Some Notes on Australian Timbers.

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(A Paper read before the Sydney University Engineering Society on May 28th, 1896.)

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DISTRIBUTION.

The forests of the Australian colonies situated in torrid and temperate zones, include a great variety of trees. The northern parts of Queensland, South Australia, and West Australia, lie within the tropics and produce characteristic trees, as cocoanut and other palms, whilst timber trees are represented by cedar, pine, black bean, sandal-wood, hickory, stunted blood-wood, box, etc.

The south of Queensland and north of New South Wales has a luxuriant growth of trees; figs, tree ferns, and sub-tropical plants abound, whilst pine, cedar, red and black bean, forest swamp and white mahogany, various oaks, ironbark, tallow-wood, turpentine, blackbutt, grey and spotted gums, etc., clothe the country east of the Dividing range and produce perhaps the best timber in Australia, that from the northern rivers of New South Wales being especially good. In Victoria and Tasmania, ironbark, tallow-wood, etc., give place to stringy-bark, messmate, peppermint and mountain ash, whilst blue, red, slaty, and mountain gums, beech and black-wood flourish. The gums, red, blue, cabbage and sugar, continue through South Australia, and in West Australia they are replaced by jarrah, karri, and red gum, whilst iron-wood, sandal-wood and acacias grow in the north. The eastern, southern, and south western coastal districts produce the best timber; inland the trees become of stunted growth, mallee, wattle and cypress pine predominating, till in the interior there are plains with little vegetation or sandy wastes.

DESCRIPTION OF FORESTS.

Australian trees from three types of forests. (1) Open forests. (2) Brush or jungle forests. (3) Scrub or stunted forests.

Open Forests are the most important. The trees best known are ironbark, turpentine, tallow-wood, jarrah, the various gums, box, karri, stingy-bark, messmate, mountain ash and similar trees. These trees grow mostly on mountain ridges, undulating slopes, and river flats. The best timbers, ironbark, jarrah, box, etc., prefer a poor stony soil, others as apple trees, oaks and various gums, flourish on the rich river flats.

The trees usually have a tall straight trunk, the branches are few and crowded at the top, the leaves evergreen and generally vertical, and so afford little shade. The land where these trees grow is as a rule well grassed, but to further its growth the trees are ringbarked, and many useful trees so wasted.

Brush or Jungle Forests are next in importance. The trees best known are red cedar, yellow cedar, rosewood, red bean, brigalow, beech, yellow-wood, tulip-wood, various pines, etc. These forests occur chiefly on the eastern coast of Australia in sheltered fertile valleys, in mountain ranges and gorges, or on rich alluvial flats. They never occur on poor soil, the brush or scrub land, as it is called, is always selected for agricultural purposes.

The trees grow close together, some with tall straight trunks with few branches as pine, brigalow, hickory ; others like cedar and fig trees have boles with wings and spurs of fantastic shape. The foliage is thick, usually a dark glossy green, the leaves of all shapes, from the narrow brigalow leaf, to the mulberry shaped leaf of the stinging tree. The trunks are dotted here and there with stag, elkshorn, and other ferns, with orchids bearing beautiful flowers, whilst creepers and climbers grow from tree to tree, and so blend the foliage that it is almost impossible to distinguish the leaves of different trees.

Scrub or Stunted Forests are least important and comprise trees or shrubs, as honeysuckle, mallee, myall, wilga, needle-bush, wattles, etc. These scrubs grow all over Australia on dry, strong and sandy soil. They consist of low stunted trees, with here and there one of moderate height, and are of little use for timber. Most of these trees bear flowers, whilst grasses, ground orchids and other flowering plants flourish amongst the undergrowth.

INFLUENCE OF LOCALITY, CLIMATE, AND SOIL.

Timber grown on mountain ridges and elevated country, attains its maximum size, strength and durability, whilst the same kind grown on low lying swampy ground is weak and brittle, and soon decays.

It has been stated that in a locality where a particular tree predominates, that the timber will last longest in the ground ; where box predominates amongst the trees, box timber will last longest, where red gum predominates, red gum will last longest, but this needs proof.

The colder climate produces the best trees of the same species, the blue gum and stringy-bark of Victoria and Tasmania are superior to those of New South Wales, the ironbark of New South Wales is superior to that of Queensland, whilst with coniferous trees, kauri and Huon pines are superior to the Australian conifers.

Trees of the same species flourish on a variety of soils, the hardwoods as a rule prefer poor soil, one that is porous and well drained, the finest timber grows on ridges of sandy loam, though good timber grows along the alluvial river flats. The figured timbers and pines prefer rich soils of decomposed rock, and flourish on mountain sides and sheltered gorges. Soils displaying rock of the Silurian period grow good timber. In Queensland, New South Wales, and Victoria we have the Silurian formation interspersed with rocks of the eruptive group as quartz, felsite and granite, and this country produces good timber. Extending north and south from Sydney the country is Triassic of the Hawkesbury and Wianamatta series and though good patches occur, it is not noted for its timber. The valley of the Murray extending into South Australia is Cainozoic, and the valley of the Darling extending into Queensland is Cretaceous, neither of these regions produce much timber. Granite country as a rule does not produce good timber.

THE AGE AND SEASON TO FELL TREES.

In Europe the inhabitants have had experience for centuries regarding the age and season to fell trees. Experience shows that trees should be felled at maturity when the sap is down to get the best results, and as the ages of existing trees are fairly well known it is, to some extent, easy to judge when the tree is mature. In Australia, however, where the trees are so different there has been no such opportunity, and the age at which various trees reach their maturity has received little or no attention. Some, like ironbark, jarrah, bloodwood, and red gum grow slowly, whilst messmate, blue gum, stringybark, and blackbutt, grow more rapidly as indicated by their annual rings.

If the trees are felled before maturity, there is a large proportion of sapwood, the heartwood has not fully hardened and the timber is not so strong and durable ; if felled after maturity the heart is generally in a state of decay, a characteristic of Australian hardwoods, which affects the strength and durability of the whole of the timber. Hence the importance to judge when a tree is mature.

A tree having reached maturity still grows, but slowly, the activity of the branches become less in spring-time, there are fewer leaves and flowers. Another indication is the relative size of the trunks to those of the same species, a trunk of average maximum size is usually mature. A tree may be deemed mature when it has reached a fair size, shows no defects and has healthy vigorous branches, the topmost branches especially.

The proper season to fell timber is when the sap is not circulating. In warmer parts of Australia this occurs in the dry season, in colder parts in the winter, from March to September would appear the best

time. Trees should not be felled when young leaves appear. When the sap is down the annual cycle of growth is complete, the tree is at rest, and the timber will be hard and durable. Sap contains saccharine, saline, and albuminous matters, these are liable to ferment and set up dry rot and decay, and the more sap, the greater tendency to warp and twist.

CLASSIFICATION AND PROPERTIES OF TREES.

Exogenous trees are divided into two classes—Dicotyledons, or broad-leaved trees, and Conifers, or narrow-leaved trees. Dicotyledons are the most common, and comprise the hardwoods and softwoods, whilst conifers yield pinewood.

The Hardwoods.—The hardwoods are trees of the species eucalyptus, syncarpia, angophora, etc., and, with few exceptions, grow in the open forests. The timber is red, brown, yellow, straw, or whitish in colour, and, as the structure is chiefly woody fibre, is hard, heavy, strong, rigid, and close in texture. The grain is sometimes straight and plain, with minute pores filled with a white secretion, but more generally interlocked, rarely finely figured, and always more or less difficult to work. These hardwood trees, when mature, are rarely sound at heart, being very subject to pipes ; and. when sound, the heart is of very little value, as it is brittle. A characteristic feature is, that they always split more readily in concentric layers than in planes radiating from the centre. They are subject to gum-veins and shakes, and, though they make a good fuel, and are valuable on that account for the heat they generate, yet they are slow to kindle, and some, like turpentine, will scarcely burn at all. Some of these timbers are very durable and almost indestructible, others resist the white ant, etc.

Selected hardwoods are unequalled for railway sleepers, piles and girders for bridges, jetties and wharves, telegraph posts, fencing, ship-building, in fact, in any situation where timber is required to withstand heavy loads and stress of weather ; others, again, are very suitable for wood-paving, flooring, carriage and house building, wheelwrights' work, etc.

The principal hardwoods are :—Ironbark (5 varieties), tallow-wood, turpentine, blackbutt, jarrah, Murray red gum, karri, tuart, forest red gum, blue gum, spotted gum, grey gum, forest mahogany, and the various species of box, whilst many others, as woollybutt, sugar gum, giant gum, mountain ash, stringy bark, peppermint, etc., are much used in minor works.

The Softwoods.—The softwoods are generally found in the brush forests, though oaks and acacias grow in the open forests, and others, as the honeysuckle, in the scrub forests. The softwoods include the fancy, or figured timbers, some of which, though hard, are of a

different nature to the hardwoods. The trees are almost always sound at heart, and split in planes radiating from the centre, are straight in grain, easily worked, and free from gum veins.

The timber is of all shades and colour—white, yellow, red, motled, brown, and black, and is light, strong, durable, and often fragrant ; as a rule, it is ornamental and beautifully figured, polishes well, and makes splendid veneers.

It is used in furniture making, carving, turning, wood engraving, veneers, in railway carriage and coach building, in coopers' and carpenters' work for casks, vats, butter-kegs, palings, shingles, etc.

The following are some of the principal softwoods and figured timbers, which are not nearly so well known as their merit demands :—Red cedar, yellow cedar, black bean, red bean, rosewood, red ash, coachwood, maiden's blush, corkwood, silky oak, beef wood, blackwood, tulipwood, yellow wood, hickory, beech, sassafras, etc.

The Conifers, or Pine Woods.—Pine is the product of coniferous trees growing in brush and scrub forests, is light yellow, mottled, or brownish in appearance, soft, light, with a long straight grain of even texture, easily worked, and useful where long lengths are required. The pinewoods are strong, but are not to be compared to the hardwoods. Their tissue consists of cells and tracheids chiefly, the sides of the tracheids are punctated, that is, there are small, lenticular hollows along the sides, which probably accounts for the small lateral adhesion or strength across the grain, whilst the absence of woody fibre renders them weak along the grain, when compared with the hardwoods. They usually abound in turpentine and resinous substances, which act as preservatives, and keep certain varieties (as cypress pine) free from white ants.

Pine wood is used where long lengths, not subject to heavy loads, are required, for house building, furniture making, and general building purposes.

The following are the principal pines :—Colonial or Moreton Bay pine, Bunya pine, brown pine, cypress pine of various species, Huon pine, and kauri pine.

DRESSING.

Round timber cut by hand, or at the mill, is called sawn timber. When squared or dressed with adze or axe, it is called hewn : and when burst open with wedges, it is termed split.

Round Timber.—Ironbark, jarrah, red gum, turpentine, etc., are much used for piles and girders, and may be had in lengths of 70 feet, and even longer, but 50 feet is a good maximum size.

Sawn Timber.—A flitch of timber, sawn with the annual rings roughly parallel to its long side, is stronger and less liable to twist than when parallel to its shorter side. All sawn timber, over 8 inches wide, should have the heart in the centre. In sawn hardwood of

the better class, ironbark, blackbutt, tallow-wood, jarrah, etc., flitches 18 inches x 7 inches, 40 feet long, can be obtained free from heart; lower sizes, 16 inches x 7 inches, 14 inches x 8 inches, etc., can be had in lengths over 40 feet; but the most useful sizes, free from heart, are flitches 12 inches x 6 inches and under, which can be had in 60 feet lengths, though the longer lengths are more costly. Blue gum *(globulus)*, giant gum, stringy bark, messmate, can be had in very wide flitches. In softwoods and pines, lengths up to 50 feet can be obtained, and widths 25 inches and over, but these are maximum sizes.

Hewn Timber.—Large square baulks, containing the heart, are mostly hewn, though sometimes sawn, but a girder hewn and then planed, is superior to one sawn, for, in hewing, the grain of the timber must be followed, and the faces worked square by cutting off little inequalities. Hewn ironbark, tallowwood, jarrah, etc., may be obtained 18 inches square, in 40 feet lengths. Lower sizes, however, as 16 inches x 16 inches, 16 inches x 14 inches, 16 inches x 12 inches, are more readily obtained, and in longer lengths, whilst 14 inches and 12 inches square are the most useful sizes, and may be had in 70 feet lengths. All hewn timber should have heart in centre, and any size below 12 inches square is bad.

Split Timber is much used for rough work, as posts, rails, half-round sleepers, slabs, shingles, palings, etc., and, as the grain of the timber is followed, it does not readily shell or crack.

DURABILITY.

Many instances might be quoted of the long life of various hardwood timbers when exposed to the weather. Ironbark, jarrah, bloodwood, turpentine, mahogany, blackbutt, tallowwood, grey, red, and bastard box, the various red gums, sugar gum, and grey gum, are amongst the most durable. When split and used as fencing, and as slabbing for houses and barns, many of the hardwoods have lasted 40, and even 50, years, and are then in good condition. Ironbark piles, taken from wharves in the salt water of Sydney Harbour, are quite sound, after 50 years immersion; whilst sleepers, bedded in ballast exposed to rain, moisture, and quick changes of temperature, are perfectly sound after 20 and 30 years' wear, though inferior ones decay long before. Many of these old specimens are to be seen in the Technological Museum, Sydney, and in kindred institutions throughout the Colonies.

The average life of girders and piles in bridges in New South Wales is about 25 years. Planking lasts 8 to 15 years, whilst wood-paving has lasted fifteen years, and is still good.

The following 12 truss and beam bridges are taken from the records of the Public Works Department of New South Wales, and in November, 1895, were still carrying the traffic. They are built of

a variety of hardwood timber, and are all over 35 years old; and many other instances might be quoted :—

1. Wallis Creek, at West Maitland, 43 years old. Superstructure renewed twice, but piles were sound, and almost good enough for a third superstructure.
2. Sandy Hollow, near Galston, 40 years old. Blackbutt.
3. Cabramatta Creek, 40 years old. In fair condition.
4. Pyrmont Bridge, Sydney, 39 years old. Ironbark.
5. Queanbeyan Bridge, 38 years old. Mountain ash and messmate.
6. Albury Bridge, 36 years old. Murray red gum.
7. Berrima Bridge, 35 years old.
8. Wingecarribee, 35 years old. Mountain ash, messmate, and blackbutt.
9. Stonequarry Creek, 35 years old.
10. Glebe Island Bridge, 35 years old. Ironbark.
11. Bungarribee Creek, 35 years old.
12. Cattai Creek, 35 years old.

STRENGTH OF TIMBERS.

Various tests have been made on Australian timbers, the earliest recorded were in 1851, but as a rule the apparatus was primitive, the samples small, the results not over accurate or reliable, and as the botanical name was not always given, similar vernacular names for different timbers led to confusion in identifying those tested. Accurate and reliable tests, however, have been made on a large variety of timbers at the University of Sydney, and the results carefully recorded. The height, diameter, time of felling, and botanical name of the tree, the geological formation on which it grew, the length of seasoning, and other particulars were carefully noted, and experiments made in the testing machine on several specimens of each timber, in cross breaking, tension, compression and shear. It was found by the experiments that the tensile strength and modulus of rupture were nearly equal, and about double the compressive strength, and the shearing strength along the grain was very high, but not proportional to the tensile, compressive or tranverse strength.

Transverse Tests.—The specimens tested were 4 feet 6 inches long, 6 inches wide, and 4 inches deep, centres of bearings 4 feet, and the test load applied at the centre. In failure, the fibres on the concave side of the beam crushed first, and those on the convex side immediately tore, except when owing to some defect as a gum vein, failure occurred by shearing along the neutral axis. The results of the more important are given below, and their great strength shows their suitability for use as girders, beams, stringers, transoms, &c., in engineering work, house, ship, and carriage building.

In 1885 the Railway Bridges Inquiry Commission tested a beam of ironbark 12¼ inches square, 28 feet 6 inches clear span, till failure occurred with a central load of 19½ tons. Allowing 1 ton distributed, or ½ ton central, as the weight of the girder, the total central load was 20 tons, and the modulus of rupture 12,500 lbs. per square inch.

Another experiment on a beam of ironbark 12 inches square, 26 feet clear span, broke with 23 tons, or 23·46 tons, allowing for the weight of girder, and the modulus of rupture was 14,200 lbs. per square inch.

Taking these two experiments, the average modulus for ironbark is 13,350 lbs., or 6 tons per square inch, whilst the average of 26 experiments on pieces 4 feet centres, 6 inches wide and 4 inches deep, gave the modulus as 18,000 lbs. per square inch, which indicates that in actual practice the modulus of rupture is about 25 % less than that given by small test pieces. In the following table the minimum modulus given is for the lowest sound specimen which is usually unseasoned, and it may be noted that the average modulus is nearer the higher than the lower limit.

TIMBER.	MODULUS OF RUPTURE LBS. PER SQUARE INCH. MAXIMUM.	MINIMUM.	NUMBER TESTED.
Ironbark, *E. Paniculata, Crebra, Siderophloia and Sideroxylon*	23,400	13,300	26
Turpentine, *S. Laurifolia* ...	21,500	10,800	12
Grey Gum, *E. Propinqua* ...	20,000	13,400	3
Tallowwood, *E. Microcorys* ...	19,700	11,500	12
Spotted Gum, *E. Maculata* ...	19,700	11,500	15
Blackbutt, *E. Pilularis*	19,100	11,400	15
Grey Box, *E. Hemiphloia* ...	19,100	12,900	9
Red Gum, *E. Tereticornis* ...	19,000	9,000	9
Bloodwood, *E. Corymbosa* ...	18,400	11,000	6
Mahogany, *E. Resinifera* ...	18,100	12,400	9
Red Box, *E. Polyanthema* ...	16,400	15,700	3
Giant Gum, *E. Amygdalina* ...	15,300	12,200	3
Blackwood, *A. Melanoxylon* ...	14,200	7,000	6
Jarrah, *E. Marginata*	14,000	10,100	7
Red Gum, *E. Calophylla* ...	14,000	6,500	3
Blue Gum, *E. Globulus*	13,600	12,800	3
Red Gum, *E. Rostrata*	12,500	8,800	3
Coachwood, *Ceratopetalum, Apetalum*	12,000	9,400	6
Black Bean, *Castanospermum Australe*	11,300	11,100	3
Red Cedar, *Cedrela Australis* ...	3,700	3,300	2