WESTERN AUSTRALIAN HARD WOODS

AND THEIR USES FOR

STREET PAVING, ENGINEERING,

AND OTHER PURPOSES,

WITH REPORTS AND RETURNS.

ISSUED FROM THE
WESTERN AUSTRALIAN AGENCY,
15, Victoria Street, London, S.W.,
UNDER THE INSTRUCTIONS OF
THE HON. H. BRUCE LEFROY,
Agent-General for Western Australia.

LONDON:
PRINTED BY WILLIAM CLOWES AND SONS, LIMITED,
Duke Street, Stamford Street, S.E., and Great Windmill Street, W.
July, 1902.

WESTERN AUSTRALIAN HARD WOODS

AND THEIR USES FOR

STREET PAVING, ENGINEERING.

AND OTHER PURPOSES,

WITH REPORTS AND RETURNS.

ISSUED FROM THE
WESTERN AUSTRALIAN AGENCY,
15, Victoria Street, London, S.W.,
UNDER THE INSTRUCTIONS OF
THE HON. H. BRUCE LEFROY,
Agent-General for Western Australia.

LONDON:
PRINTED BY WILLIAM CLOWES AND SONS, LIMITED,
Duke Street, Stamford Street, S.E., and Great Windmill Street, W.
July, 1902.

TABLE OF CONTENTS.

INTRODUCTION.

In June, 1900, a report on "The Uses of Western Australian Hard Woods for Street Paving Purposes" was issued by Sir Edward H. Wittenoom, K.C.M.G., then Agent-General for Western Australia, the main object of which was to deal with the subject, under discussion at the time, of "The Comparative Durabilities of Wood and Asphalte Pavements."

Since then the interest in wood paving has greatly increased, and the question of its suitability has formed the burden of frequent discussions in Municipal Councils and in the public Press. The time, therefore, has appeared opportune for collating such facts and opinions as the further and wider experience of Municipal Engineers may have rendered available for that purpose. Instructions were consequently given to Mr. E. T. Scammell, who has had considerable acquaintance with the subject, and by whom the report in June, 1900, had been drawn up, to prepare a statement dealing with the general question of Western Australian woods and their adaptation to street paving, engineering, and other purposes. Acting under these instructions, enquiries were sent by him to a number of Municipalities, and all other available sources of information have been drawn upon ; the result of which is embodied in this issue.

Thanks are due, and are gratefully tendered, to those gentlemen with whom correspondence was opened on the subject of wood paving, for the information so readily given, and to Drs. Norton and Hake, and Messrs. Aitken, Lowe, Mason, Palmer, and Richardson for their useful and excellent reports. The object contemplated by this publication is to assist the trend of opinion in favour of wood paving for city and suburban thoroughfares, and to show the advantages of Western Australian hard woods for engineering and other purposes, in order to promote the development of an important industry of the State of Western Australia.

H. B. LEFROY.

15, Victoria Street, London, S.W.,
July, 1902.

WESTERN AUSTRALIAN HARD WOODS

AND THEIR USES FOR

STREET PAVING, ENGINEERING, AND OTHER PURPOSES,

WITH REPORTS AND RETURNS.

The Leading Western Australian Timbers suitable for commercial purposes are the well-known Jarrah (*Eucalyptus marginata*) and Karri (*Eucalyptus diversicolor*), which are strictly indigenous to this State. Among other Western Australian timbers, however, worthy of attention are Tuart (*Eucalyptus gomphocephala*), one of the most valuable Australian woods, Red Gum (*E. calophylla*), Wandoo or White Gum (*E. redunca*), Blackbutt (*E. patens*), York Gum (*E. loxophleba*), Yate Gum (*E. cornuta*), and Flooded Gum (*E. rostrata*). These and other Eucalypts, of which there are many varieties in Western Australia, are suited for street paving, engineering (locomotive and marine), wheelwrighting, and general constructive works; and some of them, with other classes of timber, notably the Casuarinas and Acacias, may be used to great advantage in cabinet and art work.

But Jarrah and Karri, from their widely known and popular character, demand special attention.

The Jarrah forests are computed to cover an area of 8,000,000 acres, and Karri 1,200,000 acres, a total area of between 14,000 and 15,000 square miles. These compact forest areas lie in the south-western part of the State, and are within a comparatively short distance of the coast, while the Great Southern and South Western Railway systems, with their branch lines, afford communication with the principal harbours.

In view of the full information that has from time to time been given by Government publications, in technical books and journals, and the public Press respecting these timbers, it is unnecessary to describe them in detail. It should be noted, however, that their tensile and crushing strengths, as of Australian Eucalypts generally, are high, and that in these respects and others they compare favourably with the best hard woods of other countries. The average weights of these woods, deduced by the late Mr. C. Y. O'Connor, Engineer-in-Chief of Western Australia, from tests made by the Admiralty in 1894, and by Mr. J. A. McDonald, of Fremantle, in 1896, are respectively 65 and 63 lbs. per cubic foot for Jarrah and Karri, as compared with 54 lbs. for British Oak, 40 lbs. for English Elm, 40 lbs. for Beech, and 49 lbs. for Teak. In the red colour of the wood, Jarrah and Karri are very similar. To determine the difference between them it is customary to try them by burning, when Jarrah usually leaves a black cinder and Karri a light-coloured ash.

STREET PAVING.

In dealing with the uses of Jarrah and Karri in the United Kingdom the first place must be given to street paving. A number of important particulars and reports are therefore furnished on this subject.

The Table of Returns.—This table has been compiled from information received from nearly one hundred and forty Municipalities of the United Kingdom, and affords the most complete body of evidence on the general subject of wood paving that has ever been gathered together. As will be seen, the special points to which enquiries were directed related to the wood used, the methods and cost of laying blocks, and the general results. It is not proposed to summarise these returns further than to say that (1) the area of Jarrah and Karri paved streets referred to in them is about two and a half million square yards (140 miles of streets, of an average width of 30 feet); (2) the number of blocks used is over a hundred and twenty millions (of which the greater proportion is Jarrah); (3) the period covered is thirteen years; (4) the class of thoroughfare and of traffic indicated is of every variety; and (5) the general conclusion, with very few exceptions, is overwhelmingly in favour of the use of Western Australian paving woods.

The Hygienic Report of Drs. John Norton and H. Wilson Hake.—The object of this enquiry was to determine, by careful scientific examination, the sanitary character of Jarrah, Karri, Plain and Creosoted Deal, and American Red Gum, the paving woods in most common use in Westminster and other metropolitan boroughs. The whole matter was left in the hands of Dr. Norton, who, from his lengthened experience as the late Medical Officer of Health for Westminster, and as a man of high scientific attainments, was specially qualified to make such examination. Dr. Norton called to his assistance Dr. H. Wilson Hake, Chemical Analyst and Bacteriologist of Westminster Hospital. As will be seen, the report is an exhaustive and most instructive one, and the result is strongly in favour of Karri and Jarrah, in the order named, on hygienic grounds. It is shown also that they compare favourably with what has been regarded as the most sanitary of all paving materials—compressed asphalte.

The statement that oxalic acid is found in Jarrah is interesting, as it may help to determine the reason of the special immunity from the attacks of the termite (white ant) and the teredo navalis (sea worm) which this timber possesses. The presence of kino (gum), kino-tannic acid, and phlobaphene has hitherto been regarded—according to a copy of minute addressed to the Under-Secretary for Lands (Western Australian Government) on 14th July, 1900, by Mr. G. C. Richardson, of the Forestry Department—as the special preservative of various Eucalypts, but it is important to know that oxalic acid also enters into the composition of this class of timber.

To this report it may be well to add that in 1894 an examination of "the moisture and mixture from beneath the wood pavements" of Sydney, New South Wales, was made by Mr. J. McGarvie Smith, at the instance of the municipal authorities of that city. Mr. Smith examined a number of hard wood blocks laid in 1883, which had been laid with $\frac{3}{4}$-inch joints, grouted with tarred screenings and pitch. In his report he says: "After cultivating and isolating the organisms present, which consisted of bacilli and micrococci,

I injected them under the skin of guinea pigs, and in no case did they cause death. I made special search for the typhoid bacillus (which is only pathogenic in man), but failed to find a single bacillus." The result of this investigation is important, as it shows that the accumulations between and beneath wood blocks, the joints of which are open, are innocuous. (See, also, reference under "Wood Paving in Australia," page 8.)

THE VIAGRAPH REPORT OF MR. THOS. AITKEN, A.M. INST. C.E., PRESIDENT OF THE ROAD SURVEYORS' ASSOCIATION, SCOTLAND, AND COUNTY SURVEYOR, CUPAR-FIFE.—The Viagraph is an ingenious instrument designed for the purpose of automatically registering the exact profiles of road surfaces. The inventor—Mr. John Brown, F.R.S., of Dunmurry, Belfast, who is the president of the Roads Improvement Association, Ireland, and a well-known scientist—kindly rendered Mr. Aitken considerable service in the examination to which this report applies. The object of the examination was to ascertain how far the surfaces of Jarrah and Karri paved streets compared with streets paved with other woods and with some other paving materials. Mr. Aitken, who is the author of an excellent work on "Road Making and Maintenance," and who had given a great deal of attention to the Viagraph in its application to macadamised roads, was consulted as to its use for wood-paved streets, and was eventually asked to conduct the enquiry. His report, like Dr. Norton's, will be found to be of unique and special interest. The result of the twenty-eight tests taken in the course of this examination shows that it is possible for roads paved with Western Australian hard woods to retain an even surface after years of wear, and that such roads compare favourably with those paved with other classes of wood, and even with asphalte. In this report reference is made to the use of dowelled blocks for street paving. It would appear that by the use of these blocks a more even surface may be maintained.

THE REPORTS of Messrs. CHAS. HARLOWE LOWE, M. Inst. C.E., late Borough Engineer, Hampstead; CHAS. MASON, A.M. Inst. C.E., &c., President of the Society of Engineers; and P. H. PALMER, M. Inst. C.E., &c., Borough Engineer, Hastings, are of great value, as they express the matured opinions of professional men of high standing, who have had considerable experience in the work of street paving.

RECENT WORKS ON THE SUBJECT.—In Mr. THOMAS AITKEN'S book on "Road Making and Maintenance," after dealing with the history of wood paving and the systems and materials employed, he treats of the methods and cost of laying wood blocks, and says "the first cost per annum during estimated life of pavement (given as 12 years for hard and 7 years for soft wood) is, for soft woods, 13·23*d.* per square yard, and, for hard woods, 11·0*d.* per square yard." The concluding paragraph states: "If the repairs and cleansing be taken into account, there can be no doubt as to there being a further considerable annual saving in the case of hard wood; and although the first cost of the wood is greater, hard wood pavements are less expensive in the long run, particularly where vehicular traffic is heavy. In addition to this, there is a considerable advantage, especially in busy carriage-ways, by the thoroughfare being less frequently closed for renewals, which is a matter of great importance to business people, shopkeepers, and others."

Mr. FRANK LATHAM, C.E., Borough Engineer, Penzance, has written a series of papers for the *Sanitary Record* on "The Construction of Roads,

Paths, and Sea Defences," which, it is hoped, he will issue shortly in book form. Mr. Latham, in dealing with the subject of wood paving, refers to the importance of good foundations and of careful jointing. He advocates close blocking, with a grout of hot pitch and creosote oil or bitumen, and says: "All users of wood for paving purposes must be aware of the tendency the 9-inch length of block has to warp out of shape when exposed to hot weather soon after laying. Blocks so warped often become loose, and, unless removed from the pavement, the joints of others nearest to them also become injured. This is only an occasional occurrence, but would be practically prevented if smaller blocks were adopted, such as 7-inch, 6-inch, or even 5-inch; and there is no reason for their exclusion."

The Repayment of Loans from the Local Government Board.—The usual term is 10 years, but the Board has recently extended the time for the Borough of Hastings to 12 years. It is expected that, in this instance, 20 years will be allowed for the repayment of the loan on the concrete foundation, which would give an "equated period" of from 14 to 15 years on the whole work.

Specification.—Enquiries have been made for a sample form or particulars of specification as a guide to municipalities which may not have adopted wood paving. Such particulars, therefore, as applying to the Corporations of St. Pancras and Camberwell, London, have been kindly furnished by Messrs. W. N. Blair, M. Inst. C.E., and W. Oxtoby, A.M. Inst. C.E., and will be found at the end of this issue.

Wood Flooring.—Jarrah and Karri answer well for flooring purposes, if the timber is thoroughly seasoned and properly laid. Illustrations of their use for these purposes may be seen in the *Daily Telegraph* office and workshops, Fleet Street, Gatti's Restaurant, the Gaiety Buffet, and the Savoy Hotel, Strand, the Deutsche Bank, George Yard, Lombard Street, and in other places in London.

WOOD PAVING IN AUSTRALIA.

Hard wood paving blocks have been used in Australia for over twenty years, and under conditions, arising from very hot, dry seasons alternating with periods of heavy rain, which are by no means favourable to this class of paving. It is interesting, therefore, to know the result of the experience of the Municipal Engineers of such cities as Sydney and Melbourne. Although the traffic in the streets of these cities may not compare with that of some of the most busy thoroughfares of London, it is as heavy and continuous as in many London boroughs and large provincial towns. Referring to the question of traction in the wood-paved streets of Sydney, a writer says: "I have watched with astonishment the ponderous loads hauled by one, two, or three horses. Never have I seen anything approaching it. Two or three tons for a single horse, four to six tons for two horses, seven to ten tons for four horses, are no uncommon sights."

In a paper read by Mr. R. W. Richards, C.E., City Surveyor, Sydney, before the members of the Incorporated Association of Municipal and County Engineers, at a meeting held in February, 1897, at Westminster, he said that, "as the result of seventeen years' experience," he was of opinion that "a carriage-way pavement laid upon a good foundation of concrete with New South Wales hard woods, with slape or butt joints, with convexity of 1 in 60 or 1 in 80 as the longitudinal gradient may suggest, properly cleansed and

maintained, is the best and most suitable form of paving for heavy and continual traffic." After enumerating some New South Wales timbers (and the same may apply to Western Australian and other Australian woods), Mr. Richards says "these timbers have, upon examination, shown wear at the rate of $\frac{1}{60}$ to $\frac{1}{80}$ inch per annum, and have not required repairs of any kind whatever." In April, 1901, PROFESSOR WARREN, one of the leading authorities on timbers and their uses in Australia, was asked to examine the condition of the Sydney streets. In his report he says: "I consider that the present system of laying such pavements has no rival. I have never seen anything as good in any part of the world, excepting the asphalte paving in the boulevards of Paris and in the streets of Washington. These latter are as good in every respect, but I do not consider them better."

Mr. A. C. MOUNTAIN, M. Inst. C.E., City Surveyor, Melbourne, formerly City Surveyor, Sydney, in a pamphlet on "Wood Paving in Australia," issued under the authority of the City Council, Melbourne, in May, 1897, deals fully with the first trials of wood blocks in Sydney from 1880 to 1884, and with the subsequent history of wood paving in that city and Melbourne. He shows that in these two cities no less than 216 acres of streets had been laid, during 17 years, with Australian hard woods, over fifty million blocks being used. Of the various woods tried, he says that the following are "pre-eminently suited for wood paving": Tallow wood (*E. microcorys*) and Blackbutt (*E. pilularis*) of New South Wales; Red Gum (*E. rostrata*) of Victoria and New South Wales; and Karri (*E. diversicolor*) and Jarrah (*E. marginata*) of Western Australia. He cites some samples of wear in one of the heaviest trafficked streets in Melbourne—Flinders Street—which show that Red Gum wore two inches in 13½ years, and Karri the eighth of an inch in 4½ years. Mr. Mountain refers to the report submitted to the Sydney City Council by the "Wood Pavement Board" appointed (1884) specially to examine into "the alleged deleterious effects of wood paving upon the public health," and whose report was adverse to the use of wood. "Fortunately," he says, "the report had no weight with public opinion and fell dead. Now, after 17 years' experience of wood paving in the two greatest Australian cities (during which period its development has far exceeded the most sanguine expectations), we find that none of the dire results prophesied by the Wood Pavement Board have come to pass, nor has the death rate of either city been at all affected. Not only so, but careful examination of the wood blocks, after years of wear in the street, has shown no indication of the presence of any organisms deleterious to public health. After this lapse of time, it seems difficult to realise that had the recommendation of the Wood Pavement Board been supported by public opinion, Australia would have been to-day without her magnificent wood-paved streets."

Anyone who knows Collins Street and other leading Melbourne thoroughfares will admit that, for even and durable pavements, they afford an excellent illustration of what can be done with Australian hard wood paving blocks, well laid and properly supervised.

Mr. E. HOWARD GLIDDON, City Engineer, Perth, Western Australia, writing to the Conservator of Forests on the 29th of October, 1901, "with reference to enquiries *re* Jarrah wood paving," says: "Some four years ago I laid down the first wood-paved road in Western Australia, viz., High Street, Fremantle; it was and is a great success, the road, after four years' heavy

traffic, being in a perfect state of repair. Two and a half years ago I laid Hay Street, Perth, and we are now about to treat other streets in the same way. All these roads were laid on the lines of the Sydney and Melbourne specifications. I consider that a Jarrah-paved road will wear for quite twenty years, and longer, if well nursed by top dressing every year with tar and sand. This is very necessary in a hot climate like ours, to prevent contraction. Plenty of water should be used in summer to keep the blocks from contracting, as I find the real trouble arises from contraction and not expansion. I have every confidence in recommending Jarrah as a suitable, if not the best, wood for road making." Mr. Gliddon dips his blocks in tar and drains them ; he lays them close, driving them up, at each twelve courses, with heavy sledge hammers. For top dressing he employs boiled tar, which is poured over the blocks and well rubbed in with hard brooms ; the surface is then covered with a layer of dry sand.

CLASSIFICATION.

It is generally considered that a paving material to be effective should be, as far as possible, durable, economical, hygienic, quiet, safe, of easy traction, and easily cleansed and repaired. Applying this description to hard and soft woods and asphalte, the following table may be regarded as fairly representing their relative values :—

	First.	Second.	Third.
Durability	Hard Wood	Asphalte	Soft Wood
Economy	Hard Wood	Asphalte	Soft Wood
Hygiene	Asphalte	Hard Wood	Soft Wood
Quietness	Soft Wood	Hard Wood	Asphalte
Safety	Wood	Asphalte	—
Traction Resistance . .	Asphalte	Wood	—
Ease of Cleansing . . .	Asphalte	Hard Wood	Soft Wood
Ease of Repair	Asphalte	Wood	—

NOTE.—In comparing the durability and economy of hard wood and asphalte, regard must be had to the fact that the latter, in streets of continual and heavy traffic, has to undergo constant repair, so that the surface is being frequently renewed.

Although asphalte is placed first in the class of hygiene, it is a matter of common complaint that in hot weather it is often very offensive, giving off strong and unpleasant odours, while horses suffer greatly from the heat reflected from its surface. A writer on this subject refers to "the almost unbearable flame-like heat reflected from asphalte and granite setts," and says "a dull, unpainted, and unpolished wood surface reflects but little more heat than a common dirt road."

In the course of a series of observations of road accidents, continued for fifty days by the London police in the busiest streets of the metropolis, the following results were noted: 1,066 horses fell on asphalte, 719 on granite, and 542 on wood. Asphalte is also dangerous to pedestrians in moist and frosty weather.

It is acknowledged that asphalte in general presents a more uniformly smooth surface than wood, but where Western Australian hard woods are well laid the difference is slightly, if at all, in favour of asphalte, as will be seen on reference to the Viagraph Report. The same observation may apply to ease of cleansing.

REPORTS ON WOOD PAVING.

REPORT OF MR. CHAS. MASON, A.M. Inst. C.E., A.R.I.B.A., Fel. San. Inst., and President of the Society of Engineers, London.

BEESTON,
Near NOTTINGHAM,

To the Hon. H. B. LEFROY, *December*, 1901.
Agent-General for Western Australia.

DEAR SIR,—In response to your valued instructions that I should report upon the merits of the Australian hard woods known as Karri and Jarrah, imported from Western Australia for paving purposes, I have pleasure in stating that for the eight years (1890 to 1898) I held the position of Chief Surveyor to the Vestry of St. Martin-in-the-Fields, Charing Cross, London, I had a very extensive experience in wood pavements under various conditions, and many kinds of timber were used by me, both experimentally and permanently, in street-paving works.

As a result of my tests, I invariably reported in favour of hard wood being used, and such streets as Coventry Street, Panton Street, Green Street, and Pall Mall East were laid with Karri or Jarrah wood.

FIRST TRIALS: *Jarrah.*—Before my appointment at St. Martin's, a trial piece of Jarrah was laid in the Strand for a length of about 30 yards, near the Exeter Hall. This was taken up solely on account of its having been laid on a bad foundation; consequently great difficulty was experienced in getting the authorities to adopt hard wood, and it was only after severe experiments on such places as the 'bus "pull up" in the West Strand (by Charing Cross Post Office) that the Paving Committee consented to pave any considerable area of carriage-way with this material.

Karri.—With reference to the above experiment opposite the West Strand Post Office, 6-inch Karri blocks were laid, half of them close-jointed and half open-jointed—*i.e.*, with ⅜-inch of cement forming the joint; the results were in favour of the close-jointed method.

This made me advocate the close-jointed system for hard wood in every case where it was laid, and from a sanitary point of view, as well as durability, it proved the best.

The requisite conditions for a good pavement are:—

1. Durability,
2. Cleanliness,
3. Freedom from noise,

and it is the difficulty in obtaining a material combining in a decided manner these qualifications that those responsible for the maintenance of our carriage-ways have to face.

MATERIALS USED.

Soft Woods.—It has been proved that the so-called "soft" woods fail in both durability and cleanliness, as their life is about six or seven years at the most, and the disintegration of the wood under traffic causes them to be continually in want of scavenging and also prejudicial to health, owing to the fine particles of dust and wood given off into the atmosphere.

The softer woods, as their name implies, do not present so firm a surface to the traffic; consequently they are somewhat quieter than the harder woods, and there is no doubt that this fact, in spite of all others, has been the cause of soft wood being so largely used.

West Australian Hard Wood.—I consider the West Australian timber that has been so largely imported into this country for paving works to be the best wood yet introduced. The difficulty in the past has, however, been in obtaining samples of the wood that have been properly prepared and seasoned, the early consignments sent into this country having been evidently pushed on the market without proper seasoning and due care given in their selection; and it was erroneously thought that the hard woods required little, if any, seasoning; consequently, although experimental areas were paved, and comparative tests made in the depôt with great success, it was found that failure arose in many instances where the wood was adopted for large areas, solely on account of its liability to shrink and expand when laid. The paving in Green Street, Leicester Square, may be cited as an instance; in this case the durability of the pavement was destroyed on account of the want of proper seasoning, as was proved by the large amount of expansion and contraction that arose.

METHODS OF LAYING BLOCKS.

My opinion is now, and has been for a considerable time, in favour of the West Australian woods for paving purposes; and, given a firm and even foundation—covered with 4-inch or 5-inch blocks, laid close-jointed, the blocks being dipped in a composition of pitch, tar, and creosote oil for the purpose of making a joint, and the wood thoroughly well seasoned—I am convinced a pavement can be made of hard wood more satisfactorily than of any other material.

Foundation.—I have heard it stated that the hard woods are liable to injure the concrete foundation by concussion in cases where they may become loose by contraction. This cannot possibly occur if the foundation be properly formed of cement concrete, and can only result where inferior materials have been used in the concrete, or where the traffic has been admitted before the concrete has properly set.

The foundation, it must be remembered, should be considered more carefully than the pavement, it being in my opinion the most important item in all paving works. I have seen instances innumerable where the paving material has been condemned solely by being on a bad foundation, instead of on a *solid* bed of cement concrete, floated to a true and even surface of the same contour as the proposed carriage-way.

CONDITIONS OF FAILURE AND SUCCESS.

And this brings me to an important factor in the life of all pavements, viz., the incessant breaking up of streets to lay new, or repair old, mains and

sewers under the streets. It would be just as reasonable to expect a severe wound to leave no scar as to expect a pavement to remain good after repeated disintegration and careless patching; and on this head alone it is next to impossible for anyone to form a fair estimate of the wear and tear of any material used in paving, by casual observation as is so often done.

The condition of the foundation as well as the method of laying must be known, in order to report fairly on any wood pavement, and it is utterly impossible to get good results from any material when the foundation is being continually cut up by gas, water, and other trenches.

Under these circumstances it is with the greatest caution that an opinion can be formed by observation of the surface, especially by the uninitiated, as so often occurs; and no opinion should be given, unless after lengthy tests and reliable statistics, which can only be obtained by time and close attention as to the behaviour of the materials.

Pall Mall East.—Pall Mall East may be cited as a street paved with hard wood that has been quoted as a partial success only. This street was paved with Karri wood in 1896: the present pavement has therefore been down about five and a half years. These blocks were originally only 4 inches thick, and have now worn down to about $3\frac{1}{2}$ inches, thus giving only half an inch of wear in five and a half years. The blocks have suffered from being unseasoned, and although they have worked loose in many places, the small amount of wear in the five years goes to support my opinion that most favourable and satisfactory results would occur if the material were left undisturbed—by anything beyond the traffic—and the wood thoroughly well seasoned; even as it is, the street can compare very well with any other class of wood which has been laid for the same time. The blocks were laid 4 inches thick (5 inches being the previous minimum), as I considered the quality of the material sufficiently good to warrant so shallow a depth, and the results have proved it to be so.

Shingling.—I am of opinion that it is of no value to spread ballast over a newly made hard wood pavement, but the material used for ordinary ballasting is a factor in the life of any wood pavement; I found the best to be crushed river ballast broken to pass a $\frac{3}{8}$-inch mesh.

CONCLUSION.

Although I am not now practising in an official capacity, I have watched with the keenest interest all that has been done in the paving of the metropolis, especially the West End; and were I again to advise a local authority, I should unhesitatingly report in favour of such woods as those imported from Western Australia.

As before stated, these woods have in several cases been looked upon as failures, owing to the material having been sent into this country without proper care in felling, seasoning, and selection.

I have the honour to be,

Your obedient servant,

CHAS. MASON,

President of the Society of Engineers, London, Assoc. M. Inst. C.E., Assoc. Royal Inst. of British Architects, Fellow of the Sanitary Institute.

REPORT OF MR. C. HARLOWE LOWE, M. Inst. C.E., late Borough Engineer, Hampstead.

30, Somerset Street,
Portman Square,
London, W.,
18*th December*, 1901.

Dear Sir,—In accordance with your instructions contained in a communication dated 9th October, 1901, I have to lay before you a Report with regard to the adoption and use of Jarrah wood paving in the Borough of Hampstead, having acted for the past thirty years as Engineer and Surveyor in that borough.

Wood Paving.—The first introduction of the subject of adopting some more permanent material than macadam for paving purposes, in the main thoroughfares of Hampstead, was recommended in my report of works required to be executed in the year 1878, but it was not till the year 1885 that the (then) Vestry adopted my recommendation. A contract was entered into in that year for the paving of No. 1 length of the High Road, Kilburn —from the "Queen's Head" public-house to Quex Road—with 5-inch deal blocks, laid plain and grouted in cement.

In 1886 a further portion of wood paving was suggested by me to be done, but the work was not extended till 1888, when No. 2 length of the High Road, Kilburn—from Quex Road to Willesden Lane—was treated the same as No. 1.

Six years elapsed before any further wood was laid, viz., 1892, when (No. 3 length) the High Road, Kilburn, from Willesden Lane to Netherwood Street, was laid with deals in a similar manner to Nos. 1 and 2. At the same time a short length of Jarrah blocks (5-inch) was laid as a test opposite the Kilburn Brewery, High Road. This was the whole length of High Road under the charge of the Hampstead authorities paved with wood, but it took from 1878 to 1892 to complete this much-needed improvement.

In 1891 the use of Jarrah wood was brought under the notice of the Vestry, and they were strongly urged to give it a trial; its suitability for street paving purposes being strongly supported by many engineers and surveyors.

During the year 1891 considerable expense was incurred in repairs of the deal blocks laid in 1885, in parts thoroughly worn out.

From 1893 to 1898 I was strongly urging the authorities to wood-pave the Belsize Road and other main thoroughfares, and give a trial to creosoted deal and Jarrah wood; loans being then granted by the L.C.C. as follows, viz. :—For deal, extending over 5 years; Jarrah, 7 years; asphalte, 5 years to 7 years; granite setts, 20 years.

Jarrah Wood Paving.—In 1893 No. 1 length (deal), laid in 1885 in the High Road, was found to be in a bad, and in some parts ruinous, condition. Extensive repairs were executed under contract by Messrs. Mowlem & Co., and continual attention was necessary until this length was relined with Jarrah wood blocks in 1894, and this was the first extensive work executed in Jarrah wood in Hampstead.

In 1897 the second contract, laid in 1888, was found to be in bad condition; considerable repairs were executed from time to time until relining with Jarrah wood blocks in 1899.

In 1900 the third contract length was found to be very defective, and it

was ordered to be relined with Jarrah in November of that year. In progress of the work the test piece of Jarrah (laid in 1892) was removed, with the result that after eight years' wear the block had only lost about $\frac{5}{8}$ths of an inch, whilst the deal blocks had lost $2\frac{3}{8}$ inches. The Jarrah was good enough for sale, and was eventually used to pave a mews.

In 1899 I was instructed to report upon the cost of paving with wood all omnibus routes throughout Hampstead district, and I then recommended the paving of about $2\frac{1}{2}$ miles in length with 4-inch Jarrah blocks. This work was carried out in 1901, and at the same time a sample of American Red Gum and White Oak blocks were laid for a short length in the Finchley Road near Adelaide Road. With these exceptions, and a few short lengths of plain and creosoted deals, the whole of the wood paving in Hampstead is of "Jarrah."

GENERAL OBSERVATIONS.

The first introduction of Jarrah wood into Hampstead was in laying the test length in 1892, removed in 1900 (as hereinbefore stated). The result of this test was to confirm the good opinion already formed as to the advantage of Jarrah wood for paving purposes, and led the authorities of Hampstead to adopt it throughout all future contracts (the identical wood blocks removed can be seen at my offices). The result of the test not only ensured the use of "Jarrah," but also warranted me in using a 4-inch in lieu of a 5-inch block; so that at the present time Hampstead has about five miles of 4-inch Jarrah laid in various parts.

Method of Laying Blocks.—In the first laying of Jarrah wood "screeds" were used of the width of three-sixteenths between each course. I have since abandoned this custom, and used them only where the steepness of the gradients demands it. The grouting was of refined boiled tar, flushed up with cement and shingle finishing. In the last contract the blocks were dipped in hot pitch one side and end only, just before laying, and I found this plan so far to answer well.

Supervision.—My experience of the use of "Jarrah" leads me to note that it requires considerable attention in frosty weather, and under other slippery conditions, and that on a continuance of very dry weather it is necessary to pay it more than ordinary attention by way of watering to tighten up the blocks; for, although Jarrah is decidedly less absorbent than most woods, it appears to be more readily affected by heat, and this may, to some extent, be attributable to the use of a shallow 4-inch block bringing the concrete foundation more under the influence of the sun and heat, thus warming the under surface of the blocks. I have also noticed that a length of Jarrah wood paving, taken as a whole, looks much better at the end of its second year of life than it does, say, at the expiration of the first six or twelve months after laying. This is attributable, partly, to the many small inequalities in the foundation, arising possibly from recent openings made in the thoroughfare, and, partly, to a few unequal blocks which may have been used. These defects are, of course, all remedied under the two years' maintenance clause usual in each contract.

Shrinkage and Foundation.—With regard to your enquiry as to the "shrinkage" of hard wood blocks rendering them loose, so much so that it was stated the result was a pounding of the bed of the foundation on which they rested, causing, ultimately, the breaking up of the concrete into a rough

powder, I may say that my experience does not generally support this conclusion. On a well made and consolidated concrete foundation no pounding of the surface of the concrete by heavy traffic upon loose blocks has been found to have taken place. In openings for trench work, it has been found that pounding has taken place after making good, but this has been in most cases attributable to imperfectly set concrete, and the work being hurried on to completion.

Provided the hard wood blocks are properly damped during a long continuance of dry weather, no difficulty in this respect may be anticipated, as far as my experience extends.

C. HARLOWE LOWE,
M. Inst. C.E., late Borough Engineer, Hampstead.

The Honourable H. B. LEFROY,
Agent-General, Western Australia,
15, Victoria Street, Westminster, S.W.

REPORT OF MR. P. H. PALMER, M. Inst. C.E., &c., Borough Engineer, Hastings.

The Hon. H. B. LEFROY,
Agent-General for Western Australia.

SIR,—As desired by you, I have much pleasure in submitting my views on Carriage-way Pavements.

CHOICE OF MATERIAL.—The choice of a suitable material for carriage-way paving is one fraught with many difficulties, and each case should be dealt with on its merits and left to a large extent to professional guidance. The choice of material must depend upon the nature of traffic using the road, climatic conditions—such as whether the road surface is subject to extremes of temperature, whether it is screened from or open to the sun's rays—and as to whether the street is flat or on a gradient.

NATURE OF TRAFFIC.—The nature of the traffic forms an important element in the choice of a material, and much depends on whether there is any or much 'bus traffic, as this is the most destructive and difficult to deal with. The width of the carriage-way must be taken largely into account as governing the weight of traffic per square yard of road surface, and the paving should be easily repairable where opened for water, gas, or other trenches.

It is not to be supposed I think for one moment that a material and method of laying which would be suitable in one case would be suitable in all. Busy streets in such cities as London, Manchester, Liverpool, Glasgow, and centres of very heavy traffic require special treatment, and should be dealt with apart from streets having what is usually termed ordinary traffic.

There are now so many various paving materials on the market, many of which are little known and have only been tried on comparatively a small scale, that I propose to confine my remarks to soft and hard woods.

SOFT AND HARD WOODS.

The two woods may be divided for commercial purposes into "soft wood," having a less specific gravity than 0·76 or a weight of 47 lbs. per cubic foot, and "hard woods"—those that go beyond this standard.

The absorptive power of wood has much to do with its durability, as the woody tissue is susceptible to decay when its condition fluctuates between wet and dry. The grain of soft wood is usually coarse and loose, and even when creosoted or treated with one or another of the various chemical processes in use, as soon as the surface has been frayed and torn, the protective power of the creosote or chemicals is at an end; the material then becomes porous and readily admits water.

Soft Woods.—An average dry soft wood block 9 in. by 4 in. by 3 in. will absorb as much as 10 to 12 oz. of water; whereas a hard wood block of the same size should not take up more than 2½ to 4 oz., according to the kind of timber from which the block is cut.

Soft wood as a paving material is usually cut from fir or pine; the Canadian pine being, in my opinion, the best in respect of toughness and uniformity of quality.

Soft wood as a paving material is not, I venture to assert, making much headway. It has been found in actual practice, even when creosoted, that owing to its coarseness of grain it takes up and holds a large amount of impurity due to the traffic and manure on the road. It is a difficult material to deal with in respect of expansion and contraction, and on the whole, whether creosoted or not, is much less sanitary than a hard wood paving.

Creosoted Soft Woods.—The use of creosoted soft wood in very sunny localities would be attended with trouble, owing to the creosote being drawn out of the wood and forming a coating on the surface which would be sticky and difficult to remove, and give off a strong smell, and render the surface of the road most difficult to clean.

Life of Soft Woods.—With regard to the life of soft wood paving, this appears to vary very considerably in different places. There are instances where soft wood appears to have only lasted a very few years, and others where it has lasted for seven to twelve and fourteen years. This, of course, may be due to a combination of circumstances, such as the nature of the traffic, width of the roadway, and principally on the careful selection and laying of the blocks. It does not, however, seem to be in use to any very large extent in the London boroughs, with the exception of one.

Hard Woods.—In Paris and the leading Continental cities hard wood is being laid in preference to soft; and I think the life of the two may be pretty well gauged from the fact that the Local Government Board will only allow a period of five years for the repayment of a loan on soft wood, whereas they allow ten years in the case of hard wood.

With regard to the choice of a hard wood for street carriage-way paving, I am of opinion that very great care should be exercised in this matter, and it is extremely necessary that all hard wood blocks should be most carefully inspected, and any defective blocks should be rejected; and I think there is no better or more suitable wood imported into this country than the West Australian hard woods.

West Australian Hard Woods.—The quality and description of West Australian hard woods are now thoroughly well known, and they have been tried in many towns in England and abroad, and in the majority of cases have given satisfaction. Hard wood certainly is not more slippery than soft wood when wet. It is also non-absorbent, which renders it easier and cheaper to keep clean than soft wood, and causes it to dry more quickly.

The wear of hard wood is trifling compared with that of soft wood, and there are numerous instances where special tests have been made, and the results arrived at show that a much longer period than ten years can be taken for the life of a good hard wood paving.

METHOD OF LAYING BLOCKS.

FOUNDATION.—Whatever the wood which may be used, its life depends to a very large extent on the manner and care with which the foundation is laid. The materials for the concrete must be of the best; they must be properly gauged and laid, and given sufficient time to become hard before the traffic is allowed to go on the surface of the road. The screeding coat or rendering must be properly finished so as to make it perfectly true and give an even contour to the road. This should be swept perfectly clean before the blocks are laid upon it.

LAYING.—The blocks should be laid as close as possible and well driven together, and then grouted in with a mixture of creosote oil, pitch, and tar. This composition should be put on as near boiling as possible, and well worked into the joints between the blocks with squeegees.

INSPECTION OF BLOCKS.—The paving blocks should be most carefully looked over and all unsound or doubtful ones thrown out, and the blocks should be neither too dry nor too wet when laid. The traffic should then be kept off the surface of the road until the concrete has been laid at least seven days. The thickness of concrete will of course vary according to the nature of the subsoil or the class of traffic which will use the road. It is usual for the concrete not to have a less depth than 6 inches, varying up to 9 and 10 inches in depth.

RESULTS IN HASTINGS.

A very considerable quantity of West Australian hard wood has been laid in Hastings, some of it having been laid for six years, which is still in perfect order and repair. Some of the first paving laid was laid with ½-inch joints and grouted in with cement; and several test blocks taken up from this piece are not in as good a condition as those which were taken up where perfectly close joints and bitumen grouting had been used.

WOOD PAVING IN LONDON.

I have seen a considerable amount of wood paving laid in London, and I am of opinion that in many cases it has not lasted as long as it should have done owing to the fact that the concrete is both poor and had not become sufficiently hard for the traffic to be turned over the road. This, of course, allows the surface of the road to become uneven, and a corduroy surface is soon made and the blocks damaged.

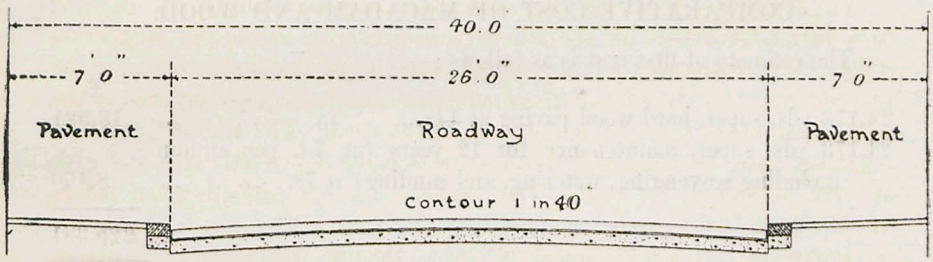
P. H. PALMER,

Memb. Inst. C.E., Memb. Incp. Society of Municipal Engineers, &c.

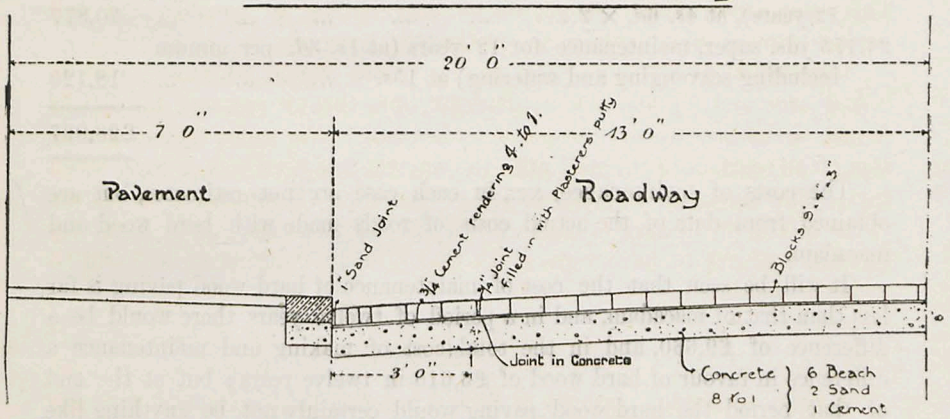
METHOD OF LAYING WOOD PAVING AT HASTINGS,

Adopted by Mr. P. H. PALMER, Borough Engineer.

Cross Section of Roadway



Half Cross Section of Roadway



[Specially prepared for *The Street* by Mr. P. H. PALMER.]

Extract from recent Report of Mr. PALMER on the "Comparative Cost of Macadam and Wood" (Jarrah), as given in *The Street* for May, 1902.

A macadam road metalled with 4 in. of granite and finished with siftings would be quite worn out in six years, whereas a hard-wood paved road, judging by the rate of wear in Queen's Road, will last twenty years; for the purpose of this report I have only taken a period of twelve years, covering only the period for which a loan could be raised for the work; and it must not be lost sight of that no loan could be obtained for remaking the road with macadam.

I have for the purposes of the estimate taken the whole of the roadway from the west side of Warrior Square to Grosvenor Gardens. The total area of roadway is 24,173 square yards, and during a period of twelve years this would have to be remetalled twice; this, in itself, causes a large amount of inconvenience to residents, and wherever trenches are cut into the road they

remain unsatisfactory for some time, and largely help to make the surface of the roadway bumpy and uneven. Wood paving is the most easily repaired of any road surface, and as instances of the satisfactory way in which trenches can be repaired, I would point to those recently cut through it at Warrior Square and Robertson Street; it is difficult even to see where they were.

COMPARATIVE COST OF MACADAM AND WOOD.

The estimate of first cost is as follows :—

	£
24,173 yds. super, hard wood paving at 14*s*....	16,921
24,173 yds. super, maintenance for 12 years (at 7*d*. per annum including scavenging, watering, and sanding) at 7*s*.	8,460
	£25,381
24,173 yds. super, granite macadam, 4 in. thick (metalled twice in 12 years), at 4*s*. 6*d*. × 2....	10,877
24,173 yds. super, maintenance for 12 years (at 1*s*. 3*d*. per annum including scavenging and watering) at 15*s*.	18,120
	£28,997

The costs of maintenance, &c., in each case are not estimates, but are obtained from data of the actual costs of roads made with hard wood and macadam.

It will be seen that the cost of maintenance of hard wood paving is far less than that of macadam, and in a period of twelve years there would be a difference of £9,660, and in the total cost of making and maintenance a difference in favour of hard wood of £3,616 in twelve years; but at the end of that period the hard wood paving would certainly not be anything like worn out.

There is another point I should like to bring forward—that when the wood blocks are worn out the concrete would be sound, and the roadway could be relaid with new blocks at a cost, on present prices, not exceeding 7*s*. 6*d*. per yard super; or whatever material might be considered the proper one to use then, the foundation would be there, and a good foundation is essential, no matter what material may be used.

The noise arising from traffic on a hard wood pavement is not greater than on a macadam road, but of a different nature; and I have not heard of any complaints from visitors or residents in houses in Eversfield Place in this respect; but, on the other hand, have heard many residents and visitors express satisfaction in respect of the wood pavements.

NOTE.—The period granted by the Local Government Board, at present, for the repayment of loans on hard wood paving, is 10 years; but the Hastings Corporation, on the recommendation of Mr. Palmer, applied for an extension of the time to 12 years, and their application has been granted. It is expected that 20 years will be given for the repayment of the loan on the concrete foundation, which would make an "equated period" of from 14 to 15 years on the whole work.

REPORT ON THE HYGIENIC CHARACTER OF WOOD PAVING.

THE Chemical and Bacterial Examination of various Wood Pavings used in the London Streets. By JOHN NORTON, M.D., D.P.H. (Lond.), M.R.C.S. (Eng.), late Medical Officer of Health for Westminster, &c.; and H. WILSON HAKE, Ph.D., F.I.C., F.C.S., Lecturer on Chemistry at the Westminster Hospital Medical School, London.

To the Hon. H. B. LEFROY,
Agent-General for Western Australia.

DEAR SIR,—We propose in the following paper to place on record a statement of facts relative to the chemical and bacterial examination of various wood pavings taken from the London streets, as offering a fair test of gauging the extent to which wood pavements become contaminated after exposure to a traffic greater than that of any other city in the world.

GENERAL REMARKS.

Before doing so, we should like briefly to call your attention to the causes of the number of failures of making wood paving a reliable paving after it has been laid down some time.

The chief causes of failures are due, firstly, to the concrete on which the blocks are laid being of bad quality and of insufficient thickness, and of not being allowed to thoroughly set before the wood is laid down; secondly, to the indifference with which wood blocks are selected: all the blocks should be properly prepared and thoroughly seasoned, and should be pressed together as closely as possible, and grouted with a substance suitable to the kind of wood which is being laid down.

In the next place, we beg to refer to the state in which the pavings are kept after being laid down. Every morning they should be thoroughly watered, and the surface well cleaned with a broom, and in the hot weather some disinfectant should be added to the water.

If the wood is not well brushed and watered, particles of horse dung and other *débris* remain on the surface, and with the sun and rain decomposition soon sets in and gives rise to the smells which are attributed to wood pavings only, but which apply equally well to asphalte, as the heat radiating from the asphalte sends all the obnoxious fumes into the atmosphere, and in addition you get the smell of the asphalte itself, especially in hot weather, when it is most disagreeable.

WOODS MOST SUITABLE FOR WOOD PAVING.

Mons. Petsche, in his able work "Le Bois et ses Applications au Pavage," states that "from the examination of the different elements of foliaceous

woods the following conclusions may be drawn," and says the best woods for paving will be those which have

(1) "The fibres predominant, long, in sections variable but rounded, with no lumen at all, or only a narrow one, with thick partition walls—grouped in bundles numerous and compact without being in definite rows. The characteristics relating to the fibres are by far the most important.

(2) "The vessels of small diameter, few in number, with thick partition wall equally divided, especially over the enlargements.

(3) "A parenchyma vertical—not very abundant, long, with thick partition wall, and distributed in thin lamellæ between the groups of fibres.

(4) "The medullary rays narrow and short.

(5) "The intercellular masses thin and without channels.

"These anatomical characters are more or less found together in exotic woods which have been tried for wood paving. They furnish for the few woods (viz., Karri, Jarrah, Liem, Teak, Ironwood, and a few others) which have been studied, a classification which coincides with that furnished by physical experiments."

OBJECTIONS TO SOFT WOODS FOR PAVING.

Soft woods have been used mostly in London on account of their being less noisy under traffic than the hard woods, but the chief objection to them is that they wear away much quicker than the hard woods. They are much more absorbent, and consequently soak up all the sewage in the streets, owing to their fibres being coarse and long; and owing to the wearing away of the fibres in hot weather innumerable particles of dust and *débris* ground down under the wheels of the traffic are thrown into the air. Moreover, they are not so easily cleansed as the hard woods. Creosoted deal, which is supposed to make the deal last longer and to be more hygienic, does not under chemical examination come out well. The creosote gets worked out of the wood, making the wood greasy and slippery, and as the creosote works out the water works in. It is, however, generally supposed to be more easily cleansed than ordinary deal.

PLACES IN LONDON FROM WHICH THE WOOD BLOCKS WERE TAKEN FOR EXAMINATION.

For Chemical Examination.

Deal (1890).—"Deal block from Malden Road, St. Pancras; laid in 1890. Original depth, 6 inches; present depth, 4½ inches; taken up 4/1/02." Weight, 1,504 grammes.

Karri (1893).—"5-inch Karri block; taken opposite 85, Park Street, Regent's Park; laid April to June, 1893. Present average depth, 4¾ inches." Weight, 2,280 grammes.

Jarrah (1894).—"Jarrah block from Euston Road; heavy fast traffic;

cement joint, laid in 1894; average depth, 3 inches in line of traffic." Dimensions, $8\frac{3}{4}$ inches by $2\frac{3}{4}$ inches by $2\frac{1}{4}$ inches; weight, 900 grammes.

American Red Gum (July, 1899).—"Red Gum block taken from Bridge Street, Westminster Bridge; laid July, 1899." Weight, 1,520 grammes.

Creosoted Deal (Sept., 1899).—"High Street, Notting Hill, by Pembridge Road; creosoted wood laid September, 1899; 5 inches deep when laid." Weight, 1,507 grammes.

For Bacterial Examination.

Karri.—Laid December, 1891; taken from Gloucester Bridge; 5 inches when laid, now $4\frac{5}{8}$ inches.

Jarrah.—Laid August, 1894; taken from Albany Street, Regent's Park.

American Red Gum.—Laid July, 1899; from Bridge Street, Westminster Bridge; $\frac{1}{4}$ inch of block worn away.

Creosoted Deal (10 lbs. creosote to cubic foot under pressure).—Laid September, 1893; 5 inches deep when laid, now 3 inches only; from High Street, Notting Hill.

Deal.—Laid September, 1879; 5 inches when laid, now $2\frac{1}{2}$ inches; taken from Grafton Street, by University College Hospital.

PHYSICAL PROPERTIES OF THE WOODS EXAMINED.

Karri (*Eucalyptus diversicolor*) is a hard, heavy, pale red wood, with very little absorptive power; the fibres are strongly interlaced, and it is of great tensile strength. It contains tannin and other gum resins.

Jarrah (*Eucalyptus marginata*) is a heavy hard wood slightly redder in colour than Karri. It has very little absorptive power, and is very durable and tenacious; it is consequently an excellent wood for paving. It also has considerable natural antiseptic properties, containing a red resin (red kino), 4 to 5 per cent. of kino-tannin, and a particular vegetable acid, viz., oxalic, which is particularly disagreeable to the various forms of insects (ants, wood beetles, &c.) which generally infest woods; and this property alone renders it a very valuable wood.

American Red Gum (*Liquidambar styraciflua*) is a softer wood of a more fibrous nature, but heavy, hard, and tough. It also contains a particular gum resin.

Deal and Creosoted Deal.—The properties of this soft resinous wood are well known and need no description. The creosoted deal is merely deal wood with 10 lbs. of creosote to a cubic foot of wood, pressed into the wood under great pressure.

NATURE OF SUBSTANCES ABSORBED INTO THE WOOD PAVINGS OF STREETS.

The London streets may be compared to a huge stable almost Augean in its character, the cleansing of which is dependent, firstly, upon Nature in the shape of rain, and, secondly, on the more or less effective sweeping and washing directed by the various municipal bodies.

As the major part of the contamination is due to horse manure and urine, it will be of use to note the following figures relating to analyses of these substances.

ANALYSIS OF HORSE MANURE.

Water, 67·28% to 73%.
Dry matter, 32·72% to 27%.

Among the constituents of the dry matter we may note :—

Phosphoric acid, 0·35% to 0·49%.
Total nitrogen, 0·47% to 0·8%.

URINE OF HORSES.

Water, 39%.
Dry matter, 11%.

Among the constituents of the dry matter we may note :—

Urea (46·6% nitrogen), 3·10%.
Hippuric acid (8% nitrogen), 0·47%.
Chloride of sodium, 0·07%.

In the case of asphalte it is claimed that these sewage matters do not penetrate the surface ; but, on the other hand, they are too often left upon the surface to undergo their various stages of putrefaction.

In the case of wood paving a certain amount of these sewage matters must be absorbed, and it seems only a fair assumption that the particular kind of wood which will absorb least, or which, after absorption, will cause the greatest destruction of objectionable constituents, whether by aerial oxidation, or from the inherent property of the natural constituents of the wood—such wood must be considered relatively superior from a hygienic point of view.

CHEMICAL EXAMINATION OF WOOD BLOCKS.

On this assumption we have made our experiments, and have examined each block under *strictly identical conditions*, which may be briefly summarised as follows :—

Each block was split down the centre with a heavy chisel, and a number of coarse shavings from each separated portion was obtained ; these were afterwards reduced to a finer state of division by means of a sharp knife, care being taken to avoid any of the actual roadway material, which in some cases still adhered to the block. A fair proportion (in all cases the same) of these parings was taken and extracted with pure distilled water free from ammonia, during forty hours, in a stoppered glass vessel, at ordinary temperature. The "aqueous extract" thus obtained was then rapidly filtered and submitted to analysis. Another portion was used for the determination of moisture by drying at 120° C. until constant.

From the general statement made above as to the chemical composition of horse manure and urine, it will be obvious that nitrogenous organic matter

takes first rank as an objectionable constituent from a hygienic standpoint. The so-called *albumenoid ammonia* expresses the proportion of nitrogenous organic matter. The free ammonia, which is of less importance (unless very excessive), may be due on the one hand to rain, or on the other to decomposition of nitrogenous organic matter. The chloride (present as common salt, in itself harmless) also points to animal origin, and a large proportion must be viewed as indicating contaminations.

Nitrates are due to the oxidation of ammonia, and must also be regarded with suspicion, if excessive.

The term "oxygen absorbed" refers to the deoxidising action of the organic matter on a solution of permanganate of potash (the strength of which has been accurately determined), and has a definite relation to the organic matter present. Sulphates and phosphates are always present in sewage matter. With these explanations the table of analytical results on the page below of this Report will, we think, be rendered intelligible, and hence the deductions we have drawn from them, so far as justifiable, will be clear.

Taking albumenoid ammonia and chlorine, therefore, as the most objectionable constituents, and next in order of objection nitrates and oxygen absorbed, then, judged by this criterion, we arrive at the following classification :—

ANALYSIS OF AQUEOUS EXTRACT* OF VARIOUS PAVING BLOCKS AFTER USE IN TRAFFIC.

Description of Block:	Karri. 1893.	Jarrah. 1894.	Red Gum. 1899.	Deal. 1890.	Deal Creosoted. 1899.
Ammonia . . .	·0008	·0016	·00016	·00016	·00112
Albumenoid ammonia	·00113	·00145	·00140	·00103	·00314
Chlorides . . .	·020	·048	·072	·1	·028
Nitrates	·0029	·0037	·0030	·0116	·0038
Oxygen absorbed from permanganate	·158	·303	·232	·048	·588
Sulphates . . .	slight traces	strong traces	strong traces	strong traces	minute traces
Phosphates . . .	slight	minute traces	nil	nil	slight traces
Total solids in solution . . .	·32	·58	·68	·70	·74
(*a*) Organic. . .	·24	·41	·51	·40	·63
(*b*) Inorganic . .	·08	·17	·17	·30	·11

DETERMINATION OF MOISTURE* IN BEFORE-MENTIONED BLOCKS.

Description :	Karri.	Jarrah.	Red Gum.	Deal.	Deal Creosoted.
Moisture. . . .	23·13	24·71	33·11	32·41	31·11

* The figures given represent the quantities present in 100 parts by weight of wood.

In other words, judging from the analytical results, we place Karri in the first rank, Jarrah in the second rank, and Red Gum in the third rank, while Deal and Creosoted Deal constitute a fourth class in order of efficiency. It seems apparent that, however excellent the creosote may be in preserving the wood, it does not appear to affect the sewage absorption.

This general classification is in fairly close agreement with the relative absorptive power of the woods, as indicated by the moisture contained in them, and with the total solids extracted by water.

One objection that might obviously be raised at first sight, is the considerable difference in the dates at which the blocks examined were laid ; but on careful consideration of the figures this objection disappears, inasmuch as the Creosoted Deal and Red Gum were laid within three months of one another in 1899 and differ considerably on analysis, while Karri, which was laid in 1893, shows a better condition than either Red Gum or Creosoted Deal.

A further objection might be raised as to the selection of the blocks from different localities ; but this is, firstly, unavoidable ; and, secondly, we have every reason to believe that great care was exercised in order to make a fair selection.

A third objection might be suggested against one block only being taken. In reply to this, the only other possibility would be experiments on a greatly extended scale ; but though a better general average might be thus obtained, we doubt whether much, if any, difference would result.

Bacterial Examination of Woods.

Here again, as in the chemical examination of the five woods mentioned, Karri and Jarrah hold first and second place respectively from a hygienic point of view ; for, considering the comparative rarity of attacks of tetanus, malignant œdema, and glanders in the human subject, the least harmful specimens of wood are those containing the smallest number of streptococcus and staphylococcus organisms known to be pathogenic and to be causally connected with many diseases. It will be observed that from a hygienic point of view Red Gum is at the bottom of the list.

Control Experiments with Unused Woods.

The five woods in an unused state were first tested to see if any organisms were present.

Five guinea pigs were inoculated with emulsions of the unused woods made with sterile saline. In every case no local lesion developed, and no ill effects followed.

Experiments with the Five Used Woods.

1. Karri Wood (used).—Inoculated small rabbit and also a guinea pig with a broth culture of the used wood. The guinea pig died, and the rabbit was killed subsequently. Cultures made from these animals showed the presence of : Glanders ; Streptococci ; Staphylococci ; Bac. Coli. Communis ; Sarcina.

2. Jarrah Wood (used).—Inoculated guinea pig with emulsion of used wood. The guinea pig died, and cultures made from the pus obtained showed

the presence of: Glanders; Staphylococci; Tetanus; Bac. Coli. Communis; Sarcina.

3. Deal Wood (used).—Inoculated two guinea pigs. Neither pig died. They were subsequently killed, and examination of cultures showed the presence of: Glanders; Streptococci; Staphylococci; Torula and Sarcina; Bac. Coli.; Bac. Proteus.

4. American Red Gum Wood (used).—Inoculated two guinea pigs. Both pigs died. One of these pigs was very thin and emaciated. The spleen contained a few small tubercles, but careful examination failed to demonstrate the presence of the Bacillus Tuberculosis. Cultures made from these animals showed the presence of: Bac. Œdematis Maligni; Streptococci; Staphylococci; Bac. Proteus; Bac. Coli.

5. Creosoted Deal Block (used).—Inoculated guinea pig and rabbit with emulsion of used deal block. Guinea pig died, and the rabbit subsequently died. The results of cultures obtained from these animals were as follows: Glanders; Anthrax; Streptococci; Staphylococci; Bacillus Subtilis; Sarcina.

In the above examination the number of organisms obtained from the used Karri wood was far less than in any other case.

Taking a final classification of the hygienic character of the woods, both as regards the number of organisms and the importance of the organisms, Karri was found to be best, Jarrah the next best, Creosoted Deal the next, Deal next, and American Red Gum last and the least hygienic.

Both the chemical and bacterial examinations of the five woods have therefore without a doubt demonstrated that Karri and Jarrah stand in the first and second ranks respectively as the most hygienic woods used for wood pavings, and these two woods are much less absorptive than any other woods yet used in the streets of London. Moreover, they possess, especially Jarrah, those natural antiseptic properties which are so essential for woods exposed to decomposing substances.

(Signed)

JOHN NORTON.
H. WILSON HAKE.

54, Queen Anne's Gate, Westminster,
April 28th, 1902.

REPORT ON CERTAIN VIAGRAPH TESTS, BY MR. THOS. AITKEN,

A.M. Inst. C.E., author of "Road Making and Maintenance," County Surveyor, Cupar-Fife, and President of the Road Surveyors' Association, Scotland.

To the Hon. H. B. LEFROY,
Agent-General for Western Australia,
15, Victoria Street, Westminster.

SIR,—I have the honour to submit my Report of certain Viagraph Tests taken in various London thoroughfares in February last, according to your instructions of the previous month. The Report would have been submitted earlier, but I have been waiting for some items of information with regard to the methods adopted in laying the wood blocks, description of joints, &c. THE VIAGRAPH gives an autographic record of the unevenness of the surface of streets; the contact parts, for recording, being a slider and a road-wheel, with a numerical index for each. *The slider* is a segment of a circle representing the rim of a carriage wheel having a diameter of 40 inches. It gives, therefore, a record of unevenness of any part of a roadway traversed by a vehicle having wheels of that diameter. The *wheel of viagraph* (6 inches diameter), acting as the road-wheel for working the mechanism, is serrated, and therefore penetrates any moderately hard material or foreign matter on the surface of a road. It likewise takes account of very minute irregularities of surface, including the joints of wood or of sett-paved streets. The *viagram* shows the profile of the road surface. It is full size vertically, and on a scale of the eighth of an inch to a foot horizontally. The unevenness recorded in the indices of the viagraph is in feet per mile of carriage-way. The length of road operated on in each test is the twentieth part of a mile, or 88 yards.

The nearer *the numerical indices* of the slider and wheel agree, the more perfect is the surface of the street, so far as smoothness is concerned; that is, the more irregular the surface, the greater will be the difference in the indices and the higher the numerical record of unevenness. This irregularity of surface, in the case of wood-paved streets, is brought about through various causes, such as badly cut blocks, defective laying, wide or irregular joints, and, of course, the continual wear incidental to all descriptions of pavement.

The streets examined in the districts of Battersea, Camberwell, Lambeth, St. Pancras, and Southwark, and the particular sections of the roadway, in each case, were selected by the Borough Engineers or their deputies, who accompanied me in the course of the operations, and were regarded as a fair average, for the time laid and the class of traffic, of their particular districts. The miscellaneous tests were made with a view to widen the area of comparison.

For convenience of arrangement and of reference, I have given the details of the carriage-ways tested, including such particulars as I have been able to obtain as to description of material, methods of forming joints, &c., and the numerical indices of unevenness, in tabular form.

BATTERSEA.

No. of Test.	Name of Carriage-Way.	Description of Pavement.	Method of Forming Joints.	Date when Laid.	Nature of Traffic.	Width of Street.	Index of Unevenness in ft. per mile.		Remarks.
							Slider.	Wheel.	
1	Bridge Road, from Prince of Wales Road, east side, 6 ft. from kerb, going southwards.	Karri	Joints laid close in pitch, and grouted with cement.	June, 1899.	Heavy. 'Bus and general.	35 ft.	9·8	17·2	Surface slightly covered with mud.
2	Battersea Park Road, from Bullen Street, north side, 5 ft. from kerb, going eastwards.	Creosoted Deal.	Ditto	1895	Heavy and continuous. 'Bus and general.	31 ft.	58·05	63·8	Ditto.
3	St. John's Road, from Comyn Road, west side, 5 ft. from kerb, going northwards.	Karri and Jarrah	Ditto	1897	Heavy and continuous. 'Bus and general.	26 ft.	11·6 8·0	21·0 17·0	Ditto.

CAMBERWELL.

4	Peckham Road, opposite Town Hall, midway between kerb and tram-rail, going southwards.	Haskinised Deal and Jarrah	Dipped, laid close, and grouted with cement.	Dec., 1899.	Heavy and continuous. 'Bus and general.	32 ft.; double line of tram-lines in centre, margins only paved with wood.	16·4 13·2	27·0 24·0	Surface slightly covered with hardened mud, owing to recent light frost.
5	Havil Street, off Peckham Road, 5 ft. from kerb, north side, going eastwards.	Creosoted Deal.	Ditto	Dec., 1899.	Fairly heavy and continuous.	18 ft.	12·25	17·3	Ditto.
6	Camberwell Road, from Avenue Road, west side, midway between kerb and tram-rail, going northwards.	American Red Gum, Jarrah	Ditto	1901	Heavy and continuous. 'Bus and general.	40 ft. between kerbs; double line of trams in centre; 16 ft. between kerb and line of trams.	13·2 11·29	27·98 17·7	Ditto.

LAMBETH.

No. of Test.	Name of Carriage-Way.	Description of Pavement.	Method of Forming Joints.	Date when Laid.	Nature of Traffic.	Width of Street.	Index of Unevenness in ft. per mile.		Remarks.
							Slider.	Wheel.	
7	Tyers Street, Vauxhall, from Prince's Road, east side, 5 ft. from kerb, going southwards.	Jarrah	Dipped one side and one end in thin mixture of pitch. Close joints. Thin fluid mixture of cement grout swept over surface when laid.	June, 1901.	General	25 ft.	9·5	13·5	Light covering of hardened mud.
8	South Lambeth Road, from Park Mansions, east side, 2 ft. from kerb, going southwards.	Karri	Ditto	June, 1899.	Heavy and continuous. 'Bus and general.	30 ft.	13·1	17·8	Ditto.
9	Clapham Road, from South Lambeth Road, west side, 5 ft. from kerb, going northwards.	Jarrah	Open joints, grouted with cement.	1895	'Bus and general	40 ft.	18·1	42·1	Surface covered with hardened mud. Slider record not reliable.
10	Ackerman Road, from Arthur Road, west side, 3 ft. from kerb, going northwards.	Jarrah	As above	1901	'Bus and general	25 ft.	10·3	13·5	Light covering of hardened mud.

ST. PANCRAS.

No. of Test.	Name of Carriage-Way.	Description of Pavement.	Method of Forming Joints.	Date when Laid.	Nature of Traffic.	Width of Street.	Index of Unevenness in ft. per mile.		Remarks.
							Slider.	Wheel.	
11	Pancras Road, by Goldington Crescent, from opposite Infirmary, west side, midway between kerb and tram-rail, going northwards.	Jarrah	$\frac{1}{10}$" to $\frac{1}{8}$" joint, grouted with pitch and creosote oil.	Aug., 1892.	Heavy and continuous. 'Bus and general.	35 to 45 ft.	46·75	104·0	Slightly covered with mud. Test taken during heavy rain.
12	Hampstead Road, north end, east side, 5 ft. from kerb, going southwards.	Jarrah	Ditto	April, 1900.	Medium to heavy	45 ft.	9·0	9·0	Surface clean. Test taken during heavy rain. Trench crossing in this test; reinstated work not so good as original. This part having been eliminated, gives result as shown.
13	Ampthill Square, north-west side, 4 ft. beyond centre of roadway, west side, going southwards.	Macadam	—	(Repaired) Sept., 1900.	Light general	30 ft.	57·75	125·0	In this test the index of unevenness is excessive, owing to the comparatively bad condition of the macadam and soft wood at each end. This viagram demonstrates, where depressions of considerable depth exist, the great irregularities arising from the use of materials of so widely different a character.
		Jarrah	$\frac{1}{10}$" to $\frac{1}{8}$" joint, grouted with pitch and creosote oil.	March, 1900.			32·37	42·43	
		Plain Deal	$\frac{1}{2}$" joints, filled with Portland cement grout.	1888			58·00	89·38	
14	High Street, Camden Town. No. 29, midway between kerb and tram-rail, going northwards.	Jarrah	$\frac{1}{10}$" to $\frac{1}{8}$" joint, grouted with pitch and creosote oil.	Aug., 1901.	Medium. 'Bus and general.	50 ft.	10·3	14·0	Surface clean. Test made during heavy rain.

SOUTHWARK.

No. of Test.	Name of Carriage-Way.	Description of Pavement.	Method of Forming Joints.	Date when Laid.	Nature of Traffic.	Width of Street.	Index of Unevenness in ft. per mile.		Remarks.
							Slider.	Wheel.	
15	Trinity Street, from Swan Street, north side, 5 ft. from kerb, going eastwards.	Jarrah	$\frac{3}{16}$" joints, filled with Portland cement grout.	August, 1898.	Comparatively light. General.	30 ft.	7·2	12·7	Surface very clean. Test made during heavy rain.
16	Kennington Pk. Road, from St. Mary's Church, north side, midway between kerb and tram-rail, going north-east.	Creosoted Deal.	$\frac{1}{8}$" joint, filled with Portland cement grout.	1898	Heavy and continuous. 'Bus and general.	30 ft.	42·0	56·7	Covered with mud in liquid state. Test made during heavy rain.
17	Blackfriars Road, from opposite stage entrance to Surrey Theatre, west side, midway between kerb and tram-rail, going northwards.	Jarrah	Close joints, grouted with pitch.	1899	Heavy and continuous. 'Bus and general.	32 ft.	15·8	19·7	Ditto.

MISCELLANEOUS TESTS.

WESTMINSTER.

18	Bridge Street, from Parliament Street, north side, 8 ft. from kerb, going eastwards.	American Red Gum,	Close joints, grouted with pitch.	1899	Heavy and continuous. 'Bus and general.	—	31·9	48·8	Surface slightly covered with mud.
		American White Oak,					30·58	47·25	
		Jarrah (4" Dowelled, Duffy's Patent)					25·23	35·75	
		Creosoted Deal.					33·77	41·41	

MISCELLANEOUS TESTS—*continued.*

No. of Test.	Name of Carriage-Way.	Description of Pavement.	Method of Forming Joints.	Date when Laid.	Nature of Traffic.	Width of Street.	Index of Unevenness in ft. per mile.		Remarks.
	WESTMINSTER—*contd.*						Slider.	Wheel.	
19	The Strand, Charing Cross Post Office, north side, 5 ft. from kerb, going northwards.	Creosoted Deal.	Close joints, grouted with pitch.	Jan., 1902.	Very heavy and continuous. 'Bus and general.	—	20·3	29·2	Surface clean.
20	Great George Street, from opposite entrance to Inst. C.E., north side, 5 ft. from kerb, going eastwards.	American Red Gum.	Ditto	Sept., 1901.	Light	—	19·81	24·81	Ditto.
21	Broad Sanctuary	Asphalte	—	—	Very light	—	7·85	7·85	Ditto.
22	Lower Regent Street, from opposite York House, west side, 9 ft. from kerb, going northwards.	American Red Gum.	Close joints, grouted with pitch.	Nov., 1900.	Heavy. 'Bus and cab.	—	42·68	74·0	Surface slightly covered with mud.
23	Pall Mall, S.W., from line of kerb, west side of Waterloo Place, 10 ft. from kerb, going north-eastwards.	Karri	Ditto	1896	Medium to heavy. 'Bus and cab.	—	34·8 (Average.)	52·1 (Average.)	Surface clean. The first portion of the viagram shows a good and regular surface (traffic medium); the eastmost portion is somewhat irregular: this is where the heavy traffic from Waterloo Place joins this thoroughfare.
24	Eaton Square, south side, 5 ft. from kerb, going westwards.	Sanitary blocks.	—	Recent	Medium	—	20·7	31·5	Surface covered with mud in liquid state.

MISCELLANEOUS TESTS—*continued.*

No of Test.	Name of Carriage-Way.	Description of Pavement.	Method of Forming Joints.	Date when Laid.	Nature of Traffic.	Width of Street.	Index of Unevenness in ft. per mile.		Remarks.
							Slider.	Wheel.	
25	FULHAM, New King's Road (opposite 311 to 313), from Ashington Road, centre of street, going eastwards.	Creosoted Deal, Do.(Dowel'd), Creosoted Deal.	Close joints, run with pitch, and grouted with cement and sand.	Mar., 1894.	'Bus and general. Heavy.	34 ft.	32·85 24·00 33·66	41·12 29·33 38·39	Surface slightly covered with mud.
26	KENSINGTON, High Street, opposite Railway Station, north side, 5 ft. from kerb, going north-eastwards.	Creosoted Deal, American Red Gum, Creosoted Deal.	Close joints, grouted with pitch and tar.	Sept., 1899.	Ditto	—	31·90 75.68 35·20	44·22 93·2 50·75	Surface covered with liquid mud. The centre of this carriage-way, especially where American Red Gum is laid, is much worse than where tested.
27	VICTORIA EMBANKMENT, from Charing Cross Railway Bridge, north side, 12 ft. from kerb, going eastwards.	Macadam	—	Repaired Feb., 1902 (Rolled.)	Cab	—	49·6	151·0	
28	Ditto, ditto, continuation of above	Ditto	—	Ditto	Ditto	—	46·3	177·75	

NOTE.—In the instances given above where the carriage-ways were somewhat hardened by frost, the exact contour could not be obtained, but this does not interfere with the relative value of the tests for the roads themselves. In all other cases the tests were complete, as the existence of liquid mud is no detriment to the operations of the machine; indeed, the best results on paved streets are often obtained in wet weather.

A scale of unevenness cannot at present be given, as many other experiments on wood and other materials for paved streets require to be made before obtaining a "standard surface." The scale for macadamised roads adopted in the treatise on "Road Making and Maintenance" was obtained after a number of experiments with the old form of viagraph, and is not comparable to that obtained with the present viagraph, which also gives a more accurate and detailed profile.

GENERAL REMARKS AND CONCLUSIONS.

It will be observed, from the viagrams and the records of unevenness, that the regularity and consequent smoothness of the surface of the streets examined vary in a remarkable degree. To determine the bearing of these variations on the subject in hand, and the relative wear of wood and other paving materials, consideration must be given to the length of time the respective pavements have been laid, the class and amount of traffic passing over them, and the methods of laying adopted. With all these matters I have attempted to deal in the Table of Tests and in this Report. Where, as in some instances, different kinds of wood have been laid contiguously, at the same time, and subject, of course, to the same class and amount of traffic, more definite conclusions may be drawn. This point and others will be referred to in the following notes.

Jarrah and Karri.—The results obtained in the case of these woods, laid in contiguous sections in St. John's Road, Battersea (Test No. 3), shows that the index of unevenness for Jarrah is 8·0 (slider) and 17·0 (wheel), while that for Karri is 11·6 and 21·0 respectively. The best individual result recorded for Jarrah was in Trinity Street, Southwark (Test No. 15), where the record gave the remarkable figure of 7·2 (slider) and 12·7 (wheel). The latter record is high in proportion, but it also shows an excellent result. A still more satisfactory piece of Jarrah paving, so far as uniformity of surface is concerned—blocks and joints combined—was that of Hampstead Road, St. Pancras (Test No. 12), where, after the irregularities due to trench work were eliminated, the record of unevenness amounted to only 9·0 for both slider and wheel. This correspondence of results gives practically what may be considered a jointless pavement, which, in my experience in using the viagraph, is only found in well-laid asphalte pavements, as in the Broad Sanctuary case (Test No. 20). For uniformity of surface I regard the Hampstead Road section as an ideal piece of work. The several tests made, where Jarrah and other descriptions of wood are laid contiguously, are worthy of note, as in Peckham Road, Camberwell (Test No. 4), where Haskinised Deal is used; Camberwell Road (Test No. 6), where American Red Gum is also laid; and, particularly, Bridge Street, Westminster (Test No. 18), where four descriptions of wood are laid—American Red Gum, American White Oak, Jarrah (dowelled), and Creosoted Deal.

American Red Gum.—Some of the tests made on this wood show a very high record of unevenness, as in Lower Regent Street (Test No. 22), and in High Street, Kensington (Test No. 26). In the latter case Creosoted Deal, which is the general class of material used in that district, is laid on either side of the American wood. The comparison is very unfavourable to the Red Gum. In Camberwell Road (Test No. 6) this wood is laid with Jarrah, where, also, the record is not favourable to the former.

Creosoted Deal.—The best record obtained on this description of wood was in Havil Street, Camberwell (Test No. 5), which compares very favourably with Battersea Park Road (Test No. 2), even if allowance be made for the difference in the period of use. In New King's Road, Fulham (Test No. 25), the record of unevenness of the dowelled section (Duffy's Patent)

appears to show that dowelling the wood blocks enhances the evenness of surface and wearing capacity of a wood-paved street.

ASPHALTE.—The result of the test of this material in Broad Sanctuary, Westminster (Test No. 21) is one of the best I have obtained up to the present time. But in this case the traffic is very light, as the section tested was near to the Raglan statue and off the main line of traffic altogether.

SANITARY BLOCKS.—The result of the test (No. 24) of these blocks, recently laid in Eaton Square, was not so good as might have been expected from the character of this material.

MACADAM.—The tests (Nos. 27 and 28) of the macadam laid on the Victoria Embankment, which has been recently repaired, and the accompanying viagrams speak for themselves.

TRACTION AND NOISELESSNESS.—It is evident that, as any irregularity in road surfaces intensifies vibration and increases friction, the more uniform and smooth the surface of a paved street is, the less the tractive effort necessary to haul loads over it. This is one special advantage of asphalte over other descriptions of pavement, although somewhat slippery under certain weather conditions. Uniformity and smoothness of surface are also necessary if the pavement is to be rendered comparatively noiseless—a great desideratum in crowded and busy thoroughfares.

SOME COMPARISONS.—The difference between the record of unevenness of the Creosoted Deal laid in Havil Street, Camberwell (Test No. 5), and that laid in the Strand (Test No. 19) is considerable, and to the advantage of the former. The comparison—or, rather, the contrast—between the Strand pavement and the Jarrah laid in Trinity Street, Southwark (Test No. 15), and in Hampstead Road, St. Pancras (Test No. 12), is still more striking. The American Red Gum laid in Great George Street, Westminster (Test No. 20), and elsewhere, compares, even when recently laid, very unfavourably both with the Australian woods and with Creosoted Deal.

CONCLUSION.—The conclusion, therefore, to which I have come is that, for wood paving, the Western Australian hard woods, particularly Jarrah, give the best results, in so far as smoothness of surface and regularity of wear are concerned, even where they have been laid a considerable time, as in most of the cases cited, and where they are subject to heavy and continuous traffic.

In concluding my Report I have to acknowledge the courtesy of the Borough Engineers of Battersea, Camberwell, Lambeth, St. Pancras, and Southwark, in whose districts most of the tests were made. Mr. John Brown, of Belfast, the inventor of the viagraph, was also present on the occasion, and rendered valuable assistance. The arrangements made by your representative were most complete, and were of much service in the accomplishment of the duty I had undertaken in accordance with your instructions.

I have the honour to be, Sir,

Your obedient servant,

(Signed) THOS. AITKEN, A.M.I.C.E.

CUPAR-FIFE,
13 *May*, 1902.

(See Viagrams at the end.)

ENGINEERING AND OTHER PURPOSES.

THE STRENGTH AND DURABILITY OF JARRAH AND KARRI TIMBERS, and some other species of Australian eucalypts, and their comparative immunity from the attacks of land and marine insects render them specially suitable for many classes of engineering work. They afford excellent pile and pier timbers; scantlings for dock gates; under-frames for railway carriages, wagons, locomotive tenders and buffer planks; bridge longitudinal timbers, planks, and crossing timbers; sleepers; planks and boards for decking and flooring piers, platforms, goods sheds, warehouses, and booking halls; telegraph poles and arms; spokes and other wheelwright works; and fences of every kind.

The value of these timbers is being increasingly recognised by the engineers of the United Kingdom. Some of the principal railway companies have adopted Karri for flooring purposes, as owing to its hardness, resistance to wear, durability, and freedom from knots it is found to be not only more satisfactory, but in the end more economical than fir or pine. Larger orders have been given during the past few years for Karri scantlings than for oak. Two of the principal English railway companies alone have ordered Karri timber during the past eighteen months sufficient to construct from 12,000 to 13,000 wagons, while quite one hundred miles of railways, including the line through the Severn Tunnel, have been laid with Karri sleepers. As pier timbers it is found that Jarrah and Karri are among the cheapest and best hard woods in the market.

"THE INDIAN AND EASTERN ENGINEER" for December, 1900, reports that "tensile and crushing tests were recently made in Bombay to ascertain the relative strengths of Karri wood and teak, which resulted in favour of Karri. It was also found that the cost of beams of Karri would be rather less than rolled steel beams, while teak would be rather more, and that a solid timber beam 12 inches by 16 inches would make a more fireproof floor than light rolled beams."

Mr. W. CANTRELL, Engineer of Ways and Works, Government Railway, Ceylon, writing under date November, 1899, says: "15,000 Karri sleepers, 9 feet by 10 inches by 5½ inches, supplied to this railway in 1888, have now been in the road from nine to ten years, and are still in good condition, showing no visible signs of decay. There has been no reason to renew any of them up to date. Their advantages over other sleepers are their comparatively long life; they hold the road to gauge better, and resist the cutting in of the bottom flange of the rail on the rail-bed (our rails are the Vignoles type), and are, in my opinion, the most economical sleepers we have tried."

Were English railway companies in the construction of new lines to adopt the system employed on most of the Continental and all the American and Australian railways, of spiking the rails to the sleepers—a system which is said to be efficient and economical—a considerable extension of the use of Western Australian sleepers would be likely to ensue.

Large quantities of Jarrah and Karri timbers have been and are being supplied to South Africa, India, South America, and other foreign countries for railway, marine, and mining purposes.

For many years—indeed, ever since the value of Jarrah and Karri came to be recognised—these timbers have been used very largely IN WESTERN AUSTRALIA ITSELF AND IN OTHER AUSTRALIAN STATES. In Western Australia, Jarrah is chiefly used for piers, piles, bridges, culverts, and sleepers, while Karri is employed for long beams, decking, and planking. "The suitability of Jarrah," says the late Mr. J. Ednie Brown, Conservator of Forests, "for any works requiring immersion in salt or fresh water has been practically noted and is worth recording. In this office (1899) there are specimens which have been obtained from piles and girders sixty years old; these were driven and used in local harbours and bridges. When obtained for the Department the timbers appeared to be perfectly sound and free from any sign of decay whatever; if anything, the wood seems to be harder, more solid, and apparently more durable than freshly cut timber. The records of this timber having lasted in the ground as fence-posts are almost without number. Railway sleepers which were laid down eighteen years ago still appear as sound as ever." Mr. Brown considers that Jarrah is a more reliable wood than Karri for marine and underground work, but he says: "For bridge-planking, spokes, felloes, and large planking of any sort, flooring, general wagon work, and beams, Karri is unequalled in Western Australia. In lateral strength it is very much stronger than Jarrah, and for works requiring the bearing up of considerable weights, such as bridges, floors, and rafters, it is of great value. Karri shrinks laterally, but not to any degree in a longitudinal direction."

In an important report of THE VICTORIAN ROYAL COMMISSION ON STATE FORESTS AND TIMBER RESERVES (1901), some particulars are given respecting AUSTRALIAN HARD WOOD SLEEPERS. The report states that "sleepers cut from the most durable Australian hard woods last much longer in the track than the timbers commonly used for this purpose in Europe and North America. Thus, the life of white oak in the United States is usually reckoned at six to twelve years, chestnut and tamarack at five to ten years, yellow pine and cedar at six to ten years; while in Europe, oak lasts ten to sixteen years, larch of the first quality ten years, and Scotch pine seven to nine years." The average life of Australian hard wood sleepers, as given in a table accompanying this report, is from twenty to thirty years. Reference is also made to the value of these timbers for telegraph posts, the life of Jarrah posts, as used in Western Australia, being given as from twenty-five to thirty years.

A forest ranger of Western Australia, in a recent report to his Department, referring specially to the uses of Western Australian woods FOR WHEELWRIGHTING PURPOSES, says: "I have seen wagons built of these woods that have been in rough and constant use for many years, during which they have been innocent of paint or shade, and yet to-day their timbers are in a splendid state of preservation and soundness."

IN CONSIDERING THE QUESTION OF THE SUITABILITY OF WESTERN AUSTRALIAN WOODS FOR ENGINEERING AND GENERAL CONSTRUCTIVE

PURPOSES, IT SHOULD BE NOTED THAT WHILE THEY ARE HEAVIER THAN EUROPEAN WOODS, YET, FROM THEIR GREATER STRENGTH, SMALLER SCANTLINGS MAY BE EMPLOYED. For example, a 10 in. by 5 in. Jarrah and Karri scantling would give as much resistance as a 12 in. by 6 in. pitch pine or creosoted fir scantling, and similarly with timber suited to other classes of engineering and, particularly, to constructive work. On this point and others connected with the engineering uses of Western Australian timbers, the accompanying report of Mr. K. C. RICHARDSON, a gentleman who has had many years' experience with Australian woods, should prove of value both to exporters and users of timber.

THE ADAPTABILITY OF JARRAH AND KARRI and other varieties of Western Australian timbers FOR CABINET AND ART WORK has received abundant proof in the Exhibitions of Paris and Glasgow, and more recently in the Colonial Exhibition at the Royal Exchange, London, where a number of samples of beautiful cabinet work wrought in Western Australian woods were displayed. In an article in *Arts and Crafts* for October, 1895, the late Mr. G. S. Perrin, Conservator of Forests for Victoria, gave a list of a number of Australian timbers suitable for the higher branches of wood work, "the exceeding beauty of which," he said, "would be a revelation to many." Of such timbers Western Australia possesses a large variety.

SPECIMENS OF THE COMMERCIAL TIMBERS of Western Australia are on view at the office of the Western Australian Agency, 15, Victoria Street, S.W., where such further information as the Government of the State has been able to collate respecting the uses of these timbers may be obtained on application.

REPORT OF MR. K. C. RICHARDSON.

The Hon. H. B. LEFROY,
Agent-General for Western Australia,
15, Victoria Street, S.W.

SIR,—I have much pleasure, at your request, to submit my views on the subject of Western Australian timbers, and the best means of increasing the export trade in them.

As I have been intimately connected with the timber trade, in this country and abroad, for forty years, my knowledge of the general conditions of the trade is wide and varied.

THE PREPARATION OF THE TIMBER.—I regard this question as one of the first importance, and am of opinion that greater care should be exercised in Australia in meeting the requirements of the home markets. For this purpose I advise that trees should be ring-barked when their growth is practically quiescent, say from April to September, and that they should not be felled for some time afterwards. On no account should trees be felled whilst green and be allowed to dry on the ground. I hold that there is no such danger from forest fires as some Australian foresters appear to think if the trees be ring-barked, seeing that trees of the nature of eucalypts cannot

in so short a time be rendered bone-dry. I shall deal with the subject of proper conversion of logs into planks and scantlings in a subsequent paragraph, meeting the objection which is frequently made to the use of Australian hard woods on account of unequal shrinkage.

OBJECTIONS TO THE USE OF AUSTRALIAN TIMBER.

It is frequently urged as an objection to the extended use of Australian hard woods that the *cost* is too high; but my reply to this is that very few descriptions of hard wood can be imported much cheaper than Australian, and the proved superiority of the latter, so far as strength is concerned, over those in general use should induce engineers to specify proportionately smaller scantlings, and thus effect a saving in cubic contents, and still attain the same results. Eucalypts grow to enormous size and length, and as Western Australian mills are supplied with well-equipped and modern machinery, logs, planks, etc., may be hewn or sawn to exact required sizes; consequently waste is avoided, and freight and charges (most important items) are payable only on what is serviceable. Many descriptions of hard wood of repute are becoming scarcer and consequently dearer. Australian woods have already an established reputation for durability, tensile strength, etc.; I therefore consider the present time most favourable to extend operations, and have no doubt that with energy and care on the part of shippers to comply with consumers' requirements a wide field is open to the timber trade of Australia.

Other objections to Australian woods are:

1. Liability to Shrink in Seasoning.—This is a fault common to all woods—hard woods in particular. A board of mahogany, beech, oak, or any hard wood, if sawn full inch thick, will, say after two years' seasoning, barely hold up $\frac{7}{8}$ inch. This must be provided for by cutting the scantlings slightly in excess of required finished sizes.

2. Unequal Shrinkage in Seasoning can be minimised by carefully cutting "on the quarter," and avoiding the "heart-wood," by which is meant the softer wood surrounding and near the pith of the tree.

3. Extreme Hardness of the Wood after Seasoning.—This also is a drawback common to all hard woods, but it is manifestly unfair to quote this as a disadvantage to Australian woods, when the same objection applies, to a greater or less extent, to nearly all kinds. In these days of nearly universal machine planing hardness is not of so much account as in former times, when all wood had to be wrought by hand.

USES OF WESTERN AUSTRALIAN TIMBERS.

In noticing the various uses to which Australian, and more particularly Western Australian, woods can be applied, one of first importance is street paving; but on this point I need say very little, as I understand this subject is fully dealt with in other reports. The two woods, Jarrah and Karri, are doubtless excellent for the purpose, and the esteem in which they are held is well merited.

For Engineering and Marine Purposes a large demand is springing

up. It is now about ten years since Jarrah piles were adopted at Hartlepool, and they have well stood the test. Since this time engineers have specified Jarrah and Karri for many important works, with the best results, and quite recently a pier has been constructed at Great Yarmouth almost entirely of West Australian wood. Continental demand is also increasing, and trade in this direction is likely to expand greatly.

For Railway Work.—Several trials have been made by some of the trunk line companies with hard wood sleepers, and it is possible that this branch of trade may expand, especially if the present pattern of rails is disused and a flange rail let into a hard wood sleeper be adopted in its place with the object of counteracting "*thrust*." This plan is having the serious consideration of one of our leading engineers. For railway wagons there is also a large demand for scantlings, but the importance of "quartering" and eliminating all heart-wood cannot be too strongly insisted on. For wagon timbers Karri is decidedly the best of Western Australian woods, on account of its great tensile strength and interlaced fibres.

For Longitudinals for Tube Lines and Tram Lines.—A good opening presents itself in this direction, more especially as there appears to be an inclination to revert to longitudinal sleepers for tram lines, as house holders and tradesmen along the route complain of the continual jarring and grating noise arising from the cars running on a metal rail bedded on concrete. For tube lines, where electricity is the motive power, and where danger from fire has to be guarded against, eucalypts might be advantageously used, as this wood is durable, comparatively non-inflammable, and gives off no suffocating fumes, as is the case with creosoted soft woods.

For Structural Purposes.—We have lately had many a sad lesson read to us by the disastrous fires that have proved the utter futility of iron, brick, and concrete in the construction of, so-called, fire-proof buildings. Although the materials are fire-proof, the joinery, wall-linings, and goods stored in the buildings are highly inflammable. When fire breaks out, the iron supports and girders quickly become red-hot and twist; the concrete floors, losing their support, give way, and the contents of the upper floors crash into the flames in the lower floors, so that in an incredibly short time the whole building becomes a raging furnace. As a rule, after extinction, the only unconsumed parts are the half charred beams of wood that formed portions of the structure. It may seem an anomaly to suggest a timber-built warehouse as better likely to resist destruction by fire than one constructed of iron and concrete; but we live in an age of contradictions. A visit to the warehouses built some years ago by the East and West India Dock Company in their docks near the river entrance (the walls only are brick), will prove to anyone interested that it is safer to trust to wood than to metal and concrete, provided the former is properly used. If a comparatively non-inflammable wood like eucalyptus were used, instead of fir and oak, still greater safety would be ensured, and the cost would not be much more, for it must be remembered that, owing to the greater strength of Australian wood as compared with fir, the same results as regards strength will be obtained with two cubic feet of hard wood as with three cubic feet of fir.

Australia possesses many fancy woods suitable for cabinet, decorative

and art purposes; but this trade is of so intricate a character that it ought to be left in the hands of experts to select and prepare the woods for the home market. The reputation of many a fine wood has been wrecked by injudicious consignments of improperly selected and prepared parcels.

In conclusion.—I am glad to note the gradual and steady increase in the demand for the varied and valuable produce of the forests of Australia; and there is no reason to doubt that if the suggestions embodied in the able papers prepared by Mr. E. T. Scammell, and read before the Society of Arts and the Australasian Chamber of Commerce, be adopted, and due attention be given to the points raised by several experts in their reports to you, a much larger trade in Australian timbers will be done in the near future, to the mutual advantage of the Colony as producer and the Mother Country as consumer.

I have the honour to be,

Sir,

Your obedient servant,

KASTIAN CHAS. RICHARDSON.

155, Fenchurch Street,
London, E.C.,
21*st June*, 1902.

FIRE TESTS OF JARRAH AND KARRI.

A valuable characteristic of Jarrah and Karri with some other Australian timbers is their comparative non-inflammability. This is a subject of great importance to those who have to do with engineering or structural works, where immunity from fire is a matter of special consideration, as, for example, in the construction of tube railways, tunnels, and deep level sections, where sleepers have to be used or any wood work, especially if electricity is employed, and in all classes of fire-proof buildings. A striking illustration of the need of some less inflammable kind of wood, for underground or tunnel railway work, than creosoted sleepers, is afforded by the recent accident on the Liverpool Electric Railway. As to so-called fire-proof buildings, it is well known that iron and concrete are no guarantee of safety or immunity from fire.

The accompanying report by The British Fire Prevention Committee on the results of tests made with Jarrah and Karri at the Committee's Testing Station, London, on January 29th, 1902, will be read with interest. In their memorandum the Committee say: "The purpose of the tests undertaken by the British Fire Prevention Committee is to obtain reliable data as to the exact fire resistance of the various materials. . . . The tests are of an entirely independent character, arranged on scientific lines, but with full consideration for the practical purpose in view. . . . All reports on tests solely state the bare facts and occurrences."

"FIRE TESTS Nos. 35 and 36, January 29th, 1902 :—

A 2 in. Jarrah Four-panel (Bead Flush both sides) Door.

A 2 in. Karri „ „ „

"OBJECT OF TEST.—To record the effect of a fire of one hour, gradually increasing to a temperature of 2,000° F. Note.—2,000° F. was attained in thirty minutes, and the temperature remained between 2,000° F. and 2,200° F. until the end of the test. The fire was to be applied from one side, and the doors were to open inwards on to the fire side. The door openings were to be approximately 3 ft. by 6 ft. 9 in.

"SUMMARY OF EFFECT.—JARRAH DOOR.—In twenty minutes smoke appeared at two points in right-hand panel next muntin. . . . In thirty minutes vapour appeared at the lower bolt. . . . In sixty minutes flame appeared over top bolt. At the close of the test the door was still standing, the slamming style burnt through in two places, much bulged, and joints of panels next slamming style open. KARRI DOOR.—In five minutes smoke appeared over top of right-hand corner and through panel near hanging style. . . . In thirty minutes both top panels buckled inwards. . . . In fifty-three minutes the lower panels and muntin were bulging outwards. . . . At the end of the test the door and frame were practically destroyed.

"THE FOLLOWING OBSERVATIONS WERE MADE AFTER CONCLUSION OF THE TEST : JARRAH DOOR standing, slamming style burnt through in two places, much bulged, and joints of panels next slamming style open. KARRI, slamming style and bottom rail standing. Hanging style inclining inwards, right-hand lower panel fallen in. Frame much charred. Door practically destroyed."

These results may be regarded as highly satisfactory, showing that with a fierce fire bearing directly upon the inside of the doors, at the end of an hour the Jarrah door was still standing, while the Karri door was intact up to within a few minutes of the hour.

"FIRE TEST No. 37, January 29th, 1902 :—

"A floor of Jarrah wood—area 222 ft. 6 in. super, in the clear (10 ft. by 22 ft. 3 in.)—loaded with 232 lbs. per square foot, put together in the following manner :—

"A 15 in. by 15 in. post was placed in the centre of the hut, standing on a bed of concrete laid on the floor for the purpose. The post was notched at the top, 1½ in. wide by 5 in. deep, to receive 12 in. by 15 in. cleats or brackets for the support of cross beams. The cleats were bolted to the posts with two ⅞ in. iron bolts.

"Two 10 in. by 12 in. beams were placed across the hut from east to west, resting on the cleats and notched 1½ in. into the post, the ends resting 4½ in. on the walls. On top of these cross beams, and running longitudinally the whole length of the hut from north to south, four 10 in. by 10 in. joists were placed, notched 1½ in. into the lower beams. They were spaced 2 ft. 6 in. apart, and rested 4½ in. on the walls at each end.

"The edges of posts and beams were rounded. On the top of the joists 8½ in. by 2½ in. boards with 1½ in. by 1¼ in. rebate at each side, were laid and spiked to the joists with 5 in. spikes, eight spikes being used to each board.

"The brickwork was carried up to the underside of boarding and between the beams and joists.

"The floor had three separate loads of bricks placed thereon, equal to 232 lbs. per square foot, that in the middle covering an area of 47 ft. 5 in. super, and the two end ones 42 ft. 8 in. super.

"OBJECT OF TEST.—To record the effect of a fire of two hours' duration at a temperature gradually increasing up to 2,000° F.

"SUMMARY OF EFFECT :—

"In 16 minutes some of the joints of the underside of the flooring were opening. In 17 minutes smoke appeared through a joint of the flooring. In 69 minutes the underside of the flooring was burnt and flaked off, so that the rebated joints were visible in many places. In 84 minutes flame came through the flooring. In 119 minutes there were numerous holes in the floor with flames coming through them, considerable portions of the flooring being burned away from under the stacks of bricks. A few bricks fell from N.E. corner of N. stack.

"The post, beams, and joists were reduced in size and charred to a depth of $\frac{3}{4}$ in."

These results, also, may be regarded as highly satisfactory, showing that it took an hour and twenty-four minutes for the flames to come through the flooring. A building, therefore, constructed of this timber would be practically fireproof, as, long before the flames could pass from one floor to another, the fire could be extinguished or would burn itself out. Similar results are likely to follow from the use of some other Western Australian hard woods.

TABULATED RETURNS

FROM VARIOUS MUNICIPALITIES

RELATIVE TO WOOD PAVING.

CONTRACTIONS USED IN TABLE.

WOOD.

A R G.—American Red Gum.
B.—Beech.
D.—Deal.
J.—Jarrah.
K.—Karri.
M.—Memel.
O.—Oak.
Prism O.—Prismatic Oak.
W.—Wood.

PREFIXES:—Cr.—Creosoted. H.—Hard. R.—Red. S.—Soft. Y.—Yellow.

METHODS OF LAYING.

bit.—Bitumen or bituminous.
ct.—Portland Cement.
cr o.—Creosote Oil.
jt.—Joint or joints.
o.—Oil.
p.—Pitch.
s.—Sand.
t.—Tar.

SUNDRY.

Gr.—Granite.
Mun. E.—Municipal Engineer.

NOTES.

Where "miles" of paving are given, the reference is to street miles of a width of, say, 30 to 40 feet.

Where no reference is made to the foundation, it is understood that 6 in. concrete (Portland cement and sand, 1 in 6 to 1 in 8) is used.

Although great care has been taken to render the returns as complete and correct as possible, a few inaccuracies may have crept in. Should this be so, any corrections or additional information that can be made or furnished by the Engineers of the various Municipalities will be esteemed a favour.

Name of Municipality.	Wood Used, Depth of Blocks, Area Laid, and Date of First Laying.				First Cost, per yard super, including Foundation.		Annual Cost of Maintenance per yard super.		Present Method of Laying, Foundation, Jointing, Grouting, etc.	Results and Opinions as to the use of Wood for Street Paving.
	Wood.	Depth.	Area.	Date.	H W.	S W.	Repairs.	Cleansing and Watering.		
		Inches.	Yds. sup.							
Aberdeen . . .	K.	4	227	1896	13/5	—	—	—	Grouted with bit.	Satisfactory, though slippery in wet weather. No signs of deterioration. The Burgh E. recommends extension.
Accrington . . .	J.	6	2,000	1896	19/6	—	—	—	—	Not quite satisfactory, owing to the centre portion of the road, 13′ in width, which is repairable by the Local Tramway Company, being left unpaved and in a bad condition, and allowing water to find its way under the new paving. Laid in front of Town Hall.
Acton	J. & Cr D.	—	—	—	—	—	—	—	—	J. for tramways. Cr D. for roadways. A considerable amount of wood paving is likely to be done, in connection with extension of tramways (Middlesex Light Railways) in this district.
Ashton-under-Lyne	Cr B.	5	2,500	1887	12/9	—	Very little to date.	No separate account.	Concrete foundation 7″. Blocks laid diagonally, $\frac{1}{8}$″ to $\frac{3}{16}$″ jt. filled with granite chippings and (about two-thirds) with p. & o. Grouted with ct.	The pavement has lasted very well, but in odd places it is showing signs of wear and decay. The surface is smooth, and generally the arrises are as even as when first laid.
Barrow-in-Furness.	B.	—	—	1885	—	—	—	—	—	Much superior to S W.
Bath	H W. & S W.	4 & 5	35,000	1895	12/6	9/0	H W. no repairs yet. S W. first 5 yrs nothing; afterwards 0/2 to 2/6.	—	—	Satisfactory. Woods used, J., K., Cr. and Jodelited R. and Archangel D.

Batley	K.	—	5,000	1897	13/6	—	None at present.	0/1¾	Specification. — Blocks free from sappy fibre, knots, worm, and gum flaws and other defects, cut die square. Dipped in p. & t. (mastic) to within 1″ of surface. Bottom of each block scraped. Close jt., knocked up tight. Brushed over with hot mastic. Grouted with ct. (one to one), and covered with sharp grit. 1¼″ expansion jt. with 2 rows of longitudinal blocks.	Laid in main street by Corporation. Experiments in short lengths with open joints. Present method found the best. Paving is as good as when first laid. To prevent dust rising, one pint of Pinolia disinfectant fluid is put into each water-cart (250 gallons capacity); has been found very effective. Perfectly hygienic. Extending use.
Battersea . . .	J. & K.	—	38,000	—	About same as Gr.	—	—	—	Close jt. Grouted with p. & t. Blocks cut by Corporation.	Satisfactory. Extending use. The steepest gradient 1 in 30, for short distance only. The Mun. E. considers that expansion and contraction are due to want of seasoning and defective oversight. *Vide* Viagraph Report.
Belfast	J. & K.	4½	4,000	1901	18/0	—	—	—	Concrete foundation 9″ finished with floated surface. Dipped in p. & cr o., laid direct on foundation. Grouted with p. & cr o. Open jt. at ends of blocks.	In two of the principal streets, as experiment. Too recent to express opinion.
Bermondsey . . .	H W. & A R G.	4 & 5	Considerable	1894	—	—	H W. cleaner	than SW.	Close jt. Grouted with p. or ct., according to the weather when laying. Expansion jt. about 2″.	General results of J. satisfactory. Some trial sections were laid with open jt., and in some cases there has been a good deal of shrinkage. This has resulted in the blocks becoming rough, although the wear has been trifling. Woods used, J., K. (very little), Blue Gum (small section), &c. A R G. is being laid (1901–2) by the London County Council in new road south of the Tower Bridge.

Name of Municipality.	Wood Used, Depth of Blocks, Area Laid, and Date of First Laying.				First Cost, per yard super, including Foundation.		Annual Cost of Maintenance per yard super.		Present Method of Laying, Foundation, Jointing, Grouting, etc.	Results and Opinions as to the use of Wood for Street Paving.
	Wood.	Depth.	Area.	Date.	H W.	S W.	Repairs.	Cleansing and Watering.		
		Inches.	Yds. sup.							
Bethnal Green .	J. &	4	8,318	1900	12/6½	—	None at present.	No separate account.	Close jt. Grouted with p.	Extending use of J. A R G. is being tried as an experiment. The Mun. E. considers that very much of the success of wood paving depends upon the method of laying and upon the blocks being true to gauge. He is satisfied as to the wearing quality of J.
	A R G.	4	2,185	1900	13/6½					
Birkenhead . . .	A R G.	5	78,572	1901	1/0 more than Gr.	—	—	—	Close jt. Grouted with p. to within 1″ of surface, then with cement mortar.	Experimenting with J., K., and other woods.
Birmingham . . .	J. & K.	4	32,775	1898	15/6	13/0	H W. 0/3	H.&SW. 0/4	Close jt. Grouted with p.	Every satisfaction. Sample of K., 2½ years' wear, $\frac{1}{16}$″. The City E. is of opinion that Australian woods should be cut into blocks and stacked for not less than 2 months, so as to get thoroughly air-dried before being laid. If this is done, the expansion and contraction will be materially lessened.
	S W.	6	135,000				S W. 0/4			
Blackburn . . .	J. & K.	—	10,700	1897	3/0 more than Gr.	—	—	—	Concrete foundation 5″, with 1″ float. Close longitudinal jts. ¼″ butt jts., run with p. & cr o. Grouted with ct.	Wearing remarkably well, and in every way satisfactory.
Blackpool . . .	J. & K.	4½	100,000	1897	12/0	—	None at present.	—	Concrete foundation 5″ (6 to 1), 1″ floating (3 to 1). Close jt. run with p. for 1½″. Grouted with ct. and s. (2 to 1). In many cases blocks dipped. Blocks cut by Corporation.	Very satisfactory. Extending use yearly. Some trouble in regard to expansion of blocks, but difficulty overcome.

Bolton	J. R D. & B.	— —	1,100 5,000	1901	Wood Gr.	13/6 11/0	—	—	Dipped about 1½″ in p. Grouted with ct.	Regard J. as an excellent paving wood. If found to answer in this case, use is likely to be considerably extended.
Bootle	J. & R Pine	—	Small	1897	—	—	—	—	—	The section of J. and R P. is in same road and subject to similar conditions. Samples, 4 years' wear, J. $\frac{1}{16}$″, R P. $\frac{7}{16}$″.
Bournemouth . .	Cr D.	—	—	—	—	—	—	—	—	About to lay 100,000 yards of Cr D.
Bradford . . .	J. & K.	—	12,270	—	3/6 more than Gr.	—	—	—	Dipped in p. & t. Close jt.	Satisfactory.
Brighton	J., K., D. & A R G.	5	129,000	1897 1901	17/10, Gr. 15/6	14/8	No repairs at present.	10/½ in one case, 0/6 in remainder.	Laid dry. Close jt. Grouted with p. Expansion jt. 2″.	Satisfactory. Extending use.
Bristol	J. & K. B., R Pine, Prism O., & A R G.	4	196,515	1895 1873 (R P.)	J. & K. 14/0 B. 12/6 Prism O. 15/0 A R G. 14/6	R P. 12/6	1/0, including cost of entirely relaying areas worn out.	—	Close jt. run with bit. Grouted with bit.	Corporation intend to replace R Pine, as it wears out, with J. or K. Work in progress. Sample of K. (Bristol Bridge—heavy traffic), 6 years' wear, ⅜″. Wood is used on following gradients: Prism O. & R P. up to 1 in 14, J. & K. up to 1 in 20, B. up to 1 in 25.
Burnley	J. & B.	4½	1,020	1900	J. 14/10 B. 15/2	—	—	—	Close jt.	An experimental length is here referred to. A further use of wood paving to the extent of about 5,000 yards has been decided upon.
Bury	Cr B.	5	12,350	1885 1895	15/0	—	—	—	A thin layer of dry sand is placed on the concrete foundation, and the blocks are laid in this, generally diagonally; about half the block is then run with p., and the remainder afterwards grouted with c. & s.	The Mun. E. intends trying J. and K., so as to compare them with Cr B.
Camberwell . . .	H W. & S W. (J.	— 5	7 miles 82,921	— 1895)	12/9½ to 14/1¾	12/10½ to 17/2	—	—	Dipped in p. Close jt. (mainly). Grouted with ct. & s.	J. regarded as very satisfactory. Extending use. A number of trial sections of various woods and other paving materials laid in this borough. *Vide* Viagraph Report.
Cambridge . . .	J.	—	Small 2 streets	1898 1901	—	—	—	—	Concrete foundation 5″. Dipped in mixture of t., p., and creosote. Close jt.	Satisfactory. Special advantages—quietness and cleanliness. Probably extending use.

Name of Municipality.	Wood Used, Depth of Blocks, Area Laid, and Date of First Laying.				First Cost, per yard super, including Foundation.		Annual Cost of Maintenance per yard super.		Present Method of Laying, Foundation, Jointing, Grouting, etc.	Results and Opinions as to the use of Wood for Street Paving.
	Wood.	Depth.	Area.	Date.	H W.	S W.	Repairs.	Cleansing and Watering.		
CANTERBURY . . .	J.	Inches. —	Yds. sup. 1 street	—	About same as Gr.	—	—	—	$\frac{1}{4}$" jt. run with t. Grouted with ct. Expansion jt.	Satisfactory. Extending use.
CARDIFF	J. & K., Cr Y D. & Prism O.	$4\frac{1}{2}$	41,758	—	16/6	12/6	—	—	—	Samples of J. (Queen Street—heavy traffic), 4 years' wear, $\frac{3}{32}$".
	A R G.	—	—	Recently.						
CHATHAM	J.	—	Main street.	—	—	—	—	—	Creosoted to within $\frac{1}{4}$" of surface. Grouted with ct.	Worn exceedingly well. Just accepted tender for J.
CHELSEA	K. Canadian Pine.	4	—	1893	—	—	—	—	Close jt. Grouted with p. & cr o. Expansion jt. 1".	Trial sections. The K. began to shrink after two years, letting the water under the blocks. It was obliged to be taken up in 1901. Canadian P. decayed after a few years.
CHELTENHAM . . .	J.	—	1 street	1900	17/0	—	—	—	Concrete foundation 8". Two methods — (1) Dipped 2" in bit.; grouted with ct. (2) Dipped and grouted with bit.	Satisfactory. Probably extending use. The Mun. E. says that the only objection he finds is the shrinkage during summer, when there is a tendency for some of the blocks to work loose.
CHESTER	J.	4	10,100	—	15/5 exclusive of foundation.	12/0 to 13/0 exclusive of foundation.	No repairs with J. for 3 years. R D., decayed blocks renewed pretty frequently.	—	Close jt. some streets; 1" jt. others. Grouted with ct.	Slippery in moist weather; otherwise satisfactory. Extending use.
	R D.	5								

Christchurch . .	None	—	—	—	—	—	—	—	—	Considered the question of adopting wood for centre of tramway track, but found, on enquiry, that there is considerable objection to laying down wooden track with macadam on either side. Decided to lay tar macadam in track and granite on sides of road.
Coventry . . .	None	—	—	—	—	—	—	—	—	Considering advisability of adopting wood.
Crewe	None	—	—	—	—	—	—	—	—	The Mun. E. would be glad to introduce wood, but it is a question of price.
Croydon	Cr D.	—	80,000	—	—	—	—	—	Close jt.	Satisfactory. Extending use.
Deptford. . . .	J.	—	Small	—	—	—	—	—	—	Too recent an experiment to express opinion.
Derby.	J. Cr D. & B.	5 5	¾ mile	1894	15/0 Gr. 9/0	11/0	—	—	Grouted with p. & t.	Satisfactory. Probably extending use. The Mun. E. recommends adoption of wood in suitable streets.
Devonport . . .	J. Baltic White & R Pine	— 5	20 18,800	—	— Gr. 12/6	11/6	—	—	⅜″ jt. run with asphalte. Grouted with ct.	Question of extending use of J. will depend on the result of trial piece laid.
Dewsbury . . .	K.	5	1,208	1897	—	—	—	—	Concrete foundation 7″. Open jt. run with p. Laths laid between blocks. Expansion jt. filled with clay puddle.	In very good condition.
Dover	J.	4	9,958	1896	15/0	—	—	—	Dipped one side and one end, leaving bottom of block dry. Close jt. Expansion jt. filled with puddled clay.	In very good condition. Further streets will be paved with J. The Mun. E. considers that by laying blocks with dry bottom a more even surface is secured. He is satisfied as to the hygienic character of J. & K.
Dublin	J. R Archangel 2nds.	5 5	44,000	1896	17/0	14/0	S W. 0/6	H.&S W. 0/3	Close jt. Interstices filled with mixture of p., cr o., and asphalte. Grouted with ct. & s.	J. wearing very well. Probable extension.
Dundee	J. A R G.	5 5	1,640 1,250	1901	17/0 16/0	—	—	—	Close jt. J. grouted with p. A R G. grouted with ct. Expansion jt. 1¼″ filled with puddled clay.	Too recent to express opinion.

Name of Municipality.	Wood Used, Depth of Blocks, Area Laid, and Date of First Laying.				First Cost, per yard super, including Foundation.		Annual Cost of Maintenance per yard super.		Present Method of Laying, Foundation, Jointing, Grouting, etc.	Results and Opinions as to the use of Wood for Street Paving.
	Wood.	Depth.	Area.	Date.	H W.	S W	Repairs.	Cleansing and Watering.		
		Inches.	Yds. sup.							
DURHAM	None	—	—	—	—	—	—	—	The City E., from previous experience, recommends bedding blocks on ¼″ sand and laying them diagonally. The jts. should be run with p. & cr o., and grouted with fine screenings or granite sand. Expansion jt. should be allowed.	The City E. is in favour of K., which he is advising his Council to adopt. He is of opinion that K. is far superior to B. or Cr R W., as it is less affected by damp or frost. He regards it as an ideal paving for flat streets.
EALING	J. & A R G.	—	—	1901	—	—	—	—	—	J. for tramways. A R G. for roadways.
EASTBOURNE . . .	None	—	—	—	—	—	—	—	—	The Mun. E. recommends the adoption of H W. He is particularly interested in the question of the sanitary character of wood paving. *Vide* Hygienic Report.
EDINBURGH . . .	J. & K.	5	43,000	1894	17/0 Gr. 15/0	—	—	—	¼″ jt. Grouted with asphalte or ct.	Foundations, wood, and jointing give perfect satisfaction, and the surfaces, at present, are in first-class order. J. and K. are thoroughly suited for heavy traffic and for giving horses good foothold. The City Road Surveyor recommends that planks be cut 3½″ instead of 3″.
EXETER	J.	—	Small	1900	—	—	—	—	—	Very satisfactory. Used for crossings.
FINCHLEY	None	—	—	—	—	—	—	—	—	The Mun. E. would recommend J. or K. if wood were adopted. He is of opinion that where certain wood does not give the same satisfaction in one place as it does in another, it is largely due to want of sufficient seasoning. The carrying out of the Middlesex Light Railways Scheme is likely to give a great impetus to the adoption of wood in this and in other parts of the county.

FINSBURY—										
Eastern Division . (late St. Luke's)	J.	5	11 streets.	1897	—	—	—	—	Dipped in p. Close jt. Grouted with p.	Chiswell St., laid in 1897, is in excellent condition. The heavier the traffic, the better the result appears to be in the use of J.
Western Division . (late Clerkenwell)	J. Cr D.	4½ & 5 5	Several streets.	1895	14/6 exclusive of foundation	11/0 to 12/0 excl. of found'n.	None at present.	No separate account.	Dipped in t. Close jt. Grouted with p. or ct. (Various methods had been tried.)	Satisfactory. Steepest gradient for J., 1 in 35. It was proposed to try a section of A R G., but the intention was abandoned.
FOLKESTONE . . .	J.	4½	8,100	—	—	—	—	—	Concrete foundation 8″. Close jt.	Satisfactory. Using J. for crossings in macadam roads. Gradients too steep for extensive adoption.
FULHAM	J. Cr D.	5 5	540 Large.	1892	18/0 Gr. 14/6	12/6	—	—	⅜″ jt. run with p. Grouted with ct. & s. Expansion jt. 3″.	Experimental area in J. was down for 8 years. Wear proved irregular, arising, in the judgment of the late Mun. E., from unseasoned wood or wood of unequal quality, and from the method of laying with open jts. Cr D. is preferred to other woods. A section of dowelled paving (Duffy's Patent) laid in 1894, with Cr D., is wearing exceedingly well. There appear to be some distinct advantages in the system, especially in view of preserving an even surface. There has been no trouble with expansion or contraction of the dowelled blocks.
GATESHEAD . . .	Cr R W.	6	900	1892	—	—	None at present.	—	—	Very satisfactory. Laid in Cross Street opposite Magistrate's Court. Traffic light.
GLASGOW	J. Pynkadoe & Pitch Pine	5	6,550 4,590 Large area.	1898	17/0	—	—	—	¼″ jt. A little p. is put in to steady the blocks, and some fine granite chips are thereafter brushed in between the joints, and the whole thoroughly grouted with p. Expansion jt. 2″ to 3″.	The J. and Pynkadoe (or Pyengadu, Burma) give excellent results. The latter, however, is a high-priced wood and not easy to obtain. The Corporation have abandoned the idea of laying any more soft wood. Extending use of J.
GLOUCESTER . . .	R D.	5	2,000	1894	10/0, about the same as Gr.	—	Repairs trifling, after 6 years' wear.	—	—	Satisfactory. Very little wear. Probably H W. will be adopted in connection with electric tramways.
GOOLE.	None	—	—	—	—	—	—	—	—	Question of adopting wood in place of macadam has been under consideration.
GRAVESEND . . .	J. & Cr D.	—	—	Recently.	—	—	—	—	—	J. for tramways. Cr D. for roadways. Had intended to use A R G., but finally adopted other woods.

Name of Municipality.	Wood Used, Depth of Blocks, Area Laid, and Date of First Laying.				First Cost, per yard super, including Foundation.		Annual Cost of Maintenance per yard super.		Present Method of Laying, Foundation, Jointing, Grouting, etc.	Results and Opinions as to the use of Wood for Street Paving.
	Wood.	Depth.	Area.	Date.	H W.	S W.	Repairs.	Cleansing and Watering.		
		Inches.	Yds. sup.							
GREENOCK . . .	H W.	—	Small	—	—	—	—	—	—	Initial cost and comparatively short life of wood, owing to climate and heavy traffic, unfavourable at present to its wide adoption.
GREENWICH . . .	J.	—	Small	—	—	—	—	—	—	—
HACKNEY	J. Y D. A R G.	5	107,500 15,000 1,500	1896 1890 1901	15/8 to 17/9 13/0 14/6	—	—	—	Concrete foundation 6", with 1" float. Dipped one side and one end in p. & cr o.; bottom dry. Close jt. Expansion jt. $1\frac{1}{2}$".	Satisfactory. Extending use. Steepest gradient in J., 1 in 38.
HALIFAX	K. R D.	5	4,000 2,500	1898	14/0	8/9	—	—	Dipped in p. Grouted with p. Close jt.	K. in as good condition as the day it was laid. Large extension contemplated.
HAMMERSMITH . .	J.	5	125,912	1890	15/8	—	—	—	Dipped 3 sides in p. & cr o. Close jt. Grouted with p. (Formerly blocks were laid with open jt., grouted with ct.) Blocks cut by Corporation.	In the judgment of the Mun. E. J. is one of the best H W. on the market. To maintain a wood-paved roadway in good repair, for any length of time, he thinks that H W. should be used. There are no complaints as to slipperiness, as the roads are kept well sanded in wet or greasy weather. Sample J., 9 years' wear, $1\frac{1}{2}$".
HAMPSTEAD . . .	J.	4	85,000	1892	14/0	—	—	—	Dipped one side and one end in p. Grouted with refined boiled t., flushed up with ct. and shingle finishing. (Formerly $\frac{3}{16}$" jt. in which small strips of lath were placed, grouted with p.)	Samples of J. and D., laid under similar conditions of traffic, showed after 7 years' wear that J. had worn $\frac{5}{8}$" and D. $2\frac{3}{8}$". The blocks were taken up in order to carry out a scheme of extension. The old J. blocks were sold to pave a mews. *Vide* Report of late Mun. E.

HANLEY	S W.	—	200	—	—	10/0	—	—	—	No J. or K. Wood inadvisable, on account of steep gradients and cost.
HARROGATE . . .	K.	4	2,000	1895	16/3	—	—	—	—	Samples of K., 6 years' wear, $\frac{1}{8}$".
HARWICH	K. Fir	4 4	2,000 800	1895	10/6	6/6	—	—	Blocks laid diagonally. $\frac{1}{2}$" jt. filled in with p. & t. Grouted with s.	K. shows little the worse for wear. The Mun. E. prefers K. on account of twisted grain, and being less slippery than J. Fir, estimated life from 6 to 8 years. "Tees Scoriage" paving setts, 9 × 3½ × 4, give good foothold for horses.
HASTINGS	J.	4	40,436	1895	13/0 if taking credit for good macadam. If not, 14/0	—	0/1 Sanding	0/4 0/2	Concrete foundation 6" to 8". Close jt. Grouted with bit. In one instance open jt., grouted with ct.	The whole of the paving is in good condition. Samples of J., 6 years' wear, $\frac{1}{8}$". The Corporation are perfectly satisfied with J., and propose laying it on the rest of the sea front. They claim that the Local Government Board should extend the time for repayment of loans from 10 to 12 years, at least. *Vide* Report of Mun. E.
HECKMONDWIKE . .	B. & O.	—	Small	—	—	—	—	—	—	Propose to try the combined paving known as the Bingham pavement—granite and wood intersections—on gradient. Wood generally satisfactory. Use will be probably extended.
HOLBORN—St. Giles .	J., K., & S W.	4 to 6	13,000	—	14/6	—	H W. 0/11 S W. 0/10	H & S W. 0/9	Various methods tried. The Mun. E. thinks there is not much difference between them, but favours laying blocks dry with close jt., grouted with ct. & s. Expansion jt. $\frac{1}{4}$" for every 6' of roadway.	The Mun. E. has examined and tested many kinds of paving woods. He is of opinion that wood is suited for moderate gradients, but for level roads with heavy traffic he prefers asphalte. He thinks S W. is quite unsuited to the traffic of London streets.
District. . . .	H W. & S W.	5	9,000	—	14/0	12/0	H W. 1/0	—	—	
HUDDERSFIELD . .	K.	4½ to 6	14,090	1898	13/0 Gr. 13/0	10/9	—		Concrete foundation 6" to 8". Dipped in mixture of p. & t. Open jt. Grouted with ct. & s. Expansion jt.	Satisfactory.

Name of Municipality.	Wood Used, Depth of Blocks, Area Laid, and Date of First Laying.				First Cost, per yard super, including Foundation.		Annual Cost of Maintenance per yard super.		Present Method of Laying, Foundation, Jointing, Grouting, etc.	Results and Opinions as to the use of Wood for Street Paving.
	Wood.	Depth.	Area.	Date.	H W.	S W.	Repairs.	Cleansing and Watering.		
		Inches.	Yds. sup.							
Hull	J. & K.	$4\frac{1}{2}$ & 5	10 miles	1895	16/0 Same as first-class Gr.	—	—	—	Concrete foundation 7″. Dipped one side in hot asphalte mixture. Close transverse, open ($\frac{1}{8}$″) butt jts.	Contemplate laying considerable quantity more. Probably J. and K. will be used, but the Mun. E. recommends H W. for main roads, and Cr R W. for streets with light traffic. Samples of section of K. laid in 1895, 6 years' wear, $\frac{1}{4}$″.
	Cr R W.			—	—	12/9				
	A R G.			1901	14/9					
Ilford	None	—	—	—	—	—	—	—	—	When tramways are constructed, wood may be laid in the principal town streets.
Ipswich	J.	—	Small	1898	—	—	—	—	Concrete foundation 3″. $\frac{1}{4}$″ jt. Grouted with ct.	J. has been found to contract in hot, dry weather, the end joints opening slightly. Cr D. wears well. Granite setts have been entirely given up.
	Cr D.	4 & $4\frac{1}{2}$	4 miles	1888						
Islington	J. & K. Y D., A R G. and other woods	$4\frac{1}{2}$ & 5	5 miles.	—	16/7 to 17/1	13/0 to 13/4	—	—	Concrete foundation 6″ and 7″. Dipped in p. Close jt., and in some cases open jt. with lath between. Grouted with bit. Expansion jt. $1\frac{1}{2}$″.	J. has been used with excellent results. The expansion and contraction, to which all woods are liable, are corrected by careful supervision. The expansion joints are watched, and when they show signs of closing they are immediately widened. If the blocks appear to be contracting they are carefully watered. By this means the chief difficulty of wood paving is met and a good road is secured. The steepest gradient in these woods is 1 in 29.
Keighley	A R G.	5	630	1901	14/0	—	—	—	—	Too recent to express any opinion as to result.
Kensington	J.	4	5,390	1891–2	—	—	—	—	Close jt. Grouted with p. & t., or ct. (Various methods have been tried.)	Experiments have been made with many sorts of wood, but Cr D. is preferred. The present depth of block used is 4″. It has been found that the recent cost of converting a macadam road into a 4″ Cr D. road (1 year maintained by the Contractor free) is 9/8 to 10/0 per yard super.
	Plain & Cr D.	4 to 6	200,000	1877						

Lambeth	J.	5	230,000	1888	14/0 Gr. 17/0	—	—	—	Dipped one side and one end in thin mixture of p. Close jt. A thin fluid mixture of cement grout is swept over the surface, when laid. (The fishmongers and butchers object to the use of pitch on surface, which, they say, creates a blue dust which is injurious to their trade.) Expansion jt. 2″. Blocks cut by Corporation.	The Mun. E. regards J. as one of the best paving woods that can be used, provided that it is properly prepared and well laid. He thinks there is no likelihood of any change of material in his district, so long as the wood is received in good, sound, and mature condition. Lambeth was the first Municipality in London to use J. for paving purposes. Samples of J. taken up from Westminster Bridge Road, laid in 1889 at a stopping and starting place for 'buses, after 10½ years' wear, showed that it had worn 1⅛″.
Lancaster . . .	R W., Fir, & B.	5	27,000	—	13/0	12/0	—	—	Dipped in p. Close jt. Laid diagonally.	The Mun. E. endeavoured to obtain J. in 1898, but could not, at the time, rely upon a continuous supply. Wood wears well and gives satisfaction.
Leeds	J. R D.	— —	6,000 4 miles.	—	— Gr. 14/0	12/6	—	—	—	Eminently satisfactory. The Highway Surveyor thinks that 7″ and 8″ lengths would suit streets of heavy traffic as well as 9″.
Leicester . . .	J. & K. Cr D.	4 & 5 5	10,035 7,500	1892	13/0 to 18/0	12/0	Much cleaner and cheaper than S W.	—	Dipped in p. Close jt. Grouted with p. & t. (Four methods tried—(1) with ¼″ jt., (2) with 1/16″ jt., (3) with close jt.—all grouted with ct. & s.; (4) with close jt., grouted with p. The last method proved the best.) Expansion jt. 1″ to 2″.	Streets generally in good condition. Samples of J., 9 years' wear, ½″.
Lincoln	J. Y D. & Black Butt	4	13,340	1899 1891 1897	13/7 Gr. 11/0	8/7½	—	—	Close jt. run with p. & t.	The Y D. laid from 1891 to 1894 was taken up in 1901. The Corporation now lay J. only.

Name of Municipality.	Wood Used, Depth of Blocks, Area Laid, and Date of First Laying.				First Cost, per yard super, including Foundation.		Annual Cost of Maintenance per yard super.		Present Method of Laying, Foundation, Jointing, Grouting, etc.	Results and Opinions as to the use of Wood for Street Paving.
	Wood.	Depth.	Area.	Date.	H W.	S W.	Repairs.	Cleansing and Watering.		
		Inches.	Yds. sup.							
LIVERPOOL . . .	J. & K. Cr R P., Prism O. & other woods	4 & 5 / 6	8 miles.	—	J. & K. 17/0 Prism O. 18/0	Cr R P. 15/6	J. & K. 1/7½ Cr R P. 1/9½ Prism O. 1/8½, including interest and sinking fund, over 15 years.	Included in maintenance.	—	Samples of J. and K. (Exchange Street East —heavy traffic), 5½ years' wear, average of blocks examined, $\frac{13}{32}$". The City Engineer is satisfied as to the wearing character of J., to which he assigns a life of about 15 years. But, taking the life of Gr. at 30 years, and the cost of maintenance, he considers wood paving is too costly. The Prism O. is wearing exceedingly well.
LLANELLY . . .	None	—	—	—	—	—	—	—	—	The Mun. E. would like to see wood adopted.
LONDON (CITY) . .	H & S W.	6	132,000	—	—	—	—	—	—	In a Report issued in 1900 it is stated that all the streets (15) in the City paved with Australian H W. are in good or fair condition, with the exception of two only; but the length of time they had been down was not sufficient to warrant an opinion as to their ultimate durability. Of the exceptions cited, the one, laid in 1893, showed signs of wear, and the other, laid in 1896, though in fair condition, showed slight signs of wear. Most of the principal streets are paved with asphalte, which the City Engineer regards as the best for the special and extraordinary traffic of those streets.
MANCHESTER . .	J. & K. Cr B.	4 & 5 / 6	7,600 / 7,500	1894	J. 18/8 K. 18/6¾ Gr. 13/6	Cr B. 15/11½	S W. 1/2	1/7¼ per 1,000 yards per ann.	Concrete foundation, sanded. Close jt. run with p.	J. does not appear to wear quite as well as the Samples of K.—7 years' wear ½". Cr B. appears to wear well. There are general complaints as to the slipperiness of wood, arising, in part, from the heavy loads drawn by Manchester horses and the method of shoeing, and also from the difficulty of keeping the streets properly cleansed.

MIDDLESBROUGH . .	None	—	—	—	—	—	—	—	—	Tar macadam, composed of local slag, is mainly used. Result is not satisfactory, owing to the heavy traffic. Enquiries are being made on the subject of H W.
NELSON	None	—	—	—	—	—	—	—	—	It was proposed to lay wood in one of the principal streets (a main road), but the Corporation did not approach the Lancashire County Council, having heard that they would not grant a subsidy for wood.
NEWCASTLE-ON-TYNE	J. & K.	5	60,000	1899	16/6 to 21/9 Gr. 18/9 to 19/9	—	—	—	Concrete foundation 6″ to 7″, with $\frac{1}{4}$″ sand on surface. Dipped in p. & t. Close jt.	Public greatly appreciate the change from granite setts. Corporation have voted £6,000 per annum to be expended on further extension. A still larger outlay is under consideration.
NEWPORT	K. M.	5	5,129 2,000	1898 1898	K. 19/0	M. 12/0	—	—	Close jt. Grouted with p.	Condition of K. paving good, but public complain of slipperiness in wet weather. M. used on gradients.
NORTHAMPTON . .	R D.	—	£1,500	—	3/0 more than Gr.	—	—	—	Close jt. run in with ct. grout.	The Mun. E. says that his experience of wood paving has not been satisfactory—due, he thinks, to the use of soft woods.
NORTHFLEET . . .	J.	4	7,200	1902	15/0	—	—	—	Dipped in p. and cr. o. $\frac{3}{16}$″ jt. Grouted with p. & cr o. to within 1″ of surface, then flushed up with ct. & s.	The Mun. E. is quite satisfied that J. is a wood well suited for street paving.
NORWICH	J. & K. Cr D.	4 5	9,700	1899	Same as Gr.	About 10% less than J. or K.	—	—	Dipped in t. Close transverse jt. $\frac{1}{16}$″ to $\frac{1}{8}$″ butt jt. Grouted with ct.	A section of 3″ deep J. was laid on a lifting bridge in 1898—carriage-way 8′ between kerbs, traffic heavy, gradient 1 in 18. Samples taken after 3 years' wear show that the blocks had worn $\frac{1}{5}$″. The whole of the J. & K. paving is in a thoroughly good and sound condition, but it has a tendency to slipperiness in wet weather. Any trouble arising from the contraction of the blocks is remedied by watering and reasonable attention.

Name of Municipality.	Wood Used, Depth of Blocks, Area Laid, and Date of First Laying.				First Cost, per yard super, including Foundation.		Annual Cost of Maintenance per yard super.		Present Method of Laying, Foundation, Jointing, Grouting, etc.	Results and Opinions as to the use of Wood for Street Paving.
	Wood.	Depth.	Area.	Date.	H W.	S W.	Repairs.	Cleansing and Watering.		
		Inches.	Yds. sup.							
NOTTINGHAM . . .	J. & K. Cr D. & B.	—	—	1893	—	—	—	—	Concrete foundation 6″ to 8″. Dipped in t. Close jt. Grouted with p. & t. Expansion jt. ½″ to 1″ for every 10′ of roadway. (Necessary to allow greater expansion with cement than pitch joints.)	J. and K. wear better than plain D.; but, in view of the cost, the City E. is doubtful whether they are cheaper, in the end, than Cr D. and B. He is of opinion that the principal advantage, from a hygienic point of view, of using Australian hard wood consists in the fact that it is less absorbent than soft woods, as shown by the former being so frequently dry, when soft wood is wet and greasy. The steepest gradient for wood is 1 in 30. Considerable quantities of J. and K. are being laid in connection with tramways.
OLDHAM	K.	4½	1,400	—	10/6, exclusive of foundation.	—	—	—	Concrete foundation, with gravelled surface.	Satisfactory, but traffic light. Laid opposite Town Hall. Propose extending use, but the gradients are too steep for wide adoption.
OXFORD	S W.	—	—	—	—	—	—	—	Concrete foundation 4″	A few sections, laid between tram lines, opposite places of worship. No H W. used.
PADDINGTON . . .	J.	5 & 6	102,357	1897	—	—	—	—	In all cases the blocks are laid on a foundation of 6″ cement concrete, and, after completion with a tar joint, the surface of the wood is washed with cement and then covered with fine hoggin or shingle.	The Jarrah-paved roads are all in good condition, with the exception of Praed Street (laid 1897), where the thoroughfare is narrow and the traffic ('bus and general) excessive. The Corporation are discontinuing the use of soft woods.
	Y. D.		42,746	1893						
	Cr D.		44,585	1898						
	A R G.	5	4,421	1901						

PENZANCE . .	J.	5	Street and wharf.	1898	—	—	—	—	Dipped in p. and cr o. or bit. to three-quarters of block. Close jt. Blocks driven up tight. Grouted with t., and surface well sanded. Expansion jt. *Vide* reference to Mun. E.'s work on "Roads, Paths, and Sea Defences."	No signs of wear. J. suffers less on wharf, where tin is tipped, than the previous paving—cement concrete blocks. The Mun. E. is of opinion that 7" and 8" lengths would do as well as 9". He was instructed last year to report on the laying of J. in a main thoroughfare. *Vide* reference to "Recent Works on the Subject."
PLYMOUTH . . .	J. K. Cr D.	4 5 5	21,000 9,000 27,000	1896 1901 1879	16/0	12/6	—	5·53*d.* cleansing 0·80*d.* watering	H W.—Dipped (bottom) in asphalte mixture. Close jt. Grouted with ct. & s. S W.—Open jt. Grouted with p. at bottom and ct. & s. at top.	H W. satisfactory. Extending use.
POOLE	None	—	—	—	—	—	—	—	—	Subject of adopting wood will probably come up for consideration soon.
POPLAR	J.	—	6 miles	—	—	—	—	—	Slips $\frac{1}{10}$" wide placed between blocks. Grouted with p. & cr. o. Flushed up with ct.	Satisfactory.
PORTSMOUTH . . .	J. & K.	—	5,000	1901	Same as Gr.	—	—	—	Close jt., longitudinal; open jt., ends. Grouted with p.	Too recent to state results.
RAMSGATE . . .	J. Cr D.	4 to 5 5	27,512 15,553	1894 1886	14/6—5"	11/9—5"	—	—	Concrete foundation 8 to 1. Blocks laid direct on rendering. Hand-dipped in asphalte grouting and laid with close jt.; afterwards grouted with thin cement grout. Tramway company have laid 19,200 yards of wood (not included in return) with open jts. Result not satisfactory.	The Mun. E. very strongly favours wood paving, both hard and soft, but does not advocate hard wood on grades steeper than 1 in 30. He does not experience any difficulty where method of laying stated in previous column has been adopted. With open jts. grouted with pitch and cement there has been much trouble. He thinks that very often too large expansion jt. is left. There have been complaints of slipperiness, but a little grit soon remedies this. Hard wood requires watering three times a day in summer, the same as asphalte. He regards the hard wood laid as an impervious sanitary pavement. Samples of 4" J. laid in Harbour Street 1894—subject to heavy wear from skidding and wheel brakes, on incline 1 in 12—taken up 1901, showed only $\frac{1}{2}$" wear.

Name of Municipality.	Wood used, Depth of Blocks, Area Laid, and Date of First Laying.				First Cost, per yard super, including Foundation.		Annual Cost of Maintenance per yard super.		Present Method of Laying, Foundation, Jointing, Grouting, etc.	Results and Opinions as to the use of Wood for Street Paving.
	Wood.	Depth.	Area.	Date.	H W.	S W.	Repairs.	Cleansing and Watering.		
		Inches.	Yds. sup.							
REIGATE	S W.	4½	—	—	—	11/6	—	—	Close jt.	Estimates have been prepared for the adoption of hard wood paving in the borough. The Mun. E. recommends J. and K.
ROCHDALE . . .	Cr B.	5	800	1896	14/0	—	—	—	Laid dry. Run with p. Grouted with ct. & s.	Satisfactory. A quantity of wood paving is likely to be used in connection with proposed tramways conversion to electric traction.
ROCHESTER . . .	K.	4½	200	1897	15/0	—	Nil	Not ascertained	Dipped in p. Close jt. Grouted with p. Pitch expansion jt. 1″.	Pavement in excellent condition. Wear ⅛″ in 4 years. Road 18′ wide. No trouble from expansion.
ROTHERHAM . . .	None	—	—	—	—	—	—	—	—	Adopting combined paving known as "the Bingham pavement"—granite setts with wood intersections—on steep gradients. The general adoption of wood in the principal streets is likely to be considered, in connection with proposed tramways extension and town improvements.
ST. MARYLEBONE. .	J. Y D. A R G.	4½ & 5 5 & 6 4½ & 5	15,200 Large. Small.	1899	5″ 15/0	6″ 12/3	H W., no cost since laid. S W., 0/4 to 0/7	—	Close jt. Grouted with p. & t.	The Corporation have given preference to S W.; but the Mun. E. thinks that H W., properly seasoned and well laid, would probably make a better and certainly a more durable pavement. Large section of 4″ J., dowelled (Duffy's Patent), laid 1897 front of Gt. Central Railway Station, is wearing exceedingly well.
ST. PANCRAS . . .	J. K. Baltic D.	4 & 5 4 & 5 6	162,006 6,046	1892 1893	14/6	11/6	Some J. down for 8 years without repairs. J. less than S W.	—	Concrete foundation 6″ or more, according to traffic and other circumstances. Spruce slips 1″ wide and about $\frac{1}{16}$″ thick are inserted between each course of blocks, thus securing a joint from	Sections of Blue Gum, Stringy Bark, Kauri Pine, Pitch Pine, American White Oak, &c., have been laid at various times, but the fact that the Highways Committee have used J. so extensively during the past 10 years is sufficient to indicate their approval of this wood. The Mun. E., while satisfied as to the wearing character of J. and K., does not approve of their being too

									$\frac{1}{16}$" to $\frac{1}{8}$" in width. The end joints are left open to the same extent. The joints are filled with a hot mixture of p. & cr o. Grouted with p. Expansion jt. 1" to $1\frac{1}{2}$". (Various methods had been tried, but this has proved, in the main, the best.)	dry or too much seasoned. He prefers to take his timbers *ex* ship. In his judgment, the slipperiness of hard wood in wet or frosty weather can be remedied by careful sanding. The steepest gradient for wood is 1 in 34, which is regarded as quite steep enough for H W. *Vide* Viagraph Report.
SALFORD	C B. & Haskinised wood blocks.	—	Small	—	16/0	—	Requires repairs in about 10 years.	—	—	Laid opposite Church and Hospital. Satisfactory.
SHEFFIELD . . .	J.,K. & R W.	5 & 6	4 miles	—	5" 14/3 6" 16/3	6" 13/6	—	—	Dipped in p. & t. Close jt. run with p. & t. to within an inch of surface. Grouted with ct. & s.	J. and K. are chiefly laid in connection with electric tramways. The wear of these woods against the rails is better than could be expected, and is certainly more satisfactory than R W. for that purpose.
SHOREDITCH . . .	J.	5	32,500	1896	10 % cheaper than Gr.	—	—	Scavenging costs less than Gr.	Dipped in p. Close jt. run with bit. Grouted with p., to 3' from kerbs. Centre of roadway grouted with ct. & s. Expansion jt. $1\frac{1}{2}$".	Roads all in good condition.
SOUTHAMPTON . .	J. & K.	4 & 5	9 streets & roads.	1898	—	—	—	—	Dipped about 3" in p. $\frac{1}{8}$" jt. Grouted with boiling p. & cr o.	Eminently satisfactory, especially as regards cleanliness and cost of scavenging. Samples of 4" K. (East Street—heavy traffic) show 3 years' wear to be $\frac{1}{32}$".
SOUTHEND-ON-SEA .	K.	5	5,600	1896	17/6	—	—	—	Close jt. Grouted with p. & t. Surface covered with layer of fine gravel.	Laid in tramway track and adjoining roadway. Too recent to judge as to wear, but is clean and noiseless.
SOUTHPORT . . .	J.	$4\frac{1}{2}$	Parts of 3 streets.	1901	—	—	—	—	Two methods of laying J. have been adopted —(1) Blocks laid dry. Grouted with p. and sprinkled with s. (2) Dipped in p., and grouted with ct.	Too recent to give opinion as to wear of J. or A R G.
	C D. A R G.	$4\frac{1}{2}$ & 5 $4\frac{1}{2}$	7,500 Large	1884 1901	—	12/0 to 13/6				
SOUTH SHIELDS . .	J. & Cr D.	—	6,000	—	Same as Gr.	—	More than Gr.	—	Dipped in p. Close jt. Grouted with ct.	Satisfactory. Extending use.

Name of Municipality.	Wood used, Depth of Blocks, Area Laid, and Date of First Laying.				First Cost, per yard super, including Foundation.		Annual Cost of Maintenance per yard super.		Present Method of Laying, Foundation, Jointing, Grouting, etc.	Results and Opinions as to the use of Wood for Street Paving.
	Wood.	Depth.	Area.	Date.	H W.	S W.	Repairs.	Cleansing and Watering.		
		Inches.	Yds. sup.							
Southwark . . .	J.	4½ & 5	109,182	1893	—	—	H W. cleaner and cheaper than S W	—	Laid dry. Run with p. ⅛″ jt. Grouted with ct. & s. (Various methods tried.)	J. laid in over 40 streets and roads. A recent Report states that of these, 34 are "good," 8 "fair," and 3 (small areas) "bad" or "uneven." The Mun. E. lays great stress upon the necessity of the concrete foundation being allowed time to set. He lays his blocks dry, owing to the difficulty of getting the paviors to dip them carefully. *Vide* Viagraph Report.
Stepney—										
Whitechapel . .	J.	4 & 5	3 miles.	1894	16/6	12/6	—	—	Close jt. run with p. Grouted with p.	J. satisfactory, although the traffic is exceptionally heavy. Extending use.
	S W.	5								
Limehouse . . .	J.	—	Large	1897	—	—	—	—	Close jt. Grouted with ct. & s.	Ditto.
Stoke Newington .	J.	4	15,000	—	14/9	4″ 11/5	—	—	Close jt. Grouted with p.	Satisfactory.
	Cr D.	4 & 5	14,000							
Stratford . . .	J.	—	—	—	Same as Gr.	—	—	—	—	Laid in front of churches and places of public resort.
Sunderland . . .	K.	—	100	—	—	16/11	—	—	K. laid diagonally with ⅛″ jt. Grouted with p.	K. is only used for a few crossings. It is found to be slippery; but the Mun. E. thinks that if it were more generally adopted this objection might disappear. Other woods are, however, preferred.
	Cr M., R D., Scotch Fir & B.	—	Large.							
Swansea	None	—	—	—	—	—	—	—	—	The subject of adopting J. and K., in connection with the extension of tramways system, is under consideration.
Taunton	J.	5	Small	1895	—	—	—	—	Open jt. divided by ¼″ strips, run with bit. Grouted with ct.	Samples of J. show ⅝″ wear in 6 years. Corporation wish to extend use of wood in main streets, but the Somerset County Council do not, at present, approve.
Teddington . . .	H W. & S W.	4	Small	—	—	—	—	—	—	For crossings.
Wakefield . . .	J.	5	1,700	1898	—	—	—	—	Concrete foundation 9″. ⅛″ jt. Grouted with p. & t. Expansion jt. 1½″.	Fairly satisfactory, but rather slippery.

WALLASEY, Cheshire	A R G.	—	—	1901	—	—	—	—	Close jt. Grouted with p.	Too recent to express opinion.
WALTHAM ABBEY .	None	—	—	—	—	—	—	—	—	If wood be adopted, it will probably be J. or K.
WANDSWORTH—										
Eastern . . .	J.	5	14,610	1895	16/6	8/9	—	—	Dipped in p. Close jt. Grouted with ct.	Various sample woods have been tried—Kauri Pine (N.Z.), Padouk (India), Ironwood, Ironbark, Crow's Ash and Bloodwood (Queensland), Blue Gum and Stringy Bark (Tasmania). With the exception of the last two, these are in fair condition. For even wearing S W. is preferred, but the Mun. E. thinks that H W. is less slippery. The chief difficulty he finds with H W. is its liability to shrink, and he suggests whether any process, similar to creosoting, could be adopted to check this tendency.
(Streatham and Balham)	D.	6	15,376	1889						
Western . . .	K.	4	4,925	1893	13/6 to 15/0	10/6 to 14/6	—	—	Dipped in p. Mainly close jt. Grouted with ct.	Generally satisfactory. Extending the use of Cr Archangel D.
(Wandsworth and Putney)	Cr Archangel D.	—	16,000							
WARRINGTON . . .	Cr D.	—	Large	—	—	—	—	—	—	Satisfactory. Extending use.
WATERLOO, Lancs .	J., American O. & A R G.	4	Small	1900	J. 13/0 O. & A R G. 12/9	—	—	—	Close jt. Grouted with p. & t.	Trial sections. The Mun. E. prefers J. to American O. or A R G.
WEST HAM.	J.	5	2,300	1898	16/0	—	—	—	Close jt. Grouted with p.	J. paving in good condition.
	Y Pine	6	800							
WESTMINSTER . .	J. & K.		60,000	1894	—	—	—	—	Usually close jt. Grouted with p.	The City of Westminster includes the late Vestries and District Boards of Works of St. James's, St. Martin's, St. George's, St. Margaret's, St. John's, and the Strand. Various woods have been tried. Objections have been raised to the use of H W. blocks on account of their liability to expansion and contraction, which, unless remedied, lead, in some instances, to wide joints and an uneven surface. The Corporation therefore have deemed it wise, in recent contracts, to adopt the comparatively new wood, A R G., and to extend the use of Cr D. Of the H W., Karri is the principal. The amount of Black Butt, Tallow Wood, and Crow's Ash is small.
	Black Butt Crow's Ash Tallow Wood									
	A R G.	—	Large	Recently.						
	Cr D.	—	400,000	1883						
WILLESDEN . . .	J.	4 & 5	4,627	1894	—	—	—	—	Close jt. Grouted with p. or ct.	In good condition.

Name of Municipality.	Wood used, Depth of Blocks, Area Laid, and Date of First Laying.				First Cost, per yard super, including Foundation.		Annual Cost of Maintenance per yard super.		Present Method of Laying, Foundation, Jointing, Grouting, etc.	Results and Opinions as to the use of Wood for Street Paving.
	Wood.	Depth.	Area.	Date.	H W.	S W.	Repairs.	Cleansing and Watering.		
		Inches.	Yds. sup.							
Wolverhampton	J.	5	3,200	1898	16/8	—	—	—	Close jt. Grouted with p. & t.	All in good condition.
	Y D.	5	About	—	—	11/6				
	Prism O.	—	½ mile	—	17/3					
	A R G.	5	240	1901	17/3					
Wood Green	J.	—	11,200	1897	—	—	—	—	Close jt. Grouted with p. & t.	Laid in High Street, now taken over by the Middlesex County Council. The Mun. E. states that the wood is highly satisfactory, and that in any further extension he should recommend J.
Woolwich	J.	5 & 6	—	1893	—	—	—	—	—	J. was first laid in front of places of worship: but a further section of it and a section of A R G. have been recently laid.
	A R G.	5	—	1901						
Worcester	J.	—	200	1897	15/0	—	—	—	Dipped about ⅔ of block in bit. Close jt. run with p. and brushed over with s. Expansion jt. 2″.	B. & Prism O. have been tried. The City E. regards the J. as wearing so well that, in the event of further extension, he would recommend its adoption.
Worthing	J.	3	Section	1898	—	—	—	—	—	Highly satisfactory.
Yarmouth	J.	—	3,000	1896	12/0 (by Corporation).	8/6 (by contract; unsatisfactory).	—	—	Close or $\frac{3}{16}$″ jt. Grouted with ct. & s.	The Mun. E. says that in laying a tramway through a portion of the paving done six years ago, he finds the J. blocks had only worn ¼″ on the crown of the road, though the traffic is heavy. He noticed also that there had been no saturation of the blocks, which appeared to be in a sound sanitary condition. Extending use.
	M.	—	12,000							
York	J. & K.	4½	7,000	1897	13/0	10/6	—	—	Close jt. run with p. to about ⅔ of block. Grouted with ct.	All the hard woods are satisfactory, but Corporation do not propose to adopt them to the exclusion of Cr R W. or other suitable woods.
	Cr R W.	4½	35,000	1888						
	Prism O.	—	217	1901	16/0					

PARTICULARS OF SPECIFICATION FOR WOOD PAVING FOR ST. PANCRAS AND CAMBERWELL.

St. Pancras.—It is specified by this Corporation that "the timber from which the blocks shall be cut shall be of the best quality of the nature referred to in this Specification and the annexed form of Tender, and of recent importation. . . . Absolute strictness in the depth of the blocks will be required, and no variation greater than $\frac{1}{8}$th inch in width will be permitted. The blocks are to be of sound wood throughout, free from every defect, and are to be delivered as directed. . . . All rejected blocks are to be removed by and at the expense of the Contractor as directed by the Engineer, or they will be regarded as forfeited and will be disposed of as may be directed by the Engineer." The work of laying is done by the Corporation, but, in the event of a contractor being employed, it is understood that "Two courses are to be laid longitudinally to form a channel, leaving an opening next the kerb of one inch. The blocks between the channels are to be laid across the road, square to the kerb, except at intersections of branch streets, where the courses are to be laid diagonally to form a mitre, to extend over the width of the branch street. All cross joints to overlap or bond by about three inches, and between the courses are to be laid pine laths one inch wide by $\frac{1}{10}$th of an inch thick, and laid on edge on the concrete so as to preserve a joint $\frac{1}{10}$th of an inch between the courses, and the same width is to be preserved in the cross joints but without laths. Closing blocks must be neatly cut to the size and shape required, to preserve the same width of joint as above described, but no closer is to be less than two inches in direction of the courses. After the blocks are paved, the joints are to be run with a mixture of pitch and creosote oil boiled together and in such proportions as to allow the mixture, when cooled down to 60° F., to be drawn out in an unbroken thread as far as can be spanned by the extended arms of one man. The mixture is to be poured on to the pavement while boiling, and in small quantities, and to be worked forward with an india-rubber squeegee, so that the material may be driven into the joints, without leaving any considerable thickness on the surface of the pavement. After the first dressing is over, when the mixture is set, all joints are to be examined and filled up, again using the squeegee, and, when all the joints are filled, the surface of the pavement is to be lightly dressed over with sharp grit."

Camberwell.—It is specified by this Corporation that "the Jarrah Wood Paving blocks are to be properly thicknessed to exactly three inches, and to be of the very best Jarrah wood, thoroughly well seasoned and free from all sap, shakes, loose or dead knots, and other defects, and to be of a close and uniform grain. A sample block must be delivered by the Contractor with his Tender, which shall be taken as a sample of the blocks he undertakes to supply, both as to measurement and in every other particular. The blocks are to be dipped by hand into a composition to be composed of pitch, tar, and creosote oil, in the following proportions:—One ton of pitch, 225 gallons of tar, 8 gallons of creosote oil—and to be laid close jointed, and to be afterwards grouted in with cement and clean sharp river sand, mixed in a proportion of

one of cement to two of sand, the water added through a rose sprinkler, and carefully brushed over the surface of the wood paving so as to thoroughly flush up all interstices, this work to be repeated until the whole is well and solidly grouted up. The blocks are to be dipped into the composition while hot, and immersed so as to thoroughly coat the bottom, ends, and sides of each block with the same. An expansion joint to be left each side of the carriage-way adjoining the kerb, equal in width to one inch for every 20 feet of roadway; this to be filled in with plastic clay or other suitable material. Three courses laid longitudinally are to form the channelling on each side of the roadway. The gully gratings, ventilation and manhole covers, &c., are to be specially framed around in the paving material. No closer will be allowed under any circumstances of a length less than half that of the wood block. At all street intersections the courses shall be laid diagonally, so as to form a triangle, with its apex towards the centre of the street being paved. The whole of the roadway to receive a coating of fine shingle, before it is opened for traffic."

VIAG

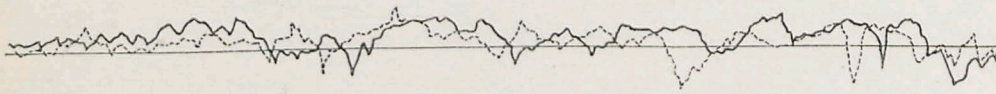
GIVING DATUM LINE AND VARIATION RECORDED BY

The Profile of the Road Surfaces is full size vertical

1.

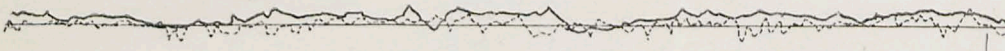
KARRI.—Bridge Road,

2.



CREOSOTED DEAL.—Bat

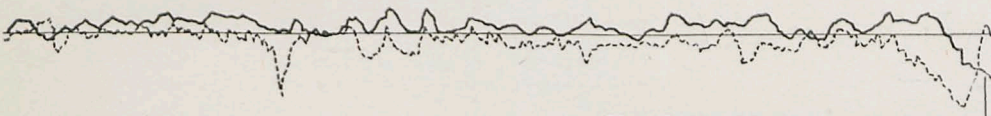
3



KARRI.

St. John's Road, B

4.



HASKINISED DEAL.

Peckham Road, Camberwell,

5.

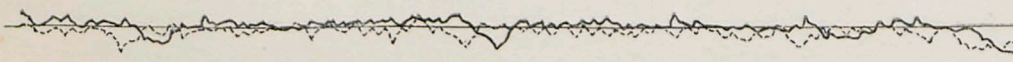
CREOSOTED DEAL.—Havil Street, o

6.

AMERICAN RED GUM.

Camberwell R

7.



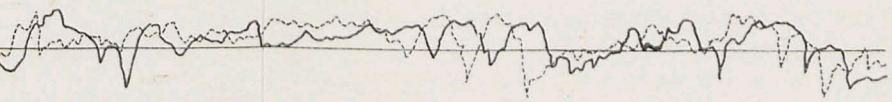
JARRAH.—Tyers Stree

RAMS

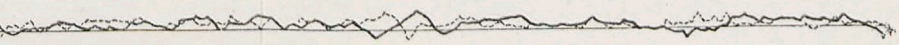
SLIDER (THICK LINE) AND WHEEL (DOTTED LINE).

ly and on a scale of $\frac{1}{8}$ inch to a foot horizontally.

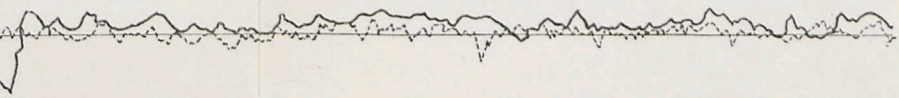
BATTERSEA (1899).



TERSEA PARK ROAD (1895).



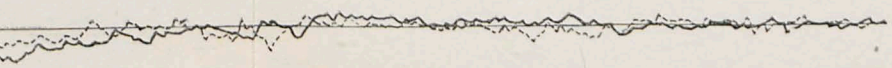
JARRAH.
ATTERSEA (1897).



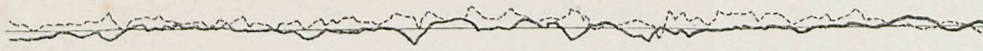
JARRAH.
OPPOSITE TOWN HALL (1899).

F PECKHAM ROAD, CAMBERWELL (1899).

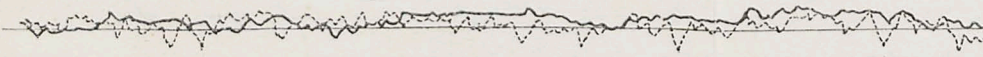
JARRAH.
OAD (1901).



T, VAUXHALL (1901).



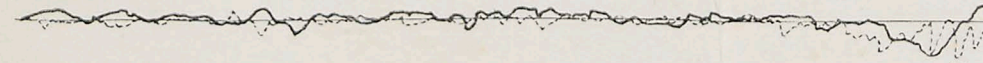
KARRI.—South L



JARRAH.—Clap

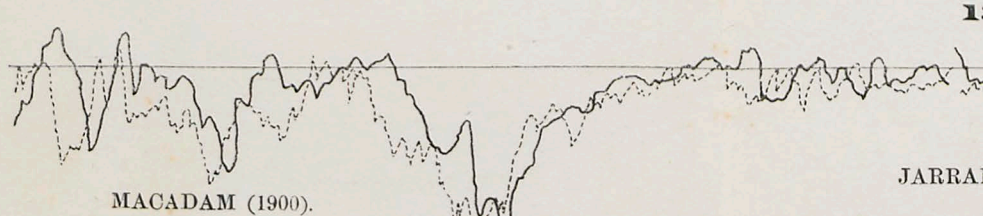
JARRAH.—Acke

JARRAH.—Pan



Tre

JARRAH.—Hampstead



MACADAM (1900).

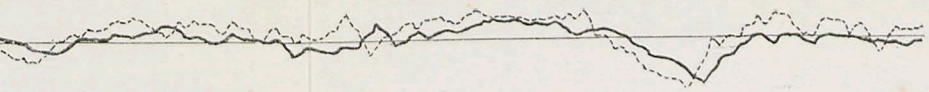
JARRA

Ampthill Squar

JARRAH.—High Street, Cam

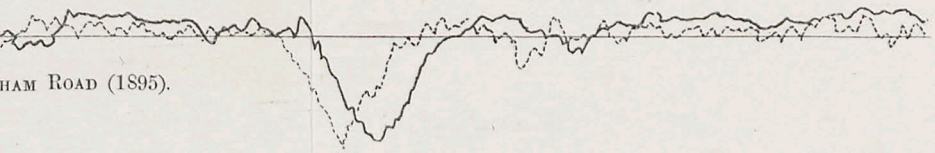
JARRAH —Trinity St

3.



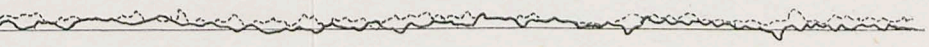
AMBETH ROAD (1899).

9.



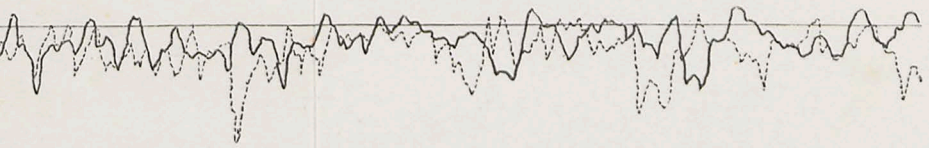
HAM ROAD (1895).

10.



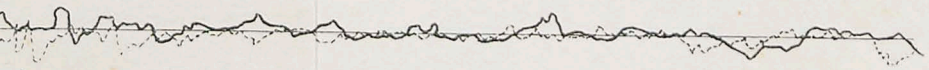
RMAN ROAD (1901).

11.



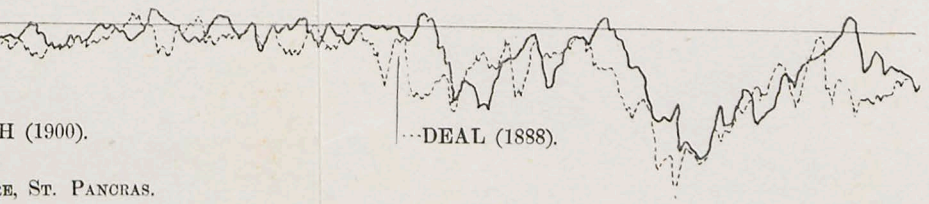
CRAS ROAD (1892).

12.



nch.
ROAD, ST. PANCRAS (1900).

13.



H (1900).

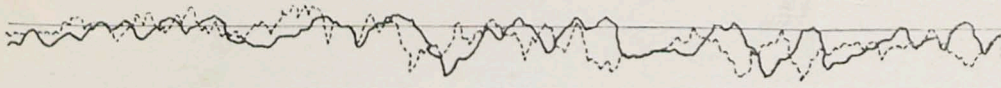
E, ST. PANCRAS.

14.

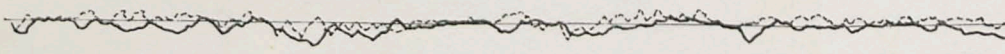
DEN TOWN, ST. PANCRAS (1901).

15.

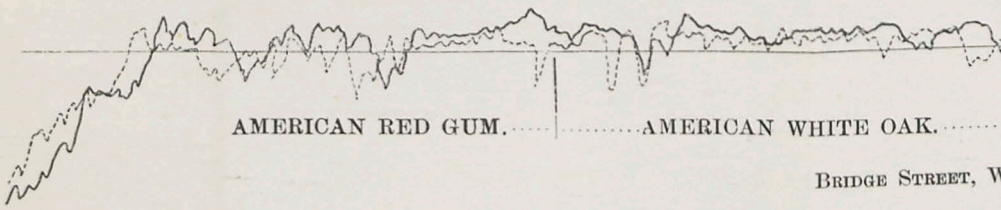
REET, SOUTHWARK (1898).



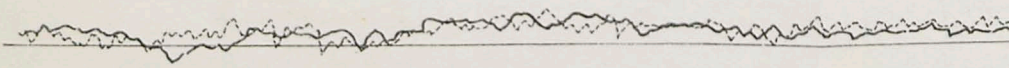
CREOSOTED DEAL.—Kenningt



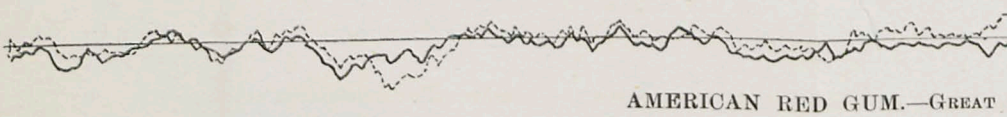
JARRAH.—Blackfriars



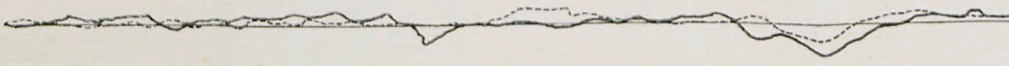
Bridge Street, W



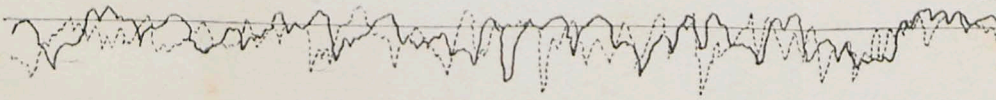
CREOSOTED DEAL



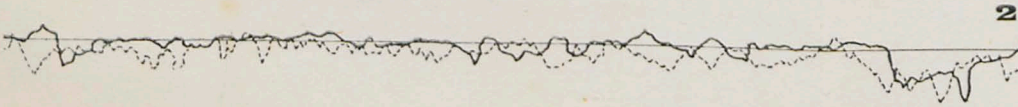
AMERICAN RED GUM.—Great



ASPHALTE.—B

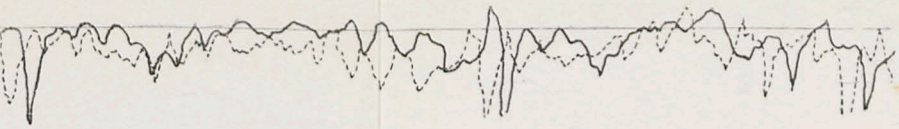


AMERICAN RED GUM.—I



KARRI.—Pall M

6.

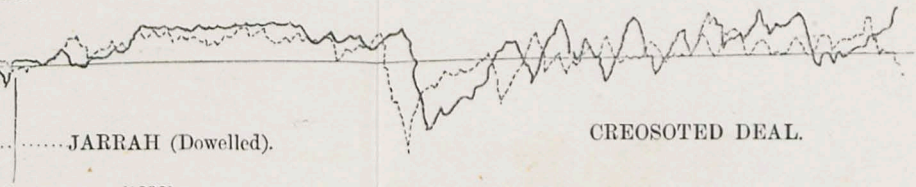


ON PARK ROAD, SOUTHWARK (1898).

7.

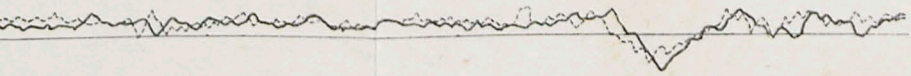
ROAD, SOUTHWARK (1899).

8.



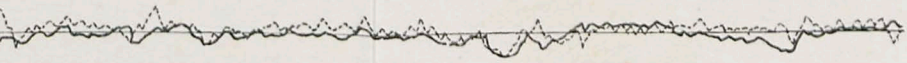
VESTMINSTER (1899).

9.



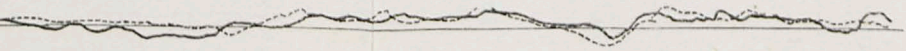
.—THE STRAND (1902).

10.



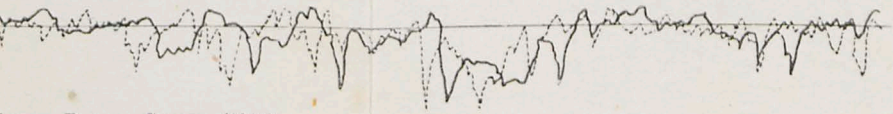
GEORGE STREET, WESTMINSTER (1901).

11.



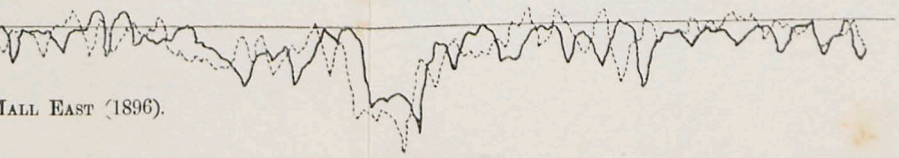
BROAD SANCTUARY.

12.



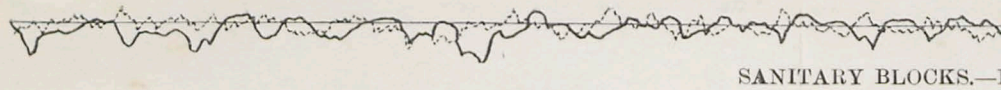
LOWER REGENT STREET (1900).

13.



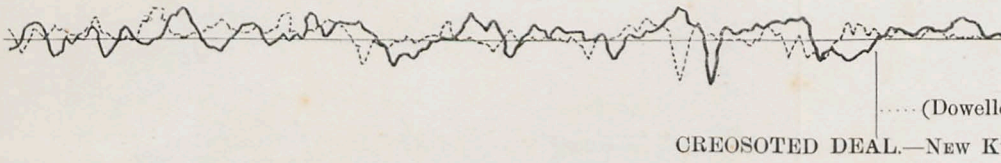
HALL EAST (1896).

24.



SANITARY BLOCKS.—

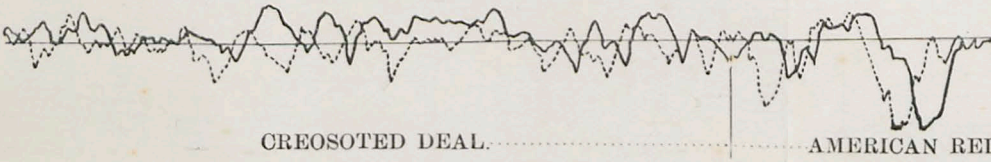
25.



(Dowell

CREOSOTED DEAL.—New K

26.

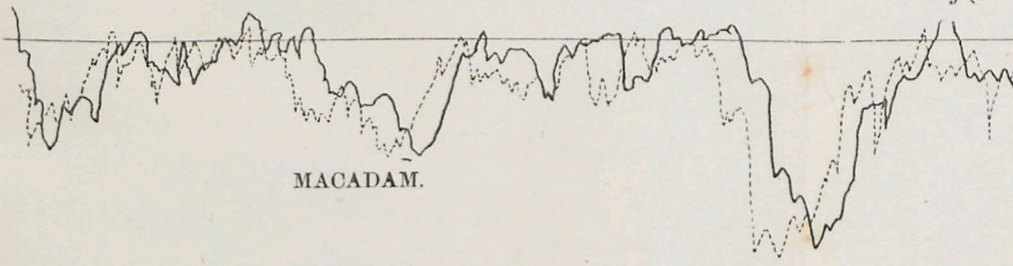


CREOSOTED DEAL. AMERICAN REI

High Street, Kens

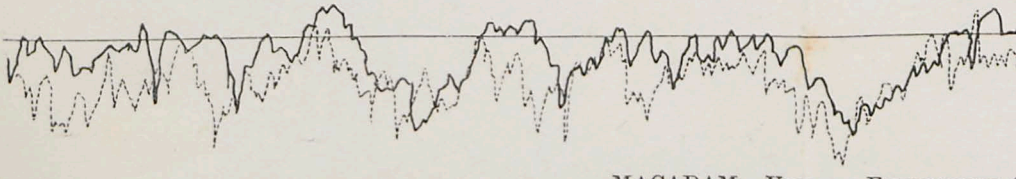
27.

Crossing (Sett



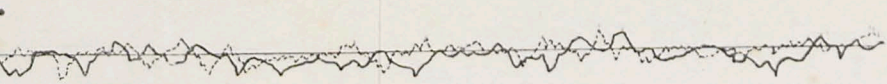
MACADAM.

28.

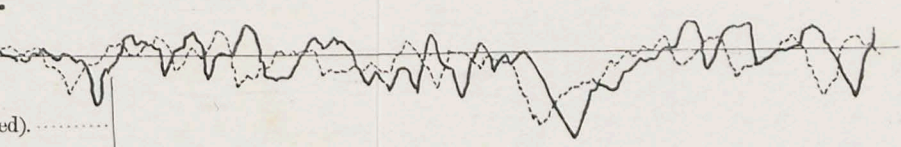


MACADAM.—Victoria Embankment (

Note.—The above Viagrams show about one-third of the distance covered by the Viagraph (88 yard
Viagram is displaced about the eighth of an inch to the left of the Slider Viagram. This displacement

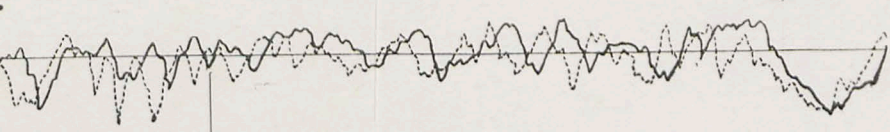


EATON SQUARE (1901).



ed). .....

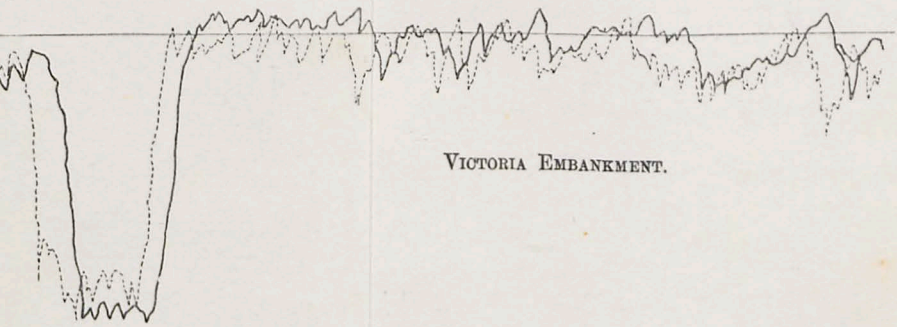
ING'S ROAD, FULHAM (1894).



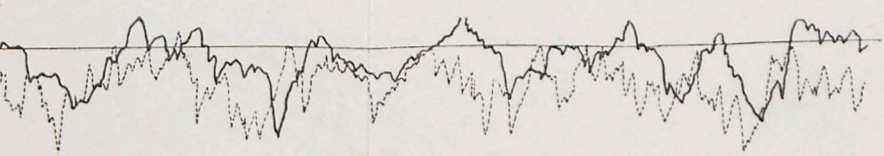
D GUM. ..... CREOSOTED DEAL.

SINGTON (1899).

s).



VICTORIA EMBANKMENT.



(repaired and rolled February, 1902).

---

s) in each road, and present an average of the surface taken. It will be noticed that the Wheel will be corrected, in future, by a slight alteration of the recording gear of the Viagraph.