

Discussion.

Mr. G. H. STAYTON said he had been told that his Paper did not deal with the obnoxious smells sometimes experienced in connection with wood pavement. He thought, however, that he had dealt with the subject fully under the head of management; he had certainly intended to do so by drawing attention to the absolute necessity for a plentiful supply of water for the purposes of cleansing. Of some samples of wood pavement which he exhibited, one block had been taken up from Oxford Street a month or six weeks ago, and it showed that wood pavement could be worn down to the thickness of a mere crust, and still retain a fair surface. It was originally about 6 inches in depth, and was laid in 1878. The wear was simply owing to the traffic upon it.

Sir JOSEPH BAZALGETTE, C.B., President, asked if the Author could give any further opinion on the subject of traction and foothold with wood pavement as compared with other kinds of pavement.

Mr. STAYTON said he could give no further opinion on the subject. It had been exhaustively treated a few years ago by Mr. W. Haywood, the City engineer; he had not, therefore, thought it necessary to deal with it again. The average thickness of the pavement at present in Oxford Street was about 3·30 inches; but at certain parts it was not thicker than the block to which he had drawn attention (1½ inch), which was a fair specimen of the pavement at those parts where the traffic was concentrated.

Mr. W. LAWFORD remembered when, in 1841, a part of Whitehall and a part of St. Giles were laid with Rankin's patent wood pavement. It was down only six or eight months when it failed, owing, as he believed, to insufficient drainage and a bad foundation; besides which the cost came to £2 10s. or £3 per square yard. The success of the present wood pavements was no doubt largely owing to the good foundations on which they were laid. He remembered seeing the pavement put down between the Chapel Royal, Whitehall, and the Horse Guards. There was no concrete, but only a wood framing as a sub-structure. A full description of it, with illustrations, would be found in 'The Civil Engineers and Architects Journal,' for September, 1841.¹ From

¹ Vol. iv., p. 307.

Mr. Lawford. the same publication he found that in 1838 many streets in Philadelphia were paved with wood, and he believed that the pavement remained to the present day, but he did not know the results.

Mr. Weaver. Mr. W. WEAVER considered that some apology was due from him as Surveyor of the parish of Kensington, where by far the largest area of wood pavement had been laid, for not having presented a Paper on the subject to the Institution. He agreed with the Author in the three propositions at the end of the Paper, especially the third, that notwithstanding many former instances of failure, the modern system had achieved a fair amount of success, and that there was no apparent reason why its use should not be extended. So far from this, he thought its use should be very much extended in consequence of an injunction that had lately been granted against his Board with reference to the use of steam-rollers. If that decision was not upset (the parish authorities were about to appeal against it) he did not think the public would like to revert to the state of things existing twenty years ago, when the traffic had to plough its way through the newly-laid macadam, and in such case wood pavement was likely to extend very much. There were some details on which he could not quite agree with the Author, one of which was the statement that wood pavement was laid down better and cheaper in Chelsea than in any other part of London. In Kensington seven different kinds of pavement had been tried—he believed every known kind except Carey's keyed-joint, and the result of his experience of those systems had led him to believe that the most economical wood pavement that could be laid was the plain deal, if it was to be laid under competitive tenders where the wood had to be inspected to see that it was of a proper description; but if the work was not tendered for, if a good price was given for a good article, and it was wished to have the work done expeditiously, he preferred the system of the Improved Wood Paving Co. with pickled blocks and asphalt joint. The work was got through much more rapidly in that way, and from the results in Kensington, he was sure that that system would last as long, if not longer, than the plain system; the cost, however, was about 1s. 6d. per square yard more. The assumed superior merits of the wood pavement in Chelsea appeared to be due, according to the Author, to the work having been executed by his own staff and the substitution of studs for asphalt or laths. But he could not see the advantage of the parish doing the work with their own staff. If they invited tenders for the supply of so many tons

of Portland cement, so many cubic yards of Thames ballast, and Mr. Weaver. for breaking up the surface, they had merely a series of competitive tenders for the work in detail, whereas in the other case they had one tender for the complete work; and he thought that the one profit in the latter case was less than the various profits in the other. He might mention a practical illustration which had come under his own notice in the Fulham Road. It was the last extensive piece of work that the Author had done, and at the same time Mr. Weaver was paving a portion of the same road under his charge extending from the Brompton Oratory to Thistle Grove. In his own case, the work was done by Messrs. Nowell and Robson under contract, at 9s. 5d. per yard, whereas in the Author's case it was 10s. 3d., or 10d. a square yard more, and the time of execution was about 40 per cent. longer. It would be apparent to everyone practically acquainted with the subject that it was necessary to consider not only the question of cheapness in first cost, but the interests of those who were to find the money for the execution of the pavement, namely the ratepayers, some of whom were abutting frontagers; and it was a matter of considerable moment to a shopkeeper on a line of thoroughfare to have his receipts diminished £5 or £20 a week in consequence of the road being up. Time therefore was of great importance. Again there was a great disadvantage in having to pick up the labourers almost as they came; it might take several weeks to get them into working condition; but if the order were given to an established firm they could at once send a number of men of experience in their several departments, so that they would get half way through their work before the others had started. The question as to when it became economical to substitute wood paving for macadamized roads was an important point for a Board to consider when about to launch a large wood-paving loan. His figures were not quite the same as the Author's, but they came to very much the same in the result. He was not able to separate the scavenging from the maintenance; but he had always advised his Board that if a macadamized road cost 1s. 6d. per square yard per annum for maintenance, it was cheaper to put down a wood pavement, and that was a very similar conclusion to the one at which the Author had arrived. With regard to the question of studs, he had tried various kinds, single pointed and double pointed, but his experience was that they did not produce such regular jointing as asphalt or lath joints, the lath being left in. If the lath was withdrawn the brooms passing over the surface sweeping in the liquid grout disturbed the regularity of the surface. Studs

Mr. Weaver. were generally driven in by boys, who were not models of carefulness, hence some were driven in very hard (perhaps after the men had had their dinner) while in other cases, when the men were tired, a good deal of the stud projected. He would leave the practical point as to superiority to be decided by members who could examine and contrast the two pieces of pavement in the Fulham Road to which he had alluded, that east of Thistle Grove, executed by Kensington, and the other portion west, carried out by Chelsea.

Mr. Isaacs. Mr. L. H. ISAACS regretted that he could not agree with either of the three proposals which the Author had asked the Institution to endorse. The Paper appeared to be written with optimistic views, the Author having charge of a suburban or semi-suburban district, and apparently not being aware of what actual London traffic was. The instances of wear and tear which he had cited were confined to King's Road and Sloane Street. Mr. Isaacs desired to set against them the experience he had obtained in a central portion of London over which London traffic in the strict sense of the term actually passed. The statement that wood pavement was calculated to last seven or eight years was, he thought, misleading. He was ready to endorse all that had been said as to the comfort and convenience of wood pavement, but the question of cost ought also to be considered. The Author's first proposition stated that where the ascertained annual cost of maintaining and cleansing a macadamized carriage-way exceeded 2*s.* 2*d.* per square yard per annum, or where the traffic was so considerable that a quieter and cleaner pavement was deemed essential, the substitution of wood was desirable. He entirely agreed with the second part of the proposition, but the first was wrong. The Author had admitted that the statistics of his own office showed that the cleansing amounted to 11*d.* per square yard per annum, leaving for maintenance 1*s.* 3*d.* per square yard per annum. If he had gone to London proper, he would have found that the cost of mere maintenance was from 6*d.* to 1*s.* In his own district the cost in some streets was 6*d.*, in others 9*d.*, and in the majority 1*s.* Mr. Weaver had stated that about 1*s.* 6*d.* was the proper sum due to maintenance. Which was right? Or would engineers be justified in rejecting the advice of both, and taking instead the evidence of a man like Mr. Haywood, the City Engineer, who had charge of streets over which true London traffic passed? With regard to the economy of wood pavement, the Author had clearly failed to prove his proposition. It was certainly convenient, indeed luxurious, and where the ratepayers were willing

to pay for the luxury, there was no reason why they should not have it. When a rich banker drew a cheque for the rates of his premises, rated perhaps at £10,000, it was of little consequence whether the amount of the cheque was £1,500 or £2,000. In like manner it was a matter of indifference to a wealthy inhabitant of Prince's Gate whether in drawing a cheque for the rates of his house the amount was £160 or £200. Such persons would rather draw for the larger amount and have the comfort of a noiseless pavement, than draw for the smaller amount and revert to the old state of things. The Author's third proposition "that notwithstanding many former instances of failure the modern system has achieved a fair amount of success, and that there is no apparent reason why its use should not be extended" had been drawn with great caution. There had been no doubt "a fair amount" of success, and enormous improvements had been made in the wooden pavements of the present day, as compared with those put down twenty-eight years ago; but, after all, the question was very largely one of cost. He would invite the members to consider Chancery Lane, Southampton Buildings, High Holborn, Lamb's Conduit Street, Hatton Garden, and Great Ormond Street, which it would be admitted were fair representatives of streets with ordinary London traffic. They were all under the jurisdiction of the Holborn District Board of Works. Chancery Lane was first laid with wood in the Michaelmas quarter of 1876 by the Improved Wood Pavement Co., which he thought was one of the best wood-paving companies in London. The area was 1,960 square yards, and the first cost was £1,557 10s., or about 15s. per square yard. The complaints against it were numerous and grave. It was laid on the principle adopted by the Company of transverse boards, with concrete as a foundation. The noise of the traffic passing over the granite pavement which previously existed was so great that the dwellers in Stone Buildings and Chancery Lane petitioned the Board to lay down wood pavement, and even offered to contribute to the cost; but after it had been down a few years they complained of the shaking of the windows and the general unpleasantness, and asked that it might be taken up again. The Company, on being communicated with, stated that they had come to the conclusion that the system adopted was a mistake, and that they were prepared to alter it. To their credit it should be stated that they took up the whole of the pavement and relaid it at their own cost upon their modern improved system, with entirely new blocks and new

Mr. Isaacs. materials. That was in 1881, and no complaints as to rumbling and vibration had been made since that time. If the pavement lasted till 1886 he should think it would have done its duty, and he would have no cause of complaint. The wooden pavement of Southampton Buildings, where the traffic was much lighter than in Chancery Lane, was laid down in the Christmas quarter of 1876. It contained 1,063 yards superficial, and the cost was £824, or 15s. per square yard. It was largely relaid in the year 1882. The first pavement that he took in hand when he was appointed Surveyor of the Holborn District was the wood pavement in High Holborn, which he removed, and for which he substituted granite pavement in 1857. In the Christmas quarter of 1877 a wooden pavement was laid down in High Holborn. The portion in the Holborn District contained 3,842 yards superficial, and its cost was £3,030 1s., which again was about 15s. per square yard. That pavement entirely failed to carry out the views, not only of himself and of the Board, but of the Company which supplied it, although they were paid the highest price for laying it down, and for subsequent maintenance. The pavement was continued through New Oxford Street, as far as Tottenham Court Road, and it was considered at the time as fine a sample of wood pavement as had been laid in London proper. In the early part of 1882, when the pavement had been down less than five years, it became evident that its life had gone, and that it would have to be taken up. It had been his duty to take up the portion in Holborn in sections, in the years 1882-3; and not one block laid in 1877 was now to be found there. He might also mention, lest it should be thought that the circumstance had arisen from some want of care on the part of the officials of the Holborn District, that the portion laid down in the St. Giles's district as far as Tottenham Court Road had also been removed and re-laid with Val de Travers asphalt. The wood pavement in Hatton Garden, which was considered a very suitable thoroughfare for the purpose, was laid in the Michaelmas quarter of 1878. It contained 4,679 yards superficial, and cost £3,743, or 15s. 6d. per square yard. It was laid in 1878, and yesterday, May 27th, 1884, the Val de Travers Asphalt Company proceeded to take it up, and they were now laying down asphalt in its stead. With those facts before them he asked the members of the Institution to pause before they too readily endorsed the propositions of the Author with reference to the economy of wood pavement.

Mr. Rich. Mr. W. E. RICH said, he thought the question asked by the President with reference to traction was most important. He

believed that wood pavement was extremely favourable in regard Mr. Rich. to its low resistance to traction, and that was an important element which should encourage its extensive adoption. He hoped that some information would be forthcoming on the subject, obtained by means of the new dynamometer belonging to the Metropolitan Board of Works. He had himself had two hours' run with it a few months ago in some preliminary trials, and he had been surprised at the immense reduction in traction on going from a macadamized road to a wood pavement. He believed that the traction over a wood pavement did not exceed one half of that over a macadamized road, and it was much less than that over a stone pavement.

Mr. E. MATHESON inquired why the Author had omitted all Mr. Matheson. reference to asphalt. The Paper seemed to imply that wood was the only alternative to macadam. Mr. William Haywood had exhausted the subject a few years ago, but he thought that later experience might induce him slightly to modify his views. In many respects asphalt was better than wood. The question of cost was not the only one to be considered. In regard to traction he had no doubt that asphalt was much superior to wood; but its alleged slipperiness had at first condemned it, and hindered its adoption. He believed it had been found that the difficulties connected with slipperiness had arisen from the inexperience of the drivers, and the strangeness of the new pavement to the horses. In Holborn, in the St. Giles's District, the wood pavement was about to be replaced with asphalt; and Cheapside also had an asphalt pavement. The low cost of cleaning, and the little delay in laying (an asphalt road being ready for use in twelve hours, while the Author of the Paper stated that wood pavement required a week), were important points in favour of asphalt over wood.

Mr. HUGH MCINTOSH said that he had not had sufficient Mr. McIntosh. experience to give a decided opinion upon the question in dispute. In his district the authorities were only just beginning the use of wood. There were certainly some disadvantages connected with asphalt, with which he had made himself acquainted by observation and inquiry, and from which wood pavement was entirely free. The little experience he had had inclined him to favour wood in preference to asphalt.

Mr. J. LOVEGROVE remarked that only a very small area of wood Mr. Lovegrove. pavement had been laid in his district. It was put down two years ago by the Improved Wood Pavement Co., and it had proved a successful piece of work. There were two rails passing through the centre of its width, and blocks of Guernsey granite,

Mr. Lovegrove. well dressed, were placed on each side of the rails. That was a very successful way of dealing with the difficulty of obtaining a comparatively noiseless pavement opposite a public building. They had had Val de Travers Asphalt at first, but the rails and the asphalt did not wear well together. Some years ago he had made some experiments with a view of testing the cost of the maintenance of macadamized roads, and the result was that he advised his Board that when the cost was found to reach 2s. per square yard, it was time to get rid of macadam and lay down wood or stone paving. There was a good deal of saving with wood and stone pavement in the matter of cartage, by far less mud being made than on macadamized roads. It was very important that all the information obtainable with reference to asphalt paving, pitching, and wood, should be laid before the members, and their thanks were therefore due to the Author for his efforts in that direction.¹

Mr. Giles. Mr. A. GILES, M.P., considered that the Author had not done justice to the subject of creosote in his statement when he said that creosote to a certain extent closed the fibres of the wood, and tended to produce premature internal decay. Mr. Giles had had great experience in creosoting, and this was the first time that he had ever heard of creosote tending to promote premature decay. It was quite true that the pickling process was worse than useless, but if the blocks, before being laid, were properly creosoted they would last much longer than they did at present. It appeared from the statistics in the Paper that the actual wear was only 0.144, or $\frac{1}{7}$ inch per annum. The average duration of wood pavement was six or seven years, and as the blocks were 6 inches deep, they only lost about one-sixth of their depth in the whole period of their life. The destruction of wood pavement was caused, not so much by wear as by decay, for every one must have noticed that when wood pavement was being taken up, a great deal of it was as rotten as touchwood. That would not occur if the wood were properly creosoted before being laid. He was sorry the Author had not gone back to the early days of wood pavement in 1842, of which Mr. Giles had a lively recollection. It was nonsense to say that the slipperiness of wood pavement was only felt by inexperienced drivers, for there were certain states of the atmosphere when the pavement became so moist and greasy as to render it absolutely unsafe for horses. If something could be devised to prevent that

¹ Minutes of Proceedings Inst. C.E., vol. Iviii., p. 61.

slipperiness, a great benefit would be conferred upon the travelling public. Mr. Giles.

Mr. S. B. BOULTON said that he had had considerable experience in creosoting, but not much in the application of that process to wood pavement. It would appear that usually the paving blocks were merely dipped in creosote, and perhaps sometimes in a mixture of that and other more doubtful substances. Was this a wise course to pursue? It was well known how much the creosoting process had been improved by the abandonment, for ordinary engineering purposes, many years ago, of the mere steeping tank, in favour of the cylinder process by vacuum and pressure. In one instance referred to by the Author, that of the King's Road, the blocks appeared to have been prepared by the latter process. In this case only 7 lbs. of creosote per cubic foot had been injected. The "resources of civilization were not exhausted" however by the injection of so small a quantity. The Author had said that these blocks were, when taken up, moist internally, although it did not appear that they were unsound. The internal moisture could only have resulted from one of two causes, either that the wood was not dry enough at the time of creosoting, or that the quantity of creosote employed was insufficient to prevent the subsequent infiltration of water. Many engineers caused to be injected for railway sleepers and other timber, 10 lbs. and 12 lbs. of creosote per cubic foot. Even with these quantities the injection was partially superficial, but the creosote completely saturated the sap wood and softer parts of the timber, filling up all cracks and fissures, whilst the ends of the logs, for some inches up, were usually gorged with the creosote. Small pieces of timber like paving blocks should if prepared be saturated with creosote like the extremities of a sleeper. When timber was unprepared the ends of a log absorbed moisture freely; and this must be the case more especially with paving blocks. Moreover, it was not pure water to which the paving block was exposed. Ammoniacal products, the very class of substances which were used in experimental putrifying pits for hastening the decay of timber, were largely present in the moisture of the London streets. It spoke well for the paving blocks, and for the selection of the wood of which they had been made, that, unprepared or slightly prepared as they were, they had lasted as well as they had done. He was surprised to hear the Author of the Paper express the opinion that creosoting, by closing the fibres of the wood, tended to produce premature internal decay. General experience in this and other countries during the last forty-five

Mr. Boulton. years was entirely to the contrary. There had recently been exhibited at the Institution a large collection of specimens of creosoted wood, sent by various railway administrations and from other sources, and which had been placed in many different kinds of soils. These specimens of ordinary creosoted fir timber had remained sound for periods varying from ten to thirty-two years, and showed conclusively that the creosote, which had filled up the outer portion of the fibres, had completely protected the inner portion of the wood from decay. To produce such results it was of course necessary that the wood should be deprived of moisture, and that the creosote should be of a suitable kind. The wearing away of the top surface of the blocks appeared to be rapid; any decay of the woody fibre would doubtless accelerate this abrasion. Creosote had not only a preservative, but also a hardening effect upon timber, and if thoroughly injected could scarcely fail to prolong the duration of paving blocks. As regarded the kind of timber to be used, he thought that a greater variety might be tried. Gothenburg had been spoken of, and excellent timber could be procured from that port, but no better than from various other Swedish ports, or from Memel, Danzig, or Riga. Beech he thought would do good service; it absorbed creosote remarkably well, and evidence had recently been brought forward of the very long duration of creosoted beech sleepers on the Western Railway of France. English elm also absorbed creosote readily, which was not the case with the American rock elm. He had recently taken three pieces of ordinary fir sleeper wood, three of English elm, and three of American elm, and had subjected them to the creosoting process under 'nine hours' pressure. The pieces of timber were all cut to the size of ordinary paving blocks, 6 inches by 6 inches by 3 inches. The results were:—

AVERAGE QUANTITY OF CREOSOTE ABSORBED PER CUBIC FOOT.

	Lbs.	oz.
Three pieces of fir	22	1
„ „ English elm	27	13
„ „ American elm	4	10

In forests through which he had travelled in Canada, the United States, Russia, and elsewhere, he had noticed a great waste of timber in cutting the lengths for the ordinary purposes of the market. If some uniform standard of size for paving-blocks were adopted in this country, and if it became known that there was a constant demand, much of this waste timber might be utilized by

being cut into blocks, either in the forest or at the shipping port, Mr. Boulton. whilst they could be brought here as convenient stowage for vessels at a very low rate of freight. He could remember some years ago when his offices were in King William Street, near London Bridge, the effect produced by taking up the granite pavement and substituting wood. No words can describe the sense of relief in the mitigation of the roar of a mighty traffic, which was at once experienced by all the busy toilers whose work had to be carried on amidst such surroundings.

Mr. E. A. COWPER agreed that if blocks were creosoted at Mr. Cowper. all they should be thoroughly saturated with creosote. It had been stated that the Author had not dealt with London streets where there was a very heavy traffic, but he had actually given the first cost and maintenance of the pavement in Ludgate Hill, Aldersgate Street, Leadenhall Street, Fleet Street, and Oxford Street.

Mr. G. ALLAN did not think that wood pavement was a material Mr. Allan. to be recommended for further extension in the Metropolis. About fifteen years ago his attention was first directed to the question when the Val de Travers asphalt was brought before him. He first had it experimented upon in Bombay, where it was used to pave the footpaths of a number of leading thoroughfares, and it was in consequence of its success that he became the founder of the Val de Travers Co., and had the material introduced for the first time in London, their first contract being for Cheapside. When that contract was being carried out, Portland cement was used for the first time on an extensive scale. Lime was proposed, but upon his recommendation Portland cement was substituted in the contract, at an increased cost to the Company of £400. No doubt it was to the excellence of that concrete foundation that the success of the asphalt was due. Wood should be regarded as simply a temporary material for paving; so perishable an article should not be thought of for a moment for permanent use. As granite sets had given place to wood, so wood would have to give place to an impervious material, as asphalt, or some future improvement upon it. Both frost and sunshine had a very destructive action upon wood, or any material of an absorbent nature, but asphalt had no absorbent qualities, so that whatever wet might fall upon it it was rapidly dried up by the atmosphere. The reason why the use of asphalt had not rapidly extended was owing to the inefficient arrangements of the Metropolis. These had no doubt been improved of late years, but not sufficiently to justify vestries and other authorities in a further extension of asphalt. Asphalt pavement should be

Mr. Allan, washed every morning as regularly as a stable or kitchen floor, and sanded if necessary, according to the state of the weather. If that were done, he believed asphalt would be everywhere demanded. In the case of wood sets there was nearly double the joint area of granite sets, and the joints were simply receptacles for dirt, mud, and horse droppings, which in dry weather were discharged in the form of dust. In asphalt there were no joints, and nothing to receive the droppings. All the dirt lay upon the surface, ready to be washed or swept away.

Mr. Stayton. Mr. G. H. STAYTON, in reply, said he had been glad to hear the various points discussed, particularly the criticisms of Mr. Isaacs; but he regretted the course he had taken, feeling convinced that his conclusions were wrong, especially as to cost, economy, and further extension. With regard to the question of absorption, he would only call attention to a block which had been four or five years in actual use in King's Road. It had been taken up from the centre of the road, and it showed clearly that the absorption had been practically nil. His experience had been that if the wood was sound there was no fear whatever of decay from absorption up to a certain point. He had no personal knowledge of the system of wood pavement referred to by Mr. Lawford as having been laid in 1841, neither had he ascertained the cause of its failure. The chief object of the Paper was to draw attention to the modern system, as from its unprecedented extension within the last few years more advantage might be gained by a consideration of its merits than by going back a period of forty-three years. The remarks of Mr. Weaver were valuable from his great practical experience in the question, and considerable weight might be attached to his opinions thereon. It was satisfactory to note that he concurred with the Author as to the advantages of the plain system, and the necessity for great care in the use of wood, but a few points demanded correction. In the first place it was to be regretted that Mr. Weaver should have fallen into the error of remarking that one of the Author's statements was "that wood pavement was laid down better and cheaper in Chelsea than in any other part of London." The statements advanced in the Paper did not in the least justify any such conclusion. He merely asserted that the Chelsea pavements comprised all the essentials of a sound and economical pavement, and that the result had been eminently satisfactory; but he readily admitted that the Improved Wood Pavement Company, Henson's Company, Messrs. Mowlem and Company, and Messrs. Nowell and Robson, had also carried out extremely good and

creditable work. The nett cost of the Chelsea pavement in Fulham Mr. Stayton. Road was rightly stated to have been 10*d.* per square yard more than the Kensington part, but Mr. Weaver was in error in asserting that the former took 40 per cent. longer time to execute. The Chelsea work had been commenced on the 5th of September, 1881, and was completed, and the road re-opened, on the 15th of November, thus giving 149 square yards per diem as the result, whilst the Kensington work was carried on in two sections between the 28th of August and the 21st of October, giving 143 square yards per diem for each section. The Kensington pavement had a large proportion of old macadam in the concrete, and the system of blocking which he considered objectionable (p. 264) had been adopted; and there was little question that the cost would eventually be as great as that of the Chelsea pavement. The wood-paving works, executed in Chelsea in 1879 by the Board's own staff, saved the ratepayers £3,160, which fact proved that the system might be attended with substantial advantages. Mr. Weaver's remark as to the difficulty of organizing an efficient staff was, in his experience, purely imaginary. The conclusion that when the cost of macadam exceeded 1*s.* 6*d.* per square yard per annum it was time to adopt wood, fully bore out the Author's view, inasmuch as the 2*s.* 2*d.* mentioned in the first proposition (p. 275) included 8*d.* for cleansing, thus leaving 1*s.* 6*d.* for repairs only. Notwithstanding what Mr. Weaver had urged against the use of studs, the Author's practical experience satisfied him that they were preferable to laths, as he had repeatedly seen considerable displacement of blocks, and irregular width of joints, where laths had been adopted. The statements of Mr. Isaacs were fallacious and misleading. He challenged the accuracy of the Author's conclusions, but failed to refute them by adducing a single reliable fact or figure as to annual cost of former or present maintenance, or records of traffic-weight, in justification of the position he had assumed. In a previous discussion in 1879, on street carriageway pavements, he also made certain statements at which Mr. Howarth expressed considerable surprise when correcting them.¹ Mr. Isaacs must either have paid no attention to the Paper and Tables attached thereto, or he must have neglected to formulate statistics as to weight of traffic and cost in his district, otherwise he could scarcely have made statements which had no practical value. Mr. Isaacs contended that London traffic, in the

¹ Minutes of Proceedings Inst. C.E., vol. lviii., pp. 77, 88.

Mr. Stayton. strict sense of the term, might be seen in the Holborn district, but not in the districts of Chelsea or Kensington. To a certain extent this was correct, but subject to qualification. In Holborn itself the daily maximum traffic-weight per yard width was approximately 1,100 tons, in Brompton Road it was 648 tons, and in King's Road 603 tons. The Author made due allowance for the variation in the traffic-weight in preparing the Table (p. 273), from which it might be assumed that the annual cost of the wood-paving in Holborn, if spread over a period of fifteen years, would be 2s. per yard, besides cleansing and sanding 5d., or a total of 2s. 5d. Mr. Isaacs had made no attempt to supply figures upon this point, and without such information it could only be assumed that he had not given full attention to the subject. He had apparently intended to show that the experience of Mr. Weaver and the Author was such that their opinions upon wood pavements with "London traffic" ought not to be endorsed, but he failed to adduce any serviceable information in opposition to those opinions. It might, therefore, be assumed that he had taken no pains to make himself acquainted with the statistics relating to his experience, which would certainly have been an easy matter in so small a district as Holborn, which had but 15 miles of streets (of which $\frac{3}{4}$ mile only were macadamized, and 16,000 square yards were wood), whereas in Chelsea and Kensington combined there were 108 miles of streets, of which 41 miles were macadamized, and 217,000 square yards were wood. But apart from this, reference to Tables III. to VII. would show that the Paper dealt with pavements subjected to "London traffic" in its broadest sense. In Table VII. several instances were given in which the actual life of blocks had exceeded seven years, notwithstanding that the daily traffic-weight was upwards of 1,000 tons per yard width. Mr. Isaacs was evidently under a misapprehension as to the meaning of the item of 2s. 2d. per yard in the first proposition, as he deducted the 11d. for cleansing from 2s. 2d. instead of 2s. 10d., as explained on pages 31 and 36, and in the foregoing reply to Mr. Weaver's remarks. The first proposition was, "That where the ascertained annual cost of maintaining and cleansing a macadamized carriage-way exceeds 2s. 2d. per square yard . . . the substitution of wood is desirable." The figures (2s. 2d.) were arrived at by working out the cost of wood pavement, including first cost, interest on loans, repairs, renewals, and cleansing, for a period of fifteen years, in the following manner, viz. :—

Mr. Stayton.

	s.	d.
First cost	10	6
Repairs	0	4
Renewals of blocks every seven years	12	8
Interest on loans	2	5
	<hr/>	<hr/>
	25	11
	<hr/>	<hr/>
Per annum	1	8 $\frac{3}{4}$
Add cleansing and sanding	0	5
	<hr/>	<hr/>
Total	2	1 $\frac{3}{4}$

If, therefore, the Author's experience was of any practical value, he was satisfied that wood was undoubtedly a desirable and economical pavement as compared with macadam under the above-named circumstances. The observations of Mr. Rich respecting traction confirmed the statement in the Paper as to the low resistance of wood pavement to traction. The Author had not used the new dynamometer belonging to the Metropolitan Board of Works, but as regarded the average distance that a horse might be expected to travel without falling, Mr. W. Haywood, M. Inst. C.E., reported in 1874 that on granite it was 132 miles, on asphalt 191 miles, and on wood 446 miles, whilst the injuries to horses and obstructions to traffic were greatest on asphalt and least on wood. Mr. Matheson's remark that in many respects asphalt was better than wood coincided with the Author's views as expressed on p. 242, which also explained why the consideration of asphalt had been excluded from the Paper. Within the last month the entire carriageway of a street under the Author's charge had been paved by the French Asphalt Company, this system of pavement having been adopted principally on sanitary grounds. The Author did not agree with Mr. Allan that wood was likely to be superseded by asphalt, at any rate in the principal West End thoroughfares, unless the reputation of the former became damaged in consequence of their neglect, as described under the head of management. Obviously, both wood and asphalt needed constant attention in the matter of washing, cleansing, and sanding; but however suitable asphalt might be for footways, the Author could only repeat, that nothing but downright neglect in the management of wood was likely to lead to its extension, on account of slipperiness and the cruelty to horses which its adoption entailed. Mr. Giles and Mr. Boulton made some pertinent remarks as to creosoting. The Author in no way desired to do injustice to the system, his experience of creosoted piles having been favourable; but however desirable in theory it might be to creosote

Mr. Stayton. wood-pavement blocks, his experience did not convince him that it was good in practice. Some few years since he had seen wood pavement taken up at Westminster, where creosoted blocks had been used. Many of the blocks were internally as rotten as touch-wood, and the sappy blocks had worn down greatly under the pressure of traffic. It was difficult to see that any advantage or economy could be gained by the adoption of creosote, and the Author was strongly of opinion that the surface of blocks gorged at the rate of 10 or 12 lbs. per cubic foot, would become so slippery, and the jointing so unsatisfactory, that the system would create dissatisfaction.

Correspondence.

Mr. Culverwell. Mr. G. P. CULVERWELL approved of the contour of the carriage-way in Fig. 2, but thought that, if anything, the slopes might be reduced. It was ordinarily admitted that wood was a most slippery roadway, and thus every precaution should be taken. The sharp camber of the old macadam or stone pavement was too often followed, but it was unsuitable, and placed vehicles at a disadvantage, especially when starting from the kerb. The cross-section should be represented by two gradients, say of 1 in 40, from the channels to the crown, the latter being slightly eased off. In level roads the cross-section necessarily varied somewhat in order to drain to the gullies.

FIG. 5.

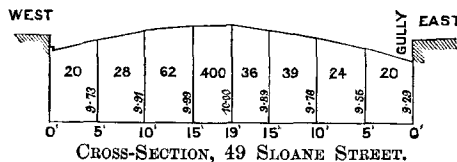
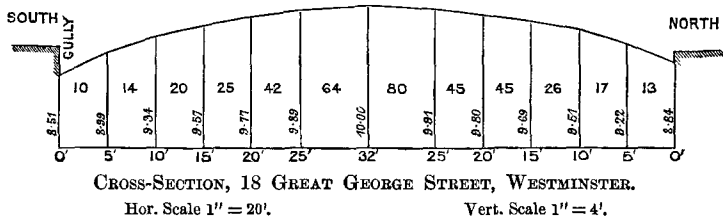


FIG. 6.



Figs. 5 and 6 were typical sections, and had been carefully taken recently. The east and south ends respectively were at