The Author.

the dust. If there were negative pressure sufficient to lift out pebbles one would hardly expect to see that clean imprint, which also showed that the driving-wheels must be practically non-slipping, otherwise there would be signs of slipping in the imprinted pattern. It seemed to have been rather assumed that the Paper was in favour of the motor and against the horse. Such was not his intention at all. What he wished to impress strongly on the members was the great evil of having hard tires or any hard metallic contact with the roads, and to emphasize the fact that if people wished to preserve the roads they must not use mortar-mills and stamps on them—for that was practically what iron tires and horses' feet were. If horses could be shod differently so much the better; but his impression was that, in the course of time, horse traffic generally and iron-tired traffic would occupy the place which sailing vessels now occupied in sea traffic, that was to say, they would be used for slow and cheap traffic. He thought the usefulness of the horse was as a cross-country beast and for sport. With regard to Professor Smith's remarks, he would explain that in the formula on p. 117 the word "arc" was used in the sense of angle. Professor Smith's contention that the expression should be multiplied by r for the length of tire subtended by that angle was correct, and of course this had been done in computing the Tables in the Paper. Another point alluded to by Professor Smith was the effect of the thickness of the carbon paper, etc., on the apparent area of contact. This matter had been investigated and was allowed for in the results given. He quite agreed with Mr. Appleyard that the pressure in pneumatic tires would not be quite uniform over the area of contact with thick motor-tires. He knew by experiment that with thin tires the pressure was nearly uniform, but with the increase of stiffness in the outer tube the variation of pressure would become more pronounced, though in any case it would be less than with solid rubber tires, the diagram for which was given.

Correspondence.

Mr. Ball.

Mr. B. Ball had constructed a number of narrow roads with the concave form suggested by the Author, and paved with stone sets, but they had been found wanting in strength compared with the usual convex form; he had therefore abandoned this method and had gone back to the old shape. A roadway, whether of macadam or of stone

Mr. Ball. paving-sets, was, from its arched shape, able to withstand compression, and any slight settlement or consolidation in the road-bed would be spanned over and do little damage; but if constructed with a concave surface the road had little strength, and with the slightest settlement it rapidly went to pieces.

Mr. Crosby. Mr. W. W. Crosby, of the Maryland Geological Survey, acknowledged that the opening paragraph of the Paper was undebatable and agreed fully with the remarks under the head of "Foundations." Under the heading "Surface of Roads" and in the paragraph about stone sets, the Author evidently had in mind pavements of this material laid without a proper joint-filling, and under such conditions his remarks were correct. With a proper joint-filling the force of these remarks would be lessened if not entirely nullified. The Author observed that the defect of asphalt pavements was that the viscous surface was driven into lumps and ridges by hard tires: this might be so at times, but it was Mr. Crosby's opinion that displacement of the asphalt surface was usually due to unsuitable cement or improper grading of the mineral aggregate for the conditions of its use. As regarded macadamized roads, in order to ensure success, not only must the metal be capable of holding the tar firmly, but also the mineral aggregate must be properly graded, and the quality of the tar or other bituminous cement must be suitable for the conditions. He had frequently recommended the cross section shown in *Fig. 4* (*c*) for alleys in the United States, but seldom, if ever, for streets. Further, it was necessary there to provide for a rainfall as heavy as 5 inches per hour for short periods. It was not clear, however, why the objections raised to side gutters would not apply with added force to a central gutter with the same gradients and outlets, especially as the water to be provided for was usually halved between the two side gutters. It was stated in the Paper that the real enemies to good roads were iron tires and iron-shod horses. This might be so if by "good roads" were meant modern roads designed and built to withstand a preponderance of automobile traffic: but if the ideal was the best water-bound macadam road, he could not agree with the Author. Theories on which they seemed to agree forced him to the conclusion that the self-propulsion of vehicles set up in any road-surface horizontal stresses related to the momentum of the vehicle. Ordinary macadam relied on the interlocking of the particles of the wearing-surface course, in conjunction with the slightly cementitious action of the finest sizes, for the maintenance of its imperviousness and compactness or for its resistance to disintegration. The partial disintegration from the stresses of an occasional self-propelled vehicle might be repaired by the successive passage of hard-tired horse-drawn vehicles, and he had found this proved conclusively in a number of instances. Further, in the climate prevailing in the United States, unless a sufficient amount of such hard-tired traffic could be relied upon to solidify the surface, as an offset to the loosening effect of temperature-changes, etc., and to supply also, by attrition, the necessary fine material to replace that removed by wind and rain from ordinary macadam roads, these surfaces would disintegrate rapidly and would prove unable to withstand successfully the simple strains of the ordinary occasional load. Highway-engineers in the States seemed fairly well agreed that the intrusion of new traffic-conditions was more than temporary, and that under these conditions the use of water-bound macadam was limited. It also seemed fairly well agreed, as he himself had stated at the Paris Roads Congress of 1908, that between the place occupied by ordinary macadam and that held by any block pavement there was a gap, best filled perhaps by a pavement of broken stone constructed on the principles of ordinary macadam, but in which the interstices were filled, and the elasticity and horizontal strength of the pavement were reinforced, by a bituminous cement such as tar. The variety of compounds offered for this purpose, and the great variations in character found at present in almost any one of them, seemed to demand some method of standardizing the material, so as to avoid as soon and as far as possible the necessity of proving by actual trial the value of each compound, to ensure the certain repetition of successful results under similar conditions, and to escape from the necessity of purchasing such cement under trade names, with consequent limiting of competition and extravagance. His department had been at work on the problem for some time, and he forwarded a copy of the form of specifications for pitch compounds[1] which showed the standard tests required to ensure suitable viscosity and other qualities. Mr. Crosby.

Mr. P. Le Gavrian, of Versailles, remarked that the first section of the Paper showed the necessity for good foundations of sufficient thickness to withstand the stresses, a principle which had been enunciated by the First International Road Congress held at Paris in 1908. The Tables giving the surface of contact on a road for metallic and other tires were interesting; but he did not think that these results, which were the outcome of experiments made on smooth and homogeneous surfaces, could be applied to macadamized surfaces. He did not share the Author's opinion that the maximum pressure for such a surface would be much the same as for a solid pavement Mr. Le Gavrian.

[1] In the Library of The Institution.

Mr. Le Gavrian. of the stone used, and he believed that macadam was much more deformable (especially if wet) than the experimental surfaces of the same material. The Author said that it would not be practical to make such experiments on macadam. But why not? It was only necessary to note in each case the constituents of the macadam and its state of dryness. Moreover, it seemed to Mr. Le Gavrian that the Author considered chiefly the effects of rolling loads on the road, and paid only minor attention to the tangential effects due to speed, gradient, camber, etc., although an equation was given connecting the amount of shock with the velocity. Mr. Le Gavrian, however, believed that in the case of motor-cars—especially fast cars with pneumatic tires—the tangential stresses of the driving-wheels were the most important factors to be considered. These stresses were due not only to the weight and speed of the car, but also to acceleration and gradients. The tangential thrust increased not only according to the square of the speed, but also in proportion to the acceleration, causing considerable damage due to the effects of resistance and slipping, and also to the efforts at starting. On this point he could not do better than call attention to the formula given by Mr. Petot[1] for calculating the reactions of a wheel on the road.

Mr. Heslop. Mr. T. H. B. HESLOP thought that while the practical work of McAdam and Telford might not have been strictly scientific, it was enough to create roads that were amply sufficient for the requirements of the period; and indeed their principles had been applied successfully down to the present time. It was only in consequence of the altered conditions of traffic that additional methods of treatment were now required. *Fig. 1* showed the distortion in the bed of the road caused by heavy weights to be lateral only; according to his own experience there would be also a distinct forcing up of the surface on either side of the depression. As to tar macadam, it was essential, as the Author stated, that the tar should hold the metal firmly. The most suitable metal appeared, therefore, to be either slag or limestone, which on account of their soft, porous nature, were more absorbent than the better kinds of road-metal, and this fact constituted a strong objection to the use of material composed in such a manner. While agreeing with the Author as to the injurious effect of over-watering roads, he could not agree that it was the cause of the transverse ridges observed upon a road-surface. He had frequently noticed that this occurred when too thick a layer of metal had been spread and steam-rolled, the material being pushed up in front as described in the Paper. The Tables of

[1] Report No. 78 to the First International Road Congress. Paris, 1908.

tire-pressure seemed to prove the greater destructiveness of iron as compared with other materials, but this was confined to comparatively slow traffic. The effect upon the road-surface of india-rubber tires shod with steel and moving at a high speed was not shown; but it might be stated that upon lengths of road which came under Mr. Heslop's observation much more actual damage was caused by these than by iron tires. In his opinion it was just as important that the road-surface should be composed of the hardest and toughest material for motor-traffic as for the ordinary vehicular traffic with iron tires and iron-shod horses. This was apparent at once where a length of road had been surfaced with granite for some distance, with a gravel or flint surface immediately adjoining. He had under his charge many such roads where motor-traffic was continuous. Upon the flint roads after a time there were formed continuous shallow troughs where the wheels of motors ran, with deeper depressions at intervals, the material having been drawn out and scattered by the action of the india-rubber tires. Upon lengths of granite subject to the same traffic nothing was apparent except a cleanness of surface in the wheel-tracks. Mr. Heslop.

Mr. C. Jansens, of Ypres, wished to consider the use of iron rails on roads, drawing attention more especially to the commercial value of a road. In France there were 23,600 miles of national roads, 107,000 miles of connecting highways, and 9,050 miles of departmental roads. In this system there were at least 6,200 miles of high roads which were subjected to a traffic of 100 tons per day. Taking the figures of Mr. Debauve, Inspector-General of Roads in France, who estimated the cost of transport by road at 4·65*d.* per ton-mile, the total annual cost of transport effected on these roads, reckoning 300 working-days in a year, would be: $6,200 \times 100 \times 300 = 186,000,000$ ton-miles at 4·65*d.* = £3,750,000. Iron rails on the road would reduce the effort of traction by at least one-half; in fact, according to Mr. Debauve, the railway-authorities, by perfecting the line, the vehicle, and the motor at the same time, had succeeded in reducing the effort of traction to $6\frac{1}{2}$ lbs. per ton for a speed of $18\frac{1}{2}$ miles per hour, which represented barely one-fifth of the effort required in present systems of transport by road. It could therefore be affirmed that with the introduction of metal rails, the cost of transport would be reduced by at least one-third—that was to say, in France, by 1·55*d.* per ton-mile. On those 6,200 miles of road the user of metal rails would realize a profit of £1,250,000 per annum. At 22*s.* per lineal yard these 6,200 miles of iron rails would cost the Government £12,500,000, which at 3 per cent. interest involved an annual charge of £375,000. There was, therefore, on the Mr. Jansens.

Mr. Jansens. one hand an economy for the user of £1,250,000 per annum, and on the other hand an annual outlay of £375,000 to the debit of the roads account. If the public administrations themselves made exclusive use of roads, the metal lines would long ago have become general. The Government now would have to resort to taxation in order to raise money for taking this new step in the improvement of coaching-roads; it would have to demand from the nation a loan, which, however, would bring in a total interest of 10 per cent. In his inaugural address at the First International Roads Congress, Mr. Barthou had estimated at £240,000,000 the capital represented by the road system of France; it was necessary to produce a maximum profit on this investment, and one way would be to adapt more roads to the different means of transport in use.

Mr. Lapage. Mr. R. H. LAPAGE stated that in the Walmer Urban District the tar-painting of carriage-ways was commenced in 1904, and now practically every road in the district was so treated. The results had satisfied him that on roads carrying medium traffic, tar applied intelligently—as regarded both weather and workmanship—effected a considerable saving in the maintenance of roads; watering was unnecessary so far as the upkeep of the surface was concerned, and a road so treated was much more comfortable for riding or driving. Against this, more frequent sweeping was perhaps necessary for sanitary reasons; but, on the other hand, mud was practically eliminated. There were, no doubt, situations in which this treatment would not be an unqualified success, such as town roads carrying heavy traffic, or roads which were damp or thickly shaded; and the system had been frequently condemned because of its failure to succeed in all situations and under all conditions. While recognizing its limitations, he maintained that the tar-painting of road-surfaces on a much more extensive scale than at present obtained would give better roads, would reduce the dust nuisance to a minimum, and would effectually prevent the ever-increasing cost of maintenance now so generally credited to motor-traffic. Since the main country road through his district had been tarred, the cost of ordinary maintenance and repair had decreased from £450 to £250 per annum, the latter figure including the cost of tar-painting. On road-watering, which formerly cost £60, nothing was now spent, and taking one item of expense with another, the saving was 2·3*d.* per superficial yard per annum. The road, which had not been repaired for some years but which previous to tar-painting required repair every 2 or 3 years, showed practically no sign of wear and would not need repair for some years to come. Small depressions, such as were usually found on the site of old sewer or other trenches, were easily and satisfactorily repaired with small tarred granite. The tar-painting was done by hand, and the cost of applying two coats was slightly less than $1\frac{1}{4}d.$ per square yard, which included manual and team labour, tar, grit, brushes and coke—the work being carried out during the months of May, June and July. Several openings had been cut from time to time in the surface of the roads referred to, and in every case the road-metal had been found to be as sharp and regular as when first put down, the period since the tar-painting was done varying between 2 and 5 years. Mr. Lapage.

Mr. L. MOISSENET, of Montauban, observed that in fine weather, when a road commenced to dry, the binding material, especially if it contained calcareous mud, hardened and became compact like a cement. If in that state the road were covered with an impervious layer of tar which prevented any further moisture from penetrating and thus softening the binding material again, the latter remained hard even when wet weather returned. Then, with the road forming a compact hard concrete under the protecting layer, there was no longer any reason for displacement of the stones, nor for them to rub and crush each other laterally. This was the reason why well-applied tarring prolonged the life of a road. To this result, which was of much importance in a wet season, could be added the fact that in dry weather the layer of tar prevented the drawing out and raising of dust. Tarring was useful and successful if the road was made as solid as possible by using the maximum quantity of stone and the minimum of binding material, but it could not be recommended on repairs completed by the traffic, or on those made by badly-done rolling, which was scarcely better. When a road was well rolled, the clean stones, under the weight of the roller, were forced into contact and interlocked. They could not then be displaced except by the passage of a wheel causing a greater pressure than that of the steam-roller. The wheels of vehicles heavily laden gave rise to such pressures, and that was why roads wore out. But on many important roads such heavy weights were rare. Thus stones consolidated and interlocked by the passage of the roller had no tendency to become displaced, and lateral crushing and rubbing were avoided, giving much more durable roads. Moreover, when the metalling was compressed the binding material spread, and consequently only enough entered into the road to fill the voids, none being left to be forced out of the road; thus that cause of displacement of stones occasioned on traffic-made roads disappeared. If on a road thus made or re-made, and when the binder was sufficiently dry and hard, a protecting layer of tar Mr. Moissenet.

Mr. Moissenet. was spread, after a sweeping which slightly stripped the joints so as to permit the tar to penetrate, a road was obtained which was as perfect as it was humanly possible to make it. But such a result could not be obtained unless certain precautions were taken when reconstructing the road; these precautions he had expounded and justified in a recent report.[1] In conclusion, he would modify the Author's statement that the real enemies to good roads were iron tires and iron-shod horses, and would say that the worst enemies were too heavy loads on too narrow wheels, causing an excessive pressure per unit area of surface with consequent lateral rubbing and crushing of the material.

Mr. Oakden. Mr. RALPH OAKDEN observed that the Author based his theories as to the profile of road-surfaces on a purely secondary consideration, namely, the rate at which water flowed across a road during a shower. Now it mattered very little what this rate was, provided the water did flow off, and it was in relation to the ability of each portion of the road to rid itself of the slight film of moisture which remained after a rainfall that questions of profile should be considered. If it were practicable to construct a road with an even fall from crown to channel—in other words, with a profile consisting of two straight lines meeting at a very obtuse angle—then the crown of the road would dry sooner than the sides, because as the water drained from the latter it was continually supplemented by more water arriving from the centre. Therefore the sides were entitled to more fall than the centre, and this fact led to the convex form almost universally adopted in practice. The profile shown in *Fig. 4* (*c*) appeared to him to be about the worst that could be adopted, because the bulk of the traffic would follow alongside the central grating, this portion being the flattest. For the same reason, and for that just given, it would be the part least capable of withstanding the traffic. The advantages of a central channel appeared questionable: the disadvantages, at any rate for a dry or a tar-macadam road, were unquestionable. Every road-surveyor knew the difficulties which arose from manhole-covers and other structures of a permanent character in such a road. The same difficulties would occur with a central channel or grating. If the road on being newly made were finished well above the grating it would cause an obstruction. If it were not so finished, then in a short time the portions alongside the grating would wear below its level and pools of water would form. Under the present system, when a vehicle had to turn close to a corner—as in going to

[1] Report No. 30 to the First International Road Congress. Paris, 1908.

the left—the raising of its outer wheel afforded some protection against skidding or overturning. With a hollow road the conditions would be reversed, and drivers would be tempted to take the outside curve, whether entitled to or not. As to the dust question, it must be remembered that the movement of each portion of the tire on coming in contact with the ground was a vertical one. Each stud struck the ground a downward blow and then rose sharply upwards. The velocity of these movements depended chiefly on that of the car, but it was also affected by the size of the wheels; the smaller the wheels, the greater this velocity and therefore the more dust. Mr. Oakden.

Mr. WOODFORD PILKINGTON noticed that in speaking of asphalt, the Author only took cognizance of those kinds which were mixtures of finely-broken stone and pitch. This paving probably required less tractive effort for haulage than any others, and when dry it was not slippery; but the hardness of the material was much affected by temperature. This defect, however, did not attach to compressed asphalt formed of the reintegrating crystallized limestone which was found naturally impregnated with true bitumen in France and Sicily. Specimens of this paving were to be seen in front of Dean's Yard, Westminster, and throughout Victoria Street. Laid on a concrete foundation in a layer 2 to 3 inches in thickness, consolidated by punning the material in a heated condition, it formed a true and regular surface quite impervious to water, and if kept clean was always free from dust and dirt, unless such were conveyed to it by contact with inferior paving at either end. It could be laid and repaired by any ordinary workman, the old material always serving for renewals when reduced to powder, as it reintegrated at once under the action of heat; it was practically everlasting, and, it seemed to him, formed the only serviceable remedy for all the ills that motor-traffic was heir to. The roads of England could be surfaced with compressed asphalt at the rate of 5*s.* 6*d.* per superficial yard, or, for a road 10 yards in width, at the rate of £3 per lineal yard, or £5,280 per mile, exclusive of the concrete foundation. The conclusion seemed inevitable that the whole question of roads would be solved by universal adoption of compressed asphalt for road-surfacing, whether the real enemies to good roads were iron tires and iron-shod horses or not, asphalt being practically everlasting and indestructible, no matter what profile of road-surface was adopted. Mr. Pilkington.

Mr. A. DE SOMER, of Bruges, could not agree that the concave form recommended by the Author was superior to the usual convex surface. A road of the latter shape would resist as an arch, the edges, if sufficiently strong and supported, forming the Mr. de Somer.

Mr. de Somer. abutments. Moreover, any slight sinking of the crown under heavy traffic would only tend to hold more firmly the stones forming the surface. In the concave form of surface, on the other hand, the road formed an inverted arch with no resistance, and any lowering of the surface would open up the joints, loosening the stones and allowing water to penetrate. Assuming, then, that in a convex road an arching effect did take place, it was not necessary that the foundations should be excessively solid; and the chief resistance of the road lay in the rigidity of the banks or edges to which the pressures were transferred. He had ascertained personally that a ballasted road constructed with a crown $24\frac{3}{4}$ inches thick had no greater resistance than one with a 14-inch crown. In the first case the foundation of rough stone, which was $4\frac{3}{4}$ inches thicker than in the second, rested on a 6-inch bed of cinders forming the foundation of the crown. In the second case there was no cinder foundation; otherwise the condition of the soil, the thickness of the upper bed of porphyry metalling (6 inches), and the support at the edges were about the same in the two cases. This experience formed an additional argument against a concave shape which, for the same strength, required a much thicker foundation than in the case of a convex curve; and he would affirm that the latter shape, combined with edges fixed either by means of footpaths or by specially consolidated sides, was indispensable for the stability and life of a road. In addition, there was considerable economy both in first cost and in subsequent maintenance.

Mr. Wood. Mr. Francis Wood wished to correct what appeared to be an inaccurate conclusion, namely, that the life of wood-paving was increased by the grit thrown on to its surface. A little consideration would show wherein the fallacy lay. The virtue of timber for wood-paving purposes lay in the very fact that the fibre was tough and perfect. American red-gum timber had been experimented upon about 4 years ago for wood-paving purposes, and had failed owing to its lack of toughness. When the crushed flint stones were scattered over the surface of the paving they were pressed by the traffic into the surface of the wood, and the fibre was either broken or crushed, thus rendering it easy for the frictional forces to wear the material. Again, the stone either remained in the surface and was pressed still farther into the wood by each tire that passed over it, or it might be forced out and leave a small depression which the traffic would wear into a larger one. The stones were thrown over the surface merely to counteract the slipperiness caused by the exuding of the creosote oil or by atmospheric conditions which rendered not only wood but other pavements greasy. Sand was far preferable, but such large quantities would be required that it would be very costly, and the mixture resulting made the remedy worse than the disease. The statement that horse-droppings and asphalt detritus were more slippery than other mud that did not contain clay also seemed to be erroneous. He was taking a number of records at the present time, which, though not complete, would give an approximate idea of what really happened. On a certain asphalt road, over which horse-omnibus traffic had been very considerable, the average wear after 17 years was 1 inch. Supposing, however, that the wear was about 1 inch in 10 years, or say, at the rate of $\frac{1}{3000}$ inch per day, there would be collected on such a road about 2 to 3 tons of horse-droppings each day, and the proportion of asphalt detritus, etc., would be only about 1 per cent. of the horse-manure; it surely would not be suggested that such a slight proportion could make the road slippery. Asphalt roads were only slippery, to horses accustomed to the surface, after or during a drizzling rain, which brought down carbon and other matter out of the atmosphere on to the non-absorbing asphalt; this, mixed with the mud which was brought from the side streets, horse manure, and the sand which was sprinkled on the road, went to render the surface greasy. It would be noticed that other forms of paving were greasy in similar weather, but to a less extent, because the character of the material of the road-surface was such that it absorbed the carbon and other matter to a greater degree. It was stated that the breaking up of asphalt was due to the material being unable to bear the shear caused by the traffic. This was true, but was also misleading, as it was not stated how long the asphalt has been laid down before the breaking up commenced. He thought that it was an exceptional instance where asphalt began to break up before it had been down 7 to 10 years. The breaking up occurred when it had worn down to about an inch thick. The statement in the Paper that hard tires wore out roads by the direct crushing of projecting stones must refer to years ago, before the advent of the steam-roller. On a properly-rolled road there should be no projecting stones. If any stones were crushed it must have been done by the roller in the first instance. Central drains for roads were by no means a new idea, but were impracticable. When some method was devised by which it would be possible to remove in an economical manner the road-detritus which might enter into the central drain, then perhaps it might be possible to consider the advantages, which were obvious. With regard to the destruction of a road by iron-shod horses and iron tires, the only force exerted by the tires was vertical pressure; Mr. Wood.

Mr. Wood. the wear was due to the want of resilience in, or the insufficient elasticity of, the material over which the tire was passing, and took place especially at the edge of the tire. In the case of horse-drawn vehicles the whole of the tractive force was exerted by means of the horse's hoofs, and he did not see how the removal of the shoes would decrease in the slightest the tractive force which the horse exerted on the road-surface through the points of the hoofs. It was the friction of the horse's hoof which really caused the wear. In the case of motors, the tractive force required was transmitted through the driving-wheels, so that what was required from the point of view of a road-engineer was a satisfactory road-surface that would resist the maximum shearing-force of any weight that might be brought upon its surface, and would give sufficient resistance to enable the vehicle to pass over its surface without, by this method also, destroying its elasticity. He was satisfied that the fact of the wear of a principal road subject to heavy traffic and having a surface of asphalt or wood paving, wearing at the rate of only $\frac{1}{10}$ inch per annum, demonstrated that on the majority of roads granite macadam had been wastefully used, and that some method would yet be found whereby it would be used with more satisfactory results and the cost of the maintenance of roads would be, as a consequence, considerably reduced. He knew of macadam roads which wore at an average rate of $\frac{1}{7}$ inch per annum, where the traffic was not one-twentieth of that of the asphalt road already referred to. The reason why tar was not successful where the road was subjected to heavy traffic was because the tar rapidly gave up the oils which were necessary to its elasticity and it therefore became brittle; it was for this reason that experiments were being made with bitumen. He had laid with this material a road subject to comparatively light traffic, at a cost less than that of tar-macadam, and so far it had been all that could be desired.

The Author. The AUTHOR, in reply to the Correspondence, observed that several of the writers appeared to attach importance to the arched section of the ordinary form of roads, and to imagine that this arched shape actually contributed to the reaction of the surface against a vertical load. It must be obvious to anyone who considered the intrinsic strength of the material used, the radius of curvature of the surface, and the nature of the abutments, that no such effect took place. With regard to concave roads in general, their advantages would be apparent in wide rather than in narrow roads, and in towns where the foot-traffic was as important as the traffic on wheels. One of the most important points was the continuity of drainage along the whole length of the road, which

The Author.

prevented the formation of deep streams on the surface; and such continuity might be arranged with properly-constructed side gutters and a road of the ordinary convex section. What would, however, be better for traffic than either a convex or a concave surface, was a flat surface properly drained at all points—a continuous flat grating, in fact. By a grating in this connection he did not, of course, mean a structure of iron bars, but one which, while allowing fluids to pass through it, presented a fair surface for wheels to roll on. Such a surface might be produced in several ways, although they would all be costly; but in some parts of London even this expense might not appear too great if it gave a road-surface clean in all weathers. Mr. Pilkington's remarks implied that the rock-asphalts were not liable to be driven into ridges by the action of the traffic. The Author had watched the pavement in Victoria Street with some care ever since the asphalt was laid, and it was in this street that he first noticed the ridges and hollows in question. At the present time the surface was so much patched that little of the original asphalt was left; but both in the new and in the older parts the ridges could be seen. They were most visible in the late afternoon sunshine during spring and autumn. The Correspondence contained several heterodox statements relative to the effect of speed on the tangential pressures on a road. Most of these might have been avoided by a little calculation of the actual forces involved.

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30 March, 1909.

JAMES CHARLES INGLIS, President, in the Chair.

The discussion on Mr. Mallock's Paper "Construction and Wear of Roads" occupied the evening.
