

Mr. Delano.

Mr. W. H. DELANO desired to ask why gas and water pipes were buried under the roads. The subject was a sore one with road-makers. He had once laid a road which was broken up four times before twelve months had expired. Seeing that gas and water pipes, telegraph wires, and the like, were all buried, it was strange that the different companies did not come to an understanding as to the time when the roads under which they were placed should be taken up. The placing of such things in the roadway was a great annoyance, not only to the roadmakers, but to the public. A greatly improved system had been adopted by Mr. Haywood at the Holborn viaduct, where the pipes were put in a gallery, and Sir Joseph Bazalgette had carried out subways in the Thames Embankment. It would be interesting to know if any bad results had arisen from this plan. With reference to the objection to asphalt, on the ground of slipperiness, the remedy was to be found in good scavenging. He had received a letter from the manager of the omnibus company in Paris (a company possessing twelve thousand horses and a large number of vehicles) recommending the Charlier system of shoeing, which was well known in England amongst veterinary surgeons and road-makers. If asphalt could be employed in the courts and narrow roadways of large cities, where so many poor children were poisoned by the vitiated air and filth, he believed the result would be very advantageous. He hoped that analyses would be made of the air over asphalt roadways as compared with roadways laid with sets. The scavenging in London was very bad, and a person coming to the metropolis, after an absence of some years, could not help noticing it. He was surprised to see the roadway in front of Buckingham Palace in a vile condition. Of course, as asphalt was impermeable, it had to be cleansed, there being no deodorising principle in it, as partially existed in macadam, before saturation. It would be observed that no remarks had been made in the Paper as to the comparative cost of asphalt and macadam. In Paris it was rather difficult to get the information, but he had ascertained that the cost price of macadam, including steam-rolling, was 6 francs 30 centimes per square mètre. The maintenance, however, of a macadamised road might reach the enormous sum of 17 francs per square mètre per annum; that was the case in such places as the Champs Elysées and the Rue Royale, where there was a heavy traffic. But the cost of macadam did not end there; it formed banks in the river, and at present steam-dredging was employed to remove the banks of sand in front of the drains in Paris. He had a report by M. Vauthier, civil engineer, and a member of the

Municipal Council of Paris, from which it appeared that the maximum cost of granite was 22 francs per square mètre. The mean cost of the Paris roadways, extending over 6,000,000 square mètres, was 17 francs, the mean cost of their maintenance being 1 franc, not including scavenging nor interest upon outlay in any case. In narrow, crowded thoroughfares, the cost of maintenance was, he believed, $3\frac{1}{2}$ or 4 francs. The chairman of the Paris Cab Company stated that the traction on asphalt was much less than on any other system of roadway. The manager of the Omnibus Company corroborated this opinion, and considered that the wear and tear of carriages, horses, harness, &c., was much less on asphalt roads than on any other. With regard to the Seyssel and Val de Travers mines, of which drawings had been sent, he might mention that they contained marine shells and shark's teeth, as well as fresh-water shells.

Mr. E. B. ELLICE-CLARK had hoped that the Paper would contain some statistics as to the cost of the porphyry sets and the macadam used in Paris, and of the different kinds of material employed in London, reduced to a standard. The only figures given were as to the cost of asphalt in Paris, 13s. per yard, and of cleansing it, 2d. per yard; but, of course, without any comparison of the traffic, it was difficult to form an idea of what the expense would be in England. He had, a short time ago, taken a good deal of trouble to ascertain the cost of different kinds of paving. He had taken Mr. Deacon's figures for the wood paving in Liverpool, believing that they were the only reliable figures ever published, and reduced them with the other calculations to the standard of 100,000 tons per annum per yard of width, with the result shown in the following Table :—

	Original Cost per Square Yard.		Annual Outlay.								
			In- terest.	Sinking Fund 3 per cent. Compound Interest.	Main- tenance.	Sea- venging.	Gravel.	Total.			
	s.	d.	d.	d.	s.	d.	s.	d.	d.	s.	d.
Wood pavement. . .	15	1·5	7·5	10·1	0	1·0	0	2·7	5·0	2	2·3
Val de Travers com- pressed asphalt . }	18	0·0	9·7	..	0	3·6	0	0·4	..	1	1·7
Granite sets, 7 inches × 3 inches laid over a layer of 12 inches of cement concrete }	17	9·0	9·6	0·5	0	1·3	0	2·5	..	1	1·9
Macadam in South of England . . }	4	9·0	2·1	..	3	6·0	1	0·0	..	4	8·1

Mr. Ellice-
Clark.

Those figures showed that if the contract entered into by the Val de Travers Company in London could be maintained, their asphalt was cheaper even than granite sets. There could be little question as to the many advantages possessed by asphalt over almost all other materials for road paving. According to his experience, compressed asphalt was the best for roadways. In the City of London, he believed, thirteen or fourteen kinds of asphalt had been tried within the last nine or ten years, and only three of them remained at present in streets with heavy traffic. It was hardly necessary for English engineers to go thoroughly into the chemical part of the question, because all that information had been reduced to practice by the actual wear and tear in the City of London. There were some curious anomalies in the behaviour of compressed asphalt to which he desired to refer. He had recently laid a footpath with that material, $\frac{3}{4}$ inch thick. In a short time a large number of cracks appeared, but the path had stood the effects of the last two very severe winters; and, although the cracks were unsightly, they did not appear to have injured the asphalt in the least. He believed the cracks were due, primarily, to the use of a cement not sufficiently purged; the concrete expanded in various directions, and the asphalt followed it, not being sufficiently elastic to extend over the fissures without rupture. Another peculiarity was that in humid weather there was a greater accumulation of dirt on the compressed asphalt than on the mastic. Perhaps the Author could state, from his experience in Paris, the reason for that peculiarity. No particulars had been given as to the amount of mud in the streets. Mr. Ellice-Clark had compiled the following Table with reference to that point:—

Material.	Load of Mud for Area.	Traffic per Annum per Yard of Width.
	Superficial Yards.	Tons.
Macadam .	344	25,000
Granite sets .	500	50,000
Wood . .	1,666	25,000
Asphalt . .	4,000	500,000

So that, as dirt meant mud in wet weather and dust in dry weather, asphalt was unquestionably a most economical paving. One of the greatest advantages possessed by asphalt for street paving was the facility with which repairs could be executed.

Cheapside had been laid with asphalt in December 1870, and the roadway had never been blocked a single day for repairs. This alone was an advantage to a city with great street traffic, which could not be said of any other kind of pavement. It would be hardly possible to overrate the importance of having streets permanently open for traffic. Again, the rapidity with which it was originally laid, compared favourably with other materials. In Paris, he believed, a given area of each road had to be opened in eight days; in London, fourteen days had been found ample time to take up the old stones and lay asphalt and concrete, and permit traffic. The Author had suggested the use of asphalt concrete costing 80s. per cubic yard; this was too high a price, because a bituminous concrete, composed of ballast, coal tar and creosote oil, could be laid for 21s. per cubic yard, 6 inches in thickness. It had been tried in Liverpool under sets with manifest success. By using a concrete of this kind the work of laying a road could be shortened by the difference in time required for Portland cement concrete to set and that required for bituminous concrete, which was a few hours only; so that a road fit for traffic might be laid in London in eight days. There was no reason why this kind of foundation should not be equal to Portland cement concrete; and it was well worth the attention of municipal engineers and asphalt companies. With regard to foothold for horses, or rather the absence of it, the City engineer had demonstrated, by a series of observations of an exhaustive nature, that asphalt occupied a position between wood and granite, in the order named; and the popular outcry against the slipperiness of asphalt arose from the greater number of horses falling at one time. He was strongly of opinion that the Author was correct when he stated that this absence of foothold was due to want of cleanliness. The City Corporation had recently put down a number of hydrants all over the City area. If these were utilised in cleansing asphalt, the falls of horses would be reduced considerably. The Author had made no allusion to the fact that during the past few years the new pavements of Paris in asphalt were much inferior to those formerly laid; it had been asserted that this was owing to the use of the Lobsann asphalt, which did not contain sufficient calcareous matter in the natural rock.

Mr. Ellice-
Clark.

Mr. A. SOUTHAM remarked that where it was desirable to lay asphalt on carriageways, there could be no doubt that compressed asphalt was the best for that purpose. He had paved about 25,000 yards of footway in the parish of Clapham, since 1872. Various small specimens were first laid. Then about 1,000 yards

Mr. Southam.

Mr. Southam. of Barnett's asphalt, 1 inch in thickness, was tried; the cost was 4s. 6d. per square yard, and it was still in existence, and might be considered a fair path. It was afterwards thought desirable to make the best footpath that could be obtained in asphalt, and, after considerable investigation, the Val de Travers compressed asphalt was selected, and more than 20,000 superficial yards of that material had been laid. A great object was to secure uniformity of paving throughout the district, also facility in executing repairs. It was somewhat unfortunate that transverse cracks had appeared about every 6 or 8 yards. They made their appearance from about three weeks to twelve months after the path was laid. Some of the cracks were cut out, when it was found that corresponding cracks existed in the concrete below. The whole piece was cut out, and new concrete put down, which was kept exposed for six or eight days to harden. Then a thin coating of mastic asphalt was laid over it, previous to the powder being restored. Similar cracks, however, appeared again in the same line, and it was difficult to account for them. He thought to some extent they depended upon the concrete. Great pains were now taken with it, and 6 parts of ballast to 1 part of cement had been substituted for 8 parts of the former to 1 part of the latter, clean Thames ballast being used; it was mixed with very little water, and was well beaten with shovels. The cement had been tested, and had broken at a pressure of 450 lbs. to the square inch after seven days, during six of which it was laid in water. The concrete for the last piece of paving was kept open for fourteen days, so that it was dry before the powder was laid upon it; the footpath was previously rolled and consolidated, and this path had shown very few cracks. He was inclined to think that compressed asphalt was scarcely so durable as had been generally supposed. The mastic asphalt he believed was somewhat harder, though it was objectionable from the uncertainty of its mixture, from the difficulty of making the repairs to match the rest of the paving, and from the furnaces for melting it having to be in the street. He had not yet decided whether it was advisable to continue the use of compressed asphalt, or to resort to the mastic. He was surprised at the immense area of footway paving laid in Paris, but the Author had not stated of what it was composed. Mr. Southam presumed that it was chiefly mastic. The Val de Travers Company had assisted him greatly by their willingness to lay the concrete in any way that might be desired, and to keep it exposed for any length of time. Their manager had suggested that lime concrete would prevent the cracking, and accordingly

one line of path had been laid with it. It was not a success; Mr. Southam. there were no transverse cracks, but it had failed from the settlement of the concrete, which was not yet hard, and had cracked longitudinally from the frost. The concrete in this instance was laid from fourteen to eighteen days before being covered with asphalt. Very few cracks had appeared in the city paths. The foundations were, perhaps, more solid, and owing to the greater traffic brought to bear upon them, the asphalt was more compressed and kept in its place. The asphalt in Clapham had suffered from cracks during the late severe winter, but they had all been longitudinal instead of transverse, and after the frost they had closed, and did not look so bad. In this district the use of asphalt would probably be largely extended if a perfect paving could be laid. He would be glad to know which was the best description of asphalt to use for footway paving.

Mr. H. C. SCOTT observed that as a director of the Val de Travers Mr. Scott. Asphalt Company, he might be permitted to refer to their experience of London roadways. The question of cracks upon compressed asphalt footways was one that he frankly confessed had once given them some concern; but they were of opinion that the fault would only last a short time. In going along the Cheapside pathway, which had been laid between three and four years, he had not observed any cracks; and in Moorgate Street, where it had been laid four or five years, there were very few. He had not discovered that the pavement was affected by the humidity of the atmosphere or by rainy weather. They sometimes found, when the drying process had set in, that there was a little streak through the footway, but in a day or two it entirely disappeared. On the grounds of economy, noiselessness, and cleanliness, after the many pamphlets that had been written and the many reports presented, there could be no doubt as to the superiority of asphalt; and he believed that compressed asphalt for roadways possessed greater advantages than any other material. The roadway in Cheapside had been laid ten years, and it was still in existence. The heaviest traffic in the world passed over it, but it had never been interrupted for an hour. The repairs were done early in the morning, and the result was that Cheapside possessed a clean, noiseless, and cheap roadway, which, as he knew from the shopkeepers, was regarded as an enormous boon. As to the objection on the grounds of slipperiness, that, as the Author had explained, was a question of cleansing, and not a question of asphalt. If engineers and district surveyors would impress upon the Vestries of London the importance of spending more money in cleansing

Mr. Scott. the roadways, they would confer an immense benefit upon the community. The condition of the lanes, slums, and alleys of London was deplorable. The rejected granite sets and York flagging from the richer districts were transported to those localities, where the children of the poor were congregated, and where they played about all day in puddles. If the authorities would only give them asphalt, they would be doing something towards making life tolerable to many who now regarded it as little better than a burden.

Mr. Lewis. Mr. W. B. LEWIS asked if any one accustomed to lay asphalt upon concrete had ever tried the plan of laying the concrete in slabs, with joints, in order to prevent cracks. Engineers who had used concrete in large masses were aware that the difficulty of cracks frequently occurred. At the Victoria docks, in one wall $1\frac{1}{4}$ mile long, and 33 feet or 34 feet high, of solid concrete, there was a hair crack through it at about every 14 feet. He presumed that this arose from the material being homogeneous, and that there must be expansion and contraction somewhere. Possibly the cracks in the asphalt pavement arose from the concrete being laid in one continuous mass. It must yield somewhere to atmospheric influences, and consequently cracked. If it were laid in slabs, with joints ever so small at intervals, possibly that would get rid of cracks in the asphalt.

Mr. Giles. Mr. A. GILES, M.P., said the Author had expressed an opinion that asphalt yielded sufficiently without cracking where any settlements in masonry took place; while Mr. Southam observed, that on investigating the causes of cracks in asphalt footways, he had found them due to the cracks in the concrete underneath. Both those views could hardly be correct. If there was sufficient elasticity in the asphalt to allow of yielding when settlements of masonry took place, it ought to possess the same elasticity in footways when the concrete cracked. He had not had great experience of asphalt, but he had had considerable experience in the use of concrete. In order to overcome the difficulty referred to by Mr. Lewis—the formation of cracks where large masses of concrete were used, especially in long walls—he had lately adopted the plan of putting in perpendicular joints, instead of making one continuous wall many hundred feet or yards in length, and that had to some extent obviated the difficulty.

Mr. Ellice-Clark. Mr. ELLICE-CLARK wished to say, in explanation, that in Brighton no cracks had been observed in the mastic asphalt, which contained a larger amount of bitumen; but they had been observed in the compressed asphalt, which had no foreign bitumen.

Mr. W. H. DELANO remarked that the coating of the masonry Mr. Delano. was made of a mixture of asphalt powder and bitumen, containing 15 per cent. of bitumen; it was therefore much more elastic than compressed asphalt powder. He had never known compressed asphalt powder used as a coating for masonry.

Mr. JOHN KNIGHT said that Portland cement concrete expanded Mr. Knight. and contracted according to the weather, while asphalt, if laid in a mastic state, neither expanded nor contracted, whether $\frac{1}{2}$ inch or 1 inch in thickness. It appeared that the asphalt in Brighton had not cracked because it was in an elastic state, while that laid in Hove in a compressed state had cracked. The reason for the cracking was that it was not of sufficient thickness—only $\frac{3}{4}$ inch; and the same reason applied to other cases that had been mentioned. No cracks had appeared in Cheapside or in Moorgate Street, because the asphalt had been laid of sufficient thickness—1 inch. Compressed asphalt should not be laid less than that thickness, otherwise it would crack in every direction. The first asphalt of the Val de Travers Company that he had noticed was in a mastic state. It did not last very long; it was not suitable as a mastic asphalt, but as compressed asphalt it was very good. When a surveyor saw a piece of York stone he could express an opinion as to whether it was good or bad; but he could pass no such opinion with regard to asphalt, whether in a mastic state, or compressed. The goodness of the material was only to be ascertained by its durability. The best piece of asphalt in the City was laid in a mastic state in King William Street eight or nine years ago, and it still existed as when first laid, with the exception of a few repairs for gas and water purposes.

Mr. J. FOGERTY observed that he had had some years' experience, Mr. Fogerty. both as an architect and as an engineer, in laying pavements and in the use of asphalt and Portland cement for the covering of roofs and other structures. He did not believe that a layer of $\frac{3}{4}$ inch of asphalt of any kind was sufficient, especially in footways. The chief cause of cracks was, he thought, to be found in the concrete, and there was only one way to get rid of them—a plan that he adopted ten years ago—never to lay more than 9 feet length of concrete at once, bringing straight joints across the footpaths by inserting boards, withdrawing them when the concrete was soft, and leaving the fissures open for a considerable period. The great trouble in getting concrete laid was, to induce the workmen not to use too much water. It could not be laid too dry, especially where it had to be covered with Portland cement or asphalt. A long discussion had recently taken place at

Mr. Fogerty. the Royal Institute of British Architects¹ on Portland cement and concrete, and it seemed to be the general opinion that one of the chief troubles connected with concrete was the over-use of water by workmen. If it was laid almost dry, and thoroughly rammed and jointed at intervals, the joints being left open until the water had evaporated, it might be covered with asphalt without any fear of cracks, provided there was a solid substratum. But where it was laid upon clay, difficulties would invariably arise unless there was interposed between the concrete and the clay a considerable amount of hard, pounded, dry filling for drainage purposes. The most difficult pavements were those laid upon a clay substratum, and he knew of no mode of curing the difficulty except by getting out a considerable depth of clay, and replacing it by dry material. For covering roofs, arches, and the like, he preferred the mastic to the compressed asphalt. For level roadways and footpaths there could be nothing better than the compressed asphalt for pavements, on the ground of cleanliness, but the danger of horses slipping in greasy weather was a serious one. He had often passed through Cheapside in muggy weather, and seen several horses down at one time, and during the recent fogs probably as many as ten were down at once. Whether that could be obviated he did not know. The question had not been fully dealt with in the Paper, and he hoped the Author would allude to it in his reply. The only remedy that could be suggested was a thorough cleansing, which, so far as Cheapside and similar streets were concerned, could only be done during the hours of traffic by means of numerous hydrants, and the constant use of hose-pipes, with large side apertures, such as those used in Paris, to carry off the washings into drains or reservoirs. Allusion had been made to the operations of gas and water companies, which destroyed the roads and pavements in cities. Some twenty years ago the parish of Marylebone offered a prize for the best section of a subway, and it was won by a young student in the engineering class of University College—Mr. Davis. Since that time very few subways had been constructed in London, and even in those, gas and water companies were very unwilling to place their pipes. The only objection he had heard was that the escape of gas in such enclosed places would be dangerous. On that point he should be glad to hear the experience of the City surveyors who had charge of streets and subways in which gas pipes were laid.

Mr. Glenn. Mr. HENRY GLENN attributed the cracks that had occurred in

¹ *Vide Transactions R.I.B.A., 1879-80, p. 109.*

the Val de Travers asphalt to the want of a sufficient quantity of Mr. Glenn. bitumen. Heating the powder drove off the bitumen to a large extent, and if the quantity was reduced, as stated in the Paper, to $9\frac{1}{2}$ or 10 per cent., cracks would be sure to occur in severe weather. In the case of mastic asphalt, the difficulty could be obviated, because the cauldron was in the street; and if the asphalt did not contain a sufficient quantity of bitumen, an addition could be easily made to it, and an experienced foreman would know what quantity to add. Some reference had been made to mastic asphalt not wearing so well as other kinds of asphalt. A good deal depended upon the size and quantity of the grit put into it. There ought not to be too much, and the size should not be too large. If it was too large, it would work out, which a small piece of grit would not do. When the Barnett Asphalt Company was in existence, it was the practice to use the large grit, and the consequence was that nearly all their work failed. He had seen concrete laid down in 6 or 7-foot lengths, and allowed to get thoroughly dry at the end; and when the next layer of concrete had been put on, it had not been sufficiently wetted and properly jointed. In such a case cracks would arise through the concrete; and if the asphalt did not contain a sufficient quantity of bitumen, it would go through to the surface of the asphalt. He did not agree with those who had said that the concrete should not be laid in long lengths. He thought the more men that were employed, the more quickly the concrete could be laid, and the longer the lengths, the better. The work was then all of a piece, and was in the best condition to receive the asphalt.

Mr. E. J. HARRISON had under his control, on behalf of the Val de Mr. Harrison. Travers Company, the majority of the asphalt roadways in the City of London. The history of the compressed roadways in London was soon told. The first that was laid was in Threadneedle Street in 1869. It consisted of a layer of 2 inches of Val de Travers compressed asphalt on a concrete foundation. He had no doubt that many members had noticed it when it was being laid, as it created a great sensation at the time. He remembered looking at it and wondering how many weeks it would last. It was now within two months of being eleven years old, and was still, as it always had been, in good condition. Some new Aberdeen granite had been laid beside it for a trial of endurance, and seven years afterwards it had got into such a state as to require re-dressing and re-setting; but that was not done, because, when the inhabitants of the street learned that the street was going to be

Mr. Harrison. closed for re-paving, they expressed a preference for an asphalt roadway, which the city authorities gave them. Since 1869 the progress of asphalt roadways throughout London, though rather slow, had been steady. There were now in the City of London alone 12,000 or 14,000 lineal yards of paving, covering a superficial area of 150,000 yards. The Val de Travers Company had upwards of one hundred roads under their charge, many of them being the main thoroughfares of the city, having a concentrated and heavy traffic; and the area would be considerably increased during the present year. One noticeable feature with regard to the use of asphalt was the great number of preparations that had been tried. Between 1870 and 1880 more than fifteen had been employed in London, most of which had proved failures. His company had already replaced eight or ten of them, not always under favourable circumstances for the company. In order to shorten as much as possible the time during which the streets were closed for re-paving, the company had generally agreed to lay its asphalt upon the old concrete foundations, some of which had been almost as bad as the asphalt that had been placed upon them, while others had been damaged by the traffic passing over them after the asphalt had worn out. In main thoroughfares like those of London, where every hour's stoppage of the traffic affected not only the occupiers of the particular street, but more or less remotely the traffic of the whole of London, the use of a paving material which required constant renewals or frequent repairs was a serious matter. He certainly could claim, on behalf of the Val de Travers Company, that it had never closed a city street for repairs, and such repairs as it had done had never affected the traffic in any appreciable degree. A very little hole, if neglected, speedily became a big hole, and for their own interest, if for no other reason, they had always taken care of the little holes; the repairs, therefore, had generally been done on a small area, rarely exceeding 2 or 3 square yards, and early in the morning before the traffic commenced. The openings for gas and cuttings for water-pipes, which were generally a source of great obstruction, were less serious with an asphalt road than with any other paving material. A hole could be cut exactly the size required, and when the work was done it might be made good immediately. Moreover, leakages in mains under an asphalt road were less frequent than under any other material, on account of the absence of vibration. Still those cuttings had to be made, and frequently there was a trifling settlement of the new work, producing hollows and forming puddles, which were more conspicuous on

an asphalt surface than on any other; so that he should be glad Mr. Harrison. to see the introduction of subways under the London streets. At the request of the Author, he had had small samples of the roadways cut out from some of the oldest roadways having the heaviest traffic, and they were on the table for inspection. Two of them were from Cheapside, ten years old; one was from Old Broad Street, and another from Gracechurch Street, nine years old; and one was from the Poultry, a relay which was only three years old. The roadway of the Poultry was only three years old, because the houses on the north side were set back several feet three years ago, necessitating an alteration in the footway and roadway. The company laid down new concrete where necessary, and faced up the old, and then spread asphalt on the top of it. They had good weather, and with the assistance of the authorities, and the good will of all the inhabitants, they managed to carry out the work in seventeen days. It had proved very satisfactory, and they had never had occasion since to spend a penny upon it. When Mr. Deacon's Paper on "Street Carriageway Pavements" was read and discussed,¹ very little was said about asphalt roadways, Mr. Deacon stating that he had had no experience of them, the gradients in Liverpool not allowing the use of asphalt. He had been struck with the unanimity with which every speaker on that occasion urged the necessity of a solid foundation for a good road. Asphalters were especially of that opinion. An asphalt road was in reality a concrete road with a surface of asphalt put upon it to carry out certain ends. If the concrete foundation were taken away, or tampered with, or negligently laid, asphalt itself would form a very sorry paving. In dealing with that question, one important point to be considered was the obligation under which the engineer or surveyor was placed to have the road closed for paving for the shortest possible time. For that reason his company had always urged the desirability of laying a concrete composed of a quick-setting Portland cement with the best obtainable ballast. As far as his experience went, if a lime concrete was sealed up hermetically by asphalt on the top, there was no knowing what might happen underneath; whereas, if Portland cement concrete were left open for a few days, and then covered with asphalt, engineers could form a pretty good idea of what would happen. In London they were indebted to the French asphalters for all that they had first learned as to the nature and treatment of asphalt; but

¹ *Vide* Minutes of Proceedings Inst. C.E., vol. lviii., p. 1.

Mr. Harrison. he thought that they had now beaten their instructors, putting down better work and maintaining it better. He had been struck, on a recent visit to Paris, with the condition in which some of the roads had been allowed to get. He believed that it had partly arisen from the system there adopted of requiring the contractor to take up every year, whether it was required or not, one-fifteenth of the work laid down, which he regarded as offering a premium on bad work. Another reason was the use of lime concrete with lime mortar on the top. The only failure that he knew in Val de Travers roadways had been in connection with the use of lime concrete under lime mortar in the roadway laid (after that in Threadneedle Street) in Holborn, opposite Gray's Inn. It had been laid by Englishmen, who were novices, and who followed slavishly the specification prepared by the French engineers. That specification prescribed a layer of about 9 inches of lime concrete with $\frac{3}{4}$ inch of lime mortar. When the concrete was ready to receive the asphalt, a fire broke out in Holborn, and the barriers protecting the concrete were broken down; the place was flooded with water, the engines drove over the concrete, and the population of Gray's Inn Lane trampled it down. It was subsequently made good; the asphalt was spread, and some time afterwards the Val de Travers Company succeeded by inheritance to its maintenance, and certainly it had been a "heritage of woe." For five or six years they had kept up the road at considerable expense and trouble, and at the end of that time they received the permission of the road authorities to relay the whole in two longitudinal strips, so as not to stop the traffic. On removing the asphalt it was found that the lime concrete had never set, that the mortar floating had never adhered to the concrete, but was mostly in powder, produced either by the action of the rammers, or by the traffic afterwards. They broke up the concrete, sifted out the lime, relaid the foundation with Portland cement, and put fresh asphalt on the top. That was done about four years ago, and the work had since proved satisfactory. Some of the workmen now in his employ, who had been previously engaged in Paris, had told him, that in several of the roads there the asphalt had been laid upon the existing macadam. The Author had referred to certain roadways of asphalt with granite channels. It appeared to Mr. Harrison that granite channels were superfluous. As between an asphalt roadway with a granite channel, and a granite roadway with an asphalt channel, *quâ* channel asphalt would be the preferable material. The Val de Travers Company had laid a great many footpaths in England, both in mastic and in

compressed asphalt, and he was of opinion that it was not desirable Mr. Harrison. to have the material of a less thickness than $\frac{3}{4}$ inch. Some years ago they laid $\frac{1}{2}$ -inch mastic footpaths, but the result had not been such as to encourage that mode of construction. It had even been adopted in some of the streets in the City of London having the heaviest traffic, such as Gracechurch Street and King William Street; but in four or five years the footpaths had become so much worn that it was thought desirable to take up the $\frac{1}{2}$ -inch mastic and lay down $\frac{3}{4}$ -inch compressed, which had stood fairly well. He had been surprised to hear that his company had been credited with a preference for lime concretes over cement concretes for footpaths. That was far from being the case. The footpath referred to was laid as a sample under some special conditions. It was a fact, that in certain footpaths, particularly those in the suburbs, where there was little traffic, transverse hair cracks appeared from time to time. The first cracks to which his attention had been directed were in the footway round the garden in Leicester Square, and appeared six years ago. The cracks were there to the present time; they had not in any way affected the stability of the work, but they were unsightly, and he should be glad to be able to prevent them. He had noticed that the better the concrete on which the footpaths were laid, the greater the number of cracks appearing in them, and the worse the concrete the fewer the cracks; indeed, if they laid the concrete bad enough there were no cracks at all. He had found it impossible to lay a horizontal ribband of good cement concrete 3 inches thick without finding a hair crack at every 10 or 20 feet. The crack in compressed asphalt followed the crack in the concrete. Of course the footpaths were not subject to that hardening effect which was produced by the rolling of wheels on roadways. He never remembered seeing a crack in an asphalt roadway, although he had little doubt that cracks might be found in the concrete underneath. Mastic asphalt being more elastic than compressed asphalt, the cracks were not so numerous in it. Nevertheless he was of opinion that, *ceteris paribus*, a compressed footpath was a more desirable one than a mastic footpath. It was pleasanter to walk upon, owing to the absence of grit; it was handsomer, and it was also cheaper to lay; moreover, it had not the disagreeableness of mastic footpaths arising from the smell of the boiling asphalt in the cauldron. With regard to the surface duration, he believed that the compressed asphalt was better than the mastic. He was not surprised that very little had been said on the subject of slipperiness in connection with

Mr. Harrison. asphalt. The matter really lay in a nutshell. Roads when dirty were slippery whether paved with granite or asphalt; but in the case of granite, a slipping horse might be pulled up by the joint of the second or third stone, whereas on an asphalt road there were no joints to prevent a fall. The true remedy was to keep the roads clean, as was done in Paris, where the asphalt road was a favourite one with cabmen and omnibus drivers. He was glad to find that, quite recently, the City authorities had arranged to have a certain number of hydrants used for washing the streets. He hoped that the experiment would be carried out carefully, and that the streets would be washed every morning before the traffic commenced.

Mr. Copland. Mr. H. S. COPLAND said that the Paper, although its title was "On the use of Asphalt in Engineering," dealt only with one kind of asphalt, the Val de Travers, and of its use chiefly in the construction of roads, or rather in the coating of road surfaces, which was only a small branch of a large and important subject. He maintained that asphalt was wrongly used if employed as the surface of a roadway. Engineers had to consider other things besides the cleanliness of the material and its noiselessness. As to the latter, though asphalt was free from one class of noise, it was attended with another—the clatter of the horses' hoofs, which was very irritating to persons of nervous temperament. Nor was it enough to pay attention to the durability of the road; they had also to take into account the foot-hold given to horses, and the amount of tractive effort required, not only to draw the vehicles along the road, but to start them; and they had further to consider the cost of construction, maintenance, and cleansing. In regard to cleanliness, a good asphalt road was undoubtedly the best that could be constructed, and as to its impermeability to water, thus affording a protection to the foundation, it was also an excellent material; but for slipperiness and deficient foot-hold it was about the worst road in existence. As laid by the Val de Travers company, it was exceedingly durable, but it was costly in the first instance as compared with other materials. Taking all the requirements into consideration, he had arrived at the conclusion that for the surface of a road no material was equal to wood. But in order to obtain a good foot-hold on wood, it was necessary to leave spaces between the courses, principally for the want of which the old wood-roads of twenty years ago had fallen into disuse. Other reasons for their discontinuance were that they had not been placed upon a proper foundation, and the blocks were not properly cemented or keyed together.

He believed that the proper mode of using asphalt was to lay a Mr. Copland. damp-proof course of that material (to prevent the infiltration of water) on a foundation of concrete, and then to place wooden blocks upon the asphalt layer to take the surface wear of the traffic. The blocks were not only keyed to the concrete, but they were keyed to each other by the asphalt running into the joints, thus forming a monolithic slab of material, which afforded a good foot-hold, could be readily kept clean, and was comparatively noiseless. As such a slab extended from one side of the road to the other, the weight of the traffic was transmitted over a large area, and was not confined to one block; the road being elastic, would wear uniformly; it would not press too directly upon the concrete foundation, and particularly on one part of it, and a smaller depth of concrete would suffice. Such a surface, if the wood were properly selected, would remain perfect for a number of years. In Boulogne, four and a half years ago, he had laid down blocks only half the depth of those used in London, for a traffic exceeding 120,000 tons per annum in a street 20 feet wide. The surface was still perfect, and there were no depressions. The wear was solely from surface attrition, and had amounted to about $\frac{3}{8}$ inch per annum. The London company formed to work his English patent had laid 60,000 square yards in London roads which had not in some cases worn quite so well as the road in Boulogne in consequence of the wood not having been so well selected. The cost of such a road, fit for the heaviest traffic in Paris, would be from 12 to 15 francs per square mètre (the amount given for the road described by the Author being 17 francs), and the average cost of maintenance would not exceed 1s. per square mètre per annum. He therefore maintained that his road, while offering all the advantages of freedom from noise, and being a better road for traction, would cost the municipality of Paris less, over a term of years, than asphalt. With regard to slipperiness, it appeared from the report presented by Mr. Haywood to the City Commissioners of Sewers in 1873, that on granite pitching one horse fell for every 132 miles travelled. On Val de Travers asphalt one horse fell for every 191 miles travelled; and on wood pavement (not asphaltic wood pavement, but the nearest approach to it), one horse fell for every 446 miles travelled. But the nature of the falls ought to be taken into consideration. Of the total number of falls on wood pavement only one-eighth might be called dangerous, while three-sevenths of those on asphalt were dangerous. The danger was not simply from broken knees and from directly observable damage done to the horse, but from sprains in the attempt to regain a foothold. Injury of

Mr. Copland. that kind was far more serious, more insidious, and less easy of cure. He concluded that, in all crowded streets, asphalt as a surface pavement should be given up. He agreed with Mr. Scott, that it might be used with advantage for the paving of narrow courts, alleys, and playgrounds for children; but the safety of grown-up people ought also to be considered, who, in crossing crowded thoroughfares, were constantly run over by horses, which on asphalt roads trotted at a great speed, and were pulled up with difficulty. The durability of all roads depended to a great extent upon the character of the concrete. He found that *lias* lime, properly used, was as good as cement, but it was necessary that it should be ground to a fine powder, and that it should be fresh and uniformly mixed, care being taken not to use too much water.

Mr. Greig. Mr. H. A. GREIG desired to challenge a statement made by the Author to the effect that some Sicilian asphalt had been tried in Paris and condemned, and that therefore very little of it was in use. Mr. Alfred Rumball, M. Inst. C.E., had visited Sicily in August 1877, and reporting on the asphalt deposits, said: "Some quarries have been worked by a French company, but are now abandoned, as all the top seams have been worked out; the quality also is very inferior, containing only a small percentage of bitumen." In the same report there was a strong recommendation that this asphalt should never be touched. The asphalt in Sicily that the United Limmer Company had purchased, on the advice of Mr. Rumball, was of a very different description. Of it he had stated, "The quality will be found very superior, for fineness of colour, closeness of grain," &c. That asphalt had been brought over rather more than two years ago; it was compressed, and Newgate Street was then laid with it, and now showed no "waves" or undulations; it was, he believed, as fine a piece of asphalt as could be seen either in London or in Paris. Other streets in London had also been laid with this Sicilian asphalt for the Commissioners of Sewers for the City.

Mr. Cowper. Mr. E. A. COWPER observed that no one had touched upon the cheap method of making footpaths in the neighbourhood of London, with tar and gravel, as now practised. A few years ago the material was mixed with stones and gravel, forming a sort of pudding, the whole thickness being put in at once, and as soon as the hot weather came, the tar exuded from the top, making a very bad, soft footpath. Of late years large stones alone had been put at the bottom, which, having received a coating of tar or pitch, just touched each other at points with their tarry surfaces. Above that a thin coating of finer material was placed, with a thin coat

of fine stuff on the top. This made a splendid path; no tar exuded from the top, as any surplus drained down to the bottom, and the path was firm, hard, durable and clean. Mr. Cowper.

Mr. J. LOVEGROVE desired, having had some experience in the use of asphalt on public footways, to make a few remarks. In the year 1869, when in Paris, he observed the peculiar condition of the roadway opposite the Tuileries; the asphalt appeared to have worked up into leaf-like layers, in a plastic state, and those layers occurred at distances of about 100 feet. He had little doubt that the cause was that the road had been repaired with asphalt too rich in bitumen. In the same year he also observed the paving of the road along the Rue St. Honoré; the process appeared to be different from that which was now adopted. There was first a layer, 4 inches thick, of hydraulic lime concrete, and then a layer of about 1 inch of mortar trowelled. The concrete was beaten with instruments similar to the tools used by gardeners for beating turf. On the top was a 3-inch layer of powdered asphalt; the channels were pressed into form by a rammer about 9 inches long and 2 inches thick, and were well rammed; then a heated roller was applied over the whole surface. A roller with eight or ten carriage wheels, working upon a common axle, was also passed over it in various ways for a considerable time. Before he left Paris a considerable portion of the asphalt had to be taken up, and he believed the whole was reinstated. He well remembered the care with which the concrete used in Threadneedle Street was mixed, and the quiet, steady way in which the foreigners worked upon the asphalt. It was a unique piece of work, and he would urge upon all asphalt representatives to endeavour to repeat it elsewhere. Great difficulty had been experienced in keeping in order a short piece of asphalt roadway opposite Hackney Town Hall, divided into three slips by tram-lines, the tram-rail and the asphalt being too unlike to be kept together. He had recently tried a rough course of granite pitching at the side of the rails, which seemed to promise well. If well-dressed stones were laid in bond course, he thought they would answer very well. In 1872 a sample of asphalt had been laid along the footpath at Dalston Junction for a length of 550 feet, by the Val de Travers company, and a second length was laid by the Limmer company. The first sample near Dalston Junction, being subjected to the greater wear, was renewed eighteen months ago; the other length was now wearing near the fence line, the concrete being exposed in patches. In 1874, a layer of $\frac{3}{4}$ inch of compressed asphalt was put along the busy part of Kingsland, and a path was also laid in a Mr. Lovegrove.

Mr. Lovegrove. quiet street in Stoke Newington. Shortly after cracks appeared at intervals of about every 12 feet, which he attributed to the contraction of the material during cooling. He did not believe that the concrete was affected. He had that day gone over a portion of the work and tested one of the cracks, and found the concrete quite sound. He had placed upon the table rubbings of three worn-out places; they looked more like a representation of the craters of the moon than of a worn-out asphalt path, but it was an interesting mode of showing the condition of the foot-path. Since 1876 about 160,000 superficial yards of gritted mastic asphalt had been laid in Hackney;¹ it was $\frac{3}{4}$ inch thick, and rested upon a bed of 3 inches of concrete. The work had been executed partly by the Limmer Company, the French Company, and Leopold Stiebel. Where the paths were narrow and the stream of traffic persistent in one track, the concrete was making its appearance in small patches. Sometimes in wide paths the stream of traffic was persistent next the fence line, and in these cases the path was apt to wear out. He would suggest that it would be advisable in such instances to lay an extra thickness. Of course, the fall would influence the traffic; if too much fall the traffic would be almost sure to keep to the fence line. It had been said that the quality of the Val de Travers asphalt was proved by its wearing to a film, but that was not peculiar to that asphalt, as the Limmer Company's asphalt behaved in precisely the same way. Common asphalt was more easily fractured, and would not wear to a fine film.

Mr. Davis.

Mr. ALFRED DAVIS observed that the compressed asphalt blocks used in Paris were stated to have been unsuccessful. In the United States a block was made of refined and tempered Trinidad asphalt and finely-crushed limestone, thoroughly heated and mixed in about equal proportions, and afterwards subjected to a uniform pressure of 1 ton to the square inch, or about 50 tons to the block. The standard size was 12 inches long by 4 inches wide, by 5 inches deep. The blocks had been laid in several of the New England States, and he believed were being extensively used in New York, Philadelphia, and other American cities. He had seen a piece of this roadway in Philadelphia, after six years' wear, and it appeared in first rate condition, although the blocks were inferior to those now produced. In laying the compressed asphalt block road, a concrete foundation at least 4 inches thick was provided, over which a thin coating of gravel was spread; upon this bed the blocks were set close together and heavily rammed.

¹ *Vide* Annual Reports to the Board of Works for the Hackney district.

The great advantage of this roadway was that it afforded a good Mr. Davis. foot-hold for horses, and at the same time possessed all the other advantages of asphalt roads as constructed in this country. The press employed in the manufacture of these blocks had a steam cylinder of 40 inches in diameter, worked with a pressure of 90 lbs. per square inch. There was an ingenious automatic arrangement for forcing the block out of the mould, and carrying it away to any desired spot for storage.

Mr. FREDERICK COX, Chairman of the Streets Committee of the Mr. Cox. City of London, said he had no connection with asphalt companies or wood paving companies; he was not an engineer, and he had no scientific knowledge whatever, but perhaps he might be permitted to make a few remarks as to the use of asphalt, past, present, and future, in the City of London. The administrators of the City Commissioners of Sewers gave encouragement to every projector to send in any kind of asphalt or wood pavement that was likely to be permanently useful. About thirty different kinds had received a fair and proper trial; most of them crumbled into dust or proved to be utterly worthless, but there were a few that had stood a severe test. In his opinion the Val de Travers was the favourite company; but other companies had laid down asphalt with good results. Mr. Haywood, the engineer of the Commissioners, who probably had had more experience in roadways than any other person in the kingdom, reported, five years ago, that, after trying the various kinds submitted, he found that good compressed asphalt was the cheapest, driest, cleanest, and most agreeable for the general purposes of traffic, and Mr. Cox ventured to say that if Mr. Haywood were giving his opinion now, it would be expressed in still stronger language. The Commissioners had carried out large paving works both with asphalt and wood, and probably the main reason that guided them in putting down so much wood was that the asphalt, especially when put down in great lengths, was found to be extremely slippery. In very dry or very wet weather the foot-hold of the horses was good, but when the pavement was muddy it was extremely inconvenient. It had been suggested that all that was necessary was to clean the streets, but what could be done with a place like Cheapside when ten or twelve thousand vehicles passed over it every day? After eight o'clock in the morning it was useless to attempt to do anything of the kind. At six o'clock that very morning Cheapside had been thoroughly cleansed; at nine o'clock it had not dried, and it was in that peculiar state that, although quite clean, it was very slippery. Grit had to be thrown upon it in order to

Mr. Cox.

enable the horses to stand, and that state of things continued until the afternoon, when the rain came on and converted the grit into mud, which was probably so still, unless the heavy rain that had since fallen had washed it into the gullies. If cleanliness could be accomplished, in his opinion asphalt would be the best roadway for all the main streets; its use had, however, been attended with great difficulties, and the authorities had not yet decided which plan to adopt. To show the difficulties that were experienced, he might mention that three years ago the Commissioners commenced washing the streets, but they were threatened with an injunction from the Court of Chancery for washing concrete down the sewers. The Metropolitan Board of Works, who had the care of the main sewers, said, "It is all very well to wash your grit into our main sewers, but we must be careful what we do, because the Conservancy Board are threatening an injunction against us for raising shoals in the bed of the river." That, however, did not frighten the authorities in the City, who went to an expense of £10,000 in providing large catch-pits to the gullies in the City in order that the deposits might be removed, which was done almost daily. Then arose a question about the water-carts, which caused so much obstruction in the crowded streets that the police interfered. The authorities had endeavoured to deal with that, and they had spent £20,000 during the last two years in erecting hydrants in every street and court in the City, both for the purpose of extinguishing fire and of watering the streets. Those hydrants were just completed, but had not been set to work. With regard to wood pavement, he believed it was one of the dirtiest and greasiest pavements ever put down in the City of London. Dirt was carried from it over 100 or 200 yards of the asphalt, and rendered that which was previously clean excessively dirty. He believed if the Commissioners could succeed in getting clean asphalt, so as to avoid slipperiness, wood pavement would make very little progress in the City of London, except upon gradients that were not suitable for asphalt.

Mr. Delano.

Mr. W. H. DELANO, in reply, said his experience in reference to scavenging was confined to Paris, where the work was effectually done both in wet and dry weather. Gangers were constantly at work, and they were paid about 3½*d.* an hour. The gully holes placed under the curbs were large and the drains were roomy, so that the slush was easily passed down them. Hydrants had been erected all over the city, and after heavy rains they were used to flush the roadways and carry the mud into the drains. Of course it got into the river and formed banks, but that was the

affair of other authorities. He would suggest that the catch-pits to which Mr. Cox had alluded might be emptied by a pneumatic system of pumping into carts. Formerly mud-carts were employed with revolving brushes to take up the slush; but he believed they had been superseded. It was evident that scavenging could not be done in London without considerable expense; but probably London mud, like Paris mud, contained fertilising qualities, so that some set-off might be obtained. With regard to the granite sets in Paris to which Mr. Ellice-Clark had referred, he had given particulars of the cost, and also of the cost and maintenance of the macadam, in the Appendix to his Paper, and an interesting report had been presented upon the subject by M. Vauthier. As to the cracks which had been so frequently mentioned, he believed they resulted in nine cases out of ten from the concrete. If mastic asphalt was placed on wet concrete it would blister and sometimes crack, especially if the bitumen used as a flux to melt it was not well purified. Some engineers used straight joints to prevent cracks. He had also seen hoop iron put in between the concrete at certain distances when it was not too thick. It was always well that the asphalt, liquid and mastic as well as compressed, should be sufficiently thick. Unfortunately Municipal Boards often required things to be done cheaply, and hence the thickness of the asphalt was less than it ought to be. In Paris, where a fifteenth part had to be renewed every year, thickness was not such a desideratum. In the case of gritted mastic, the thinner the mastic the finer the grit should be. Where the mastic was thick, a coarse grit might be used, as shown by the specimen of asphaltic concrete on the table. There were few compressed footpaths in Paris. In 1874 he laid on the Pont Royal about 200 square mètres of this material, under the orders of M. Allard, now Chief Engineer of the City of Paris, and it was now in good order. At one part it was laid $\frac{3}{8}$ inch thick, in other parts $\frac{1}{2}$ inch, and in others 1 inch. It had a better appearance than mastic, but it cost more, because the thickness was greater. The specific gravity of compressed and mastic asphalt was about the same, but the grit put into the mastic made it harder than the compressed material. The statement that asphalt neither contracted nor expanded was certainly an error. Of course the laying down of footpaths with gritted mastic depended a great deal upon the climate. In Marseilles the workmen would put into the cauldrons as much grit as they did asphalt, making a stiff mixture, which required great muscular strength to lay down $\frac{1}{6}$ inch in thickness, but when it was laid it answered very well. No practical worker

Mr. Delano.

Mr. Delano.

of asphalt would ever use compressed asphalt as a coating for masonry, because it had not sufficient elasticity. Coatings of masonry were generally put down $\frac{9}{16}$ inch thick, and they required a good deal of bitumen; sometimes the layers were vertical, at other times convex, and frequently had to be inserted in recesses in the masonry prepared for the purpose. Portland slabs had been suggested as a concrete, but he did not think they would answer, because they would require concrete underneath to keep them level. He had been reproached for not having alluded to asphalt as a covering for roofs, but his experience having been limited to France, where such applications were well known, particularly in the south, he supposed that engineers in London who were familiar with such applications would themselves refer to them. The applications of asphalt were almost endless. He had just seen a veteran asphalter in London who had shown him some work that he had done at the Horse Guards stables forty years ago. Up to the 31st of December, 1877, the chief cause of the want of stability of the compressed asphalt roadways in Paris was owing to the hydraulic lime concrete being only 4 inches thick, covered with a lime mortar floating, whereas a layer of 6 to 9 inches of Portland cement without floating was indispensable. Since the 1st of January, 1878, Lobsann asphalt had been used instead of Val de Travers and Seyssel as heretofore, which, according to the report of the Paris engineers, had not sufficient stability. Seyssel mastic was chiefly employed in France for footpaths and coatings for masonry, whereas Val de Travers had been more largely used for compressed asphalt roadways, although by no means exclusively. Wood pavement had not succeeded in Paris, the only important specimen on the patent plank foundation being the Rue St. Georges, which was partially in a bad state, although subject only to light traffic. In several cases wood pavements had been taken up in Paris within the last eight years, and replaced with granite sets and compressed asphalt. Wood was not a material of invariable density like compressed asphalt, the heart being always harder and less absorbent than the outer rings. It had, however, the great advantage of comparative insonority, though vibration was perceptible, and it was excellent for inclines exceeding 1 in 50. He thought that sound oaken sets, with bevelled edges carefully laid on good cement concrete with $\frac{1}{4}$ inch joints filled in with pure asphalt mastic, would render good service for roadways in dry climates, but he doubted if any pure wood pavements would last in Paris or in London much over three years without costly repairs. The smell from rotting wood pave-

ments saturated with the filth of large towns must be deleterious. Mr. Delano. It was well known in Paris that Sicilian asphalt had been taken out of the list of asphalts approved by the city engineers for roadways since 1872. He had been prohibited from employing about 1,500 tons from Ragusa, Sicily, for roads in Paris, and had used a good deal of it as ashlar. This rock was available for flags, staircases and balconies; it was susceptible of delicate carving for architectural ornaments. There were three qualities, one rich in bitumen, the second medium, and the third poor, the latter being a coarse grained yellow stone with the appearance of sandstone. If it would last three years under heavy traffic in London without repairs, such a test would class it as a material for roadways. It was quite possible to make bad work with good materials, though the converse was not true. Still, when good asphalt, properly ground and heated and well laid by careful workmen, did not stand, it was almost always the fault of the concrete. Laying on wet concrete, or using burnt powder was sometimes a cause of failure. Sets of pure Seyssel and Val de Travers powder, compressed in a mould 4 inches square and 2 inches deep, had been successfully used in Paris, but there would be a difficulty in repairs; it was also cheaper to lay hot powder in large towns. Some artificial sets, 8 inches cube, composed, he believed, of gas tar mastic and gravel, had been laid last autumn in the Rue Neuve des Petits-Champs, at the angle of the Rue Vivienne. The piece had been frequently repaired, as the surface wore away and crumbled under the traffic, which was not heavy. He had no confidence in bituminous concrete for roadways, except when used as a foundation for compressed asphalt instead of Portland cement concrete. With reference to the Seyssel and Val de Travers mines, he had hoped that the engineers who had worked them would have been present and given personal explanations. He might mention that the mines were easily worked; there was no choke-damp in them, and little water. The rock was blasted with powder, dynamite not being used because the asphalt was tenacious in its nature. It had been stated that the test of asphalt was its durability. His object in writing the Paper was that any engineer, surveyor, or architect, in specifying asphalt might have some other test. Asphalt might be adulterated; but the tests he had given would enable an architect or engineer to satisfy himself. With reference to the question of nomenclature, "asphalt concrete" had been alluded to in Mr. Deacon's Paper; but he was sure from the context that gas-tar concrete was meant, which was a different thing. Mr.

Mr. Delano.

Cowper also had referred to pitch and tar pavements; but pitch and tar were not asphalt. It was most important not to confound them in specifications, as their respective values and properties were widely different. Considerable areas of compressed asphalt had been laid in Berlin, Vienna, Pesth, Brussels, and New York, and he regretted that no engineer had described the mode of laying.

Correspondence.

Mr. Bixio.

Mr. MAURICE BIXIO, President of the Paris General Cab Company, owning about twelve thousand horses and six thousand vehicles gave the results of his experience as to the most suitable material for roadways for vehicular traffic. The worst pavement was porphyry (grey Belgian granite sets, 4 inches by 6 inches). Falls of horses were much less frequent on asphalt, macadam, or rough pitching (sets of Fontainebleau gritstone 8 inches cube). For the horses, falls on asphalt were less dangerous than on any other material. Beyond all doubt traction was less on asphalt than on any other pavement. His company had made many experiments on this subject, from which he would quote, at random, the following, relating to the French four-wheeled cab, weighing 658 kilogrammes (1,447 lbs.):—

		Kilogrammes.	
Traction on rough pitching		16·37	(36 lbs.)
„ small sets		14·79	(32·5 lbs.)
		Min.	Max.
„ macadam		14·0	to 20·5 (30·8 to 45 lbs.)
„ compressed asphalt (Val de Travers)		12·79	(28 lbs.)

It was probable, though difficult to establish otherwise than by comparison, that the wear and tear of the different parts of a vehicle was less rapid on asphalt than on other pavements. But the comparison did not apply in its entirety to macadam, in which case the tires of the wheel and the horse-shoes were the only parts that wore out more rapidly than on asphalt. The difference of wear was due to the jolting produced by sets, which naturally induced friction between all parts susceptible to that action. He thought that, traction being less, fatigue to the horse would also be less; but that was only an opinion, and not based on actual experiment. Asphalt was excellent also for granaries and for lining wooden mangers. For the paving of stables his company had made few experiments with the material, but as far as they had gone they were well satisfied.

Mr. Chabrier

Mr. ERNEST CHABRIER wished to deprecate a practice which had been tolerated for some time in the dépôts of the city of Paris,