or piers.

Window frames built up with hollow sides to receive the balance of weights for vertical sliding sashes. cf. Double Hung Window.	Boxed frames.
A joint formed between the squared edges of two jointing pieces which come together but do not overlap—e.g., verandah flooring.	Butt-jointed.
A hinged sash.	Casement.
Light horizontal beams for carrying the ceiling.	Ceiling joist.
A finishing surface of cement and sand, sometimes mixed with lime, applied to masonry walls.	Cement rendered.
The surface produced by bevelling an edge or corner.	Chamfer.
Small battens, nailed or fitted, serving a temporary purpose.	Cleats.
A horizontal beam connecting two common rafters together.	Collar-tie.
A moulding of fairly large section fixed in the corner between wall and ceiling.	Cornice.
A strong solid frame for a door—for external doors usually from 5" x 3" stock.	Door frame.
The vertical and top horizontal members attached inside a door frame acting as a door-stop.	Door jamb.
The piece holding the feet of door posts and serving as a threshold.	Door sill.
Sash and frame windows in which both sashes are supported by springs.	Double hung window.
The lower part of the roof which projects beyond the walls.	Eave.
Random length flooring, tongued and grooved on the sides and ends to fit.	End-matched flooring.
Finished timber covering rough work or inferior surfaces.	Facings.
A flat wide board with or without moulding as used to finish eaves in a building.	Fascia.
The timbers in a building carrying the floor boards—usually 4" x 2" and laid across the bearers.	Floor joists.
Doors with smooth level faces usually framed and faced with plywood, or consisting of a core with veneered facings.	Flush doors.
Doors fitted with stiles, top rails, ledges and vertical boarding.	Framed and ledged doors.
The triangular part of an outside wall, between the sides of the roof and the line of the eaves.	Gable.
An end wall surmounted by a gable.	Gable-end.
A ridge roof terminating in a gable end.	Gable roof.
A rendering of cement and fine granite chippings, used as a covering (often coloured) for concrete floors, on which it is floated in a layer 1" to 2" thick.	Granolithic.
Jointing by removing part of the timber in each piece of a cross-joint so that both surfaces are flush.	Halving.
The outer angle (more than 180°) formed by the inclined ridge between two intersecting roof slopes. cf. "valley."	Hip.
The wood fixtures of buildings in the form of finished work such as doors, windows, panelling, framing, etc.	Joinery.
Thin boards, usually tongued and grooved, used internally only to cover rough work or to provide a finished surface. Interior finishings in furniture.	Linings.
An angle joint between two members in which each is cut to a corresponding angle at their intersection.	Mitre.
A hole or slot to receive a tenon or dowel of corresponding size.	Mortise (Mortice).
Like parquetry flooring may be defined as "small pieces of wood, sometimes of different species, fitted together to form geometrical designs." However, the mosaic flooring pieces are smaller, being commonly 4"-6" long and $\frac{3}{4}$"-1" wide, five to six pieces forming an approximate square.	Mosaic flooring.

Mouldings.	Lengths of wood in shaped patterns to cover the joints of external and internal corners.
Mullion.	(a) A vertical member dividing the light of a window frame. (b) A vertical member between the door and sidelight of a door frame—e.g., French Door.
Nog and nogging pieces.	Nog:—A small block of wood. A block projecting from a wall to carry a shelf. Nogging Pieces:—The stiffeners fitted between studs. (Trimmers.)
Nosing.	The projecting edge of a tread or board, usually rounded.
Ogee (O.G.).	A moulding consisting of convex and concave arcs.
Ovolo.	A convex moulding in the form of a quadrant with listels (projecting flat surfaces).
Parquetry flooring.	Same definition as for mosaic flooring but the pieces are longer—10" to 12"—and cut from standard width flooring boards. Usually five pieces form an approximate square.
Priming coat.	The first coat of paint on woodwork, thin enough to penetrate the pores and crevices.
Purlins.	Horizontal beams fixed across the principals of a roof truss, and to which sheet roofing is attached. *Under Purlins:* Stiff horizontal members fixed under the rafters to eliminate sag where heavy roofing or long rafters are used. These are usually strutted above walls.
Quarter round.	A moulding in the shape of a quadrant.
Rafters.	The pieces laid from ridge to wall plate and carrying the roof covering—Common rafters as in gable roof. *Creeper Rafters:* Laid from hip or valley to wall plate. *Jack Rafter:* Laid from end of ridge to wall plate.
Rail.	The horizontal member of a frame, sash, door, panelling, fence, etc.
Rebate (Rabbitt).	A recessed edge designed to receive another piece, or a door, sash, etc.
Ridge.	The summit-line of a roof: the line on which the rafters meet.
Sash.	A frame, in particular the frame to a window holding the glass. It may be sliding, hinged or fixed.
Sash bars.	The intermediate members of a sash dividing the glass into smaller squares.
Sash door.	One with glazed upper panel.
Scotia.	A concave moulding.
Siding (Boarding).	The exterior sheathing of timber houses—e.g., weatherboards.
Sill.	The bottom horizontal members of a frame or of other structural work.
Skillion roof.	A flat inclined roof.
Slats.	Narrow, thin pieces of wood.
Soffit battens.	Battens fixed to the underside of the eaves at the gable end only.
Splay.	A bevel or large chamfer.
Spandrel.	Commonly, but wrongly, referred to the boxed-in triangular section at the end of a verandah. Strictly speaking, any spandrel is a filled in section, roughly triangular in shape where the "hypotenuse" is the concave arc of a circle.
Splice.	A splayed joint.
Stiles.	The vertical members of a frame, door, or sash.
Stopping.	Plastic material used to fill holes and cracks in timber, after the priming coat and before the final painting.
Stud.	The vertical timbers forming a wall or partition.
Strings.	Sloping wooden joists supporting the steps in wooden stairs.
Tenon.	The end of a piece prepared for jointing by a reduction in section so as to fit snugly in a recess, or mortise, of the other piece to be jointed.

Battens, usually 2″ x 1″, upon which roof tiles are laid.	Tile battens.
An intermediate horizontal member of a window frame, separating adjacent panes. Sometimes in large sections refers to the transverse members connecting the upright posts in a trestle—capsills.	Transom (e).
The horizontal parts of steps.	Treads.
A horizontal member which is framed in between full-length members to afford intermediate support. A nogging piece.	Trimmer.
A framework fitted with triangular bracing and designed to carry a load.	Truss.
The outer angle (less than 180°) between two intersecting roof slopes. Cf. Hip.	Valley.
A horizontal timber used to bind together piles driven in a row. In lookout towers the horizontal members binding the legs near the base and at the landings are called walings.	Wale.
The main top horizontal member of a wall frame. The bottom member is usually called a bottom plate.	Wall plate.
Derived from "wrought." The hand or machine finished surfaces on the exterior of a building which require painting.	Wrot.
Refers to a board, about 6″ x 1″, attached to a post just below ground level, in loose soil, to counteract thrust and prevent leaning. There are other types.	Yankee strut.