Whether net receipts on this scale would be sufficient depends on the policy regarding toll traffic. Road transport already pays £361 million a year for the use of public roads that get only £80–£90 million worth of attention; vehicle owners would get infinitely better value for money in paying tolls for the use of the B.R. system: possibly tolls would cover the entire cost of upkeep, and also make some contribution towards interest on capital—more than this is achieved in the Mersey tunnel. On the whole the standard $\frac{1}{2}d$-per-mile fare is adjudged practicable.

It should be noted that the 40-seat bus can be equated to a 20-ton freight vehicle with "fare" 1*d* per ton-mile. However, dead milage is a greater factor in freight services, so 1·5*d* ton-mile is probably a fairer estimate of what would be practicable. The comparable British Railways rates for 1952 were 1·94*d* for minerals, 2·35*d* coal and coke, 2·69*d* all classes. The British Road Services rate was 4·03*d*.

The owner-driver of a 60-m.p.h. hire car, with fare 9*d* per mile (of which 3*d* goes at once on fuel, lubricants, and tires) would clear 30*s* per hour. If he could average 4 hours employment a day this would amount to £2,190 a year—enabling him to write off a £790 vehicle and remain £1,400 in pocket. The 9*d* fare therefore appears practicable; divided between four passengers it would be less than the present first-class train fare of 2·6*d* per mile (third class is 1·75*d*).

The foregoing examples of high journey-speed reducing the costs of transport are no more than an extension of current experience; an express railway service is normally very much more profitable than an ordinary one. But there are many technical and sociological factors limiting the proportion of railway services that can be express. From the financial viewpoint conversion can be seen as a means of vastly increasing the proportion of express services on the British Railways' system.

The Paper was received on the 6th January, 1955.

Discussion

The Author, introducing the Paper, paid a tribute to Mr T. E. Hutton, whose valuable work on the design and layout of motorways had been discussed at the Institution almost exactly 2 years previously.[12] That discussion had covered and disposed of many of the details of the present subject, and had also prevented it from seeming unduly iconoclastic; for the question had arisen whether Mr Hutton's motorways should be aligned alongside the railways, and now the Author proposed merely lifting them over the fence and putting them where he thought they belonged.

The main issue, presumably, lay between rails and a plain road surface, but the Author hoped that the ensuing discussion would not resolve into yet another debate on the rival merits of rail transport and ordinary road transport. His proposals were for a distinctive third form of transport which was truly an amalgam of the other two and, like any amalgam, it would finally bear no very close resemblance to either of its constituents, though it would have to preserve certain of their qualities. Which of their qualities would be preserved and which eliminated?

He proposed dealing very briefly with two or three of the qualities in question, starting with the low rolling friction of railways. That had been their vital characteristic when mechanical power was in its infancy. Brunel had based his advocacy of the 7-ft gauge on the axiom: "the larger the wheel the less the friction". He had intended constructing his carriages

between large wheels instead of over small ones, as was necessary with the standard gauge, and he had hoped thereby to reduce the tractive effort required to overcome friction between tire and rail from 10 lb/ton to perhaps 8 lb/ton. But today power was plentiful and cheap, and the Author suggested that neither financially nor technically did there remain any merit in the low friction of railways. On the financial side—to consider one form of power that was by no means the cheapest—one pennyworth of electricity disposed of the friction directly attributable to 700 railway-passenger-miles bringing in a revenue of 1,225 pence (third class). So the low friction was not reflected in fares, and indeed it could be halved or doubled or increased tenfold without affecting fares or freight charges. On the technical side, the stage had been reached where the abundant power now available in various compact mobile forms simply could not be harnessed effectively or safely without wheel grip derived from adequate friction between tire and running surface.

Research in Brunel's day had gone into minimum friction; today it went into minimum acceptable friction, which was virtually the opposite. Indeed, friction within reasonable limits had ceased to be an enemy and had become an ally. Hence the Paris Metro's quaint experiments with pneumatic tires. But it seemed that the optimum friction could be obtained only with pneumatic tires on a carefully specified road surface and, thanks to the Road Research Laboratory, everyone could be confident that one feature of the roads that British Railways might make of their permanent ways would be precisely that of optimum friction.

Next he wished to refer to the herculean task of railway-track maintenance which, it was predicted, would increase as a result of the £1,200 million modernization scheme. The reasons for the great disparities in expense and in effort between railway maintenance and road maintenance had been ably brought out by Mr Barnes in a Paper,[29] from which he would select just two of many relevant passages. First, Mr Barnes had deemed worth mentioning, enviously, the elementary fact that in modern roads rainfall was kept out of direct contact with the subgrade; and secondly, in dealing with the blanketing of a clay subgrade, he had admitted that vertically the adopted grading of materials was opposite to the conventional one met with in road practice. In short, the ballasted permanent way became a macadam road upside down; and it seemed only sensible, especially in the British climate, to reconstruct it the right way up as a road, when it would largely look after itself, changing the task of the permanent way engineers into one of high-grade road construction and maintenance—in which they should have no difficulty in achieving their declared aim of mechanizing their work.

But there was one valuable quality of railways that would be inherited lock, stock, and barrel by the proposed third form of transport, which was

[29] References 29 *et seq.* are given on p. 787.

that it would be operated to professional standards, like sea or air transport, with none of the ragged amateurishness inevitable on public roads.

The Author had given three examples—wheel grip, route maintenance, and professional operation—to add to those already in the Paper of the manner in which the good qualities, and only the good qualities, of rail and motor transport would accumulate in the amalgamated system. The case for railway conversion could not be expressed in a phrase or a sentence. It was founded on a wide accumulation of qualities, which, on commonplace evidence, without allowing for improvements in road making and in motor vehicles, would yield a transportation system with the very minimum of imperfections. In fine, British Railways could become the sole purveyors of the highest quality of transport on earth if only they would abandon rails !

Rails had been a valuable expedient, for they had tided the world over a lengthy period when mechanical power had been scarce. They had done much for Britain, because British engineers had been the first to realize the potentialities of rails, whereupon the country's inland transport, through the medium of railways, had become so vastly superior to that of any other country that it had been able to play a predominant part in the nation becoming and remaining for a long time supreme economically among the peoples of the world. But now those railways had declined in usefulness to such an extent that their share of the yearly turnover in domestic transport was less than £500 million out of a total of more than £2,200 million. They had been outgrown and outmoded by the volume and pattern of the nation's transport requirements. They were indeed now no more than a sedate and orderly supplement to Britain's inadequate and crazy network of roads. They were now to be given an injection of £1,200 million, merely to keep them in being, carrying no higher a proportion of the nation's traffic for a period hesitantly defined as " many years to come ".

Desiring to aim higher than that, the Author esteemed it a privilege to open an exploration of the one seemingly possible means of re-establishing British Railways as Britain's primary system of transport vastly superior to that of any other nation. Just as a century and a quarter ago the nation's well-being had depended on engineers realizing the value of rails, so today, against a totally different engineering background, including new sciences, new materials, new power units, new vehicles, and new road structures, much depended on their realizing the potentialities of the permanent ways as roads reserved for modern vehicles matching in excellence the road surfaces that could nowadays be produced by the civil engineering profession.

Dr W. H. Glanville (Director of Road Research, D.S.I.R.) said that after the Author's stimulating introduction of the Paper he found it somewhat difficult to know where to begin.

He thought that the main point to mention at the beginning was that unless the railways were revolutionized in their speed and efficiency or unless road transport was hamstrung in some way, by heavy taxation, preventive legislation, or inadequate roads (as might indeed seem likely from the rapid growth of traffic within recent years, for half a million new vehicles were coming on the roads every year and possibly in a few years' time there would be as many as a million new vehicles coming on the roads each year, if the motor manufacturers had their way), then the railways were wellnigh obsolete. If something was done to put the road conditions right, then the railways would have to revolutionize their speed and efficiency, and, as he saw it, the Author had suggested one way in which that speed and efficiency might, perhaps, be revolutionized.

In the Paper the Author had stated that he proposed to concrete over the railways and run special motor vehicles on them; the vehicles would remain on the concreted ways, with all the terminal difficulties that that would involve in the transport of goods and of people from the termini to the places for which they were destined. In other words, although the Author referred in passing to the "amalgam preserving the mercurial qualities of road transport", it was important to realize that his proposals would only partially do that.

The Author had not given what Dr Glanville would regard as really satisfactory figures of the cost of the conversion. The Appendix on "Finance of Vehicle Operation on the Converted B.R. System" was, to say the least, very optimistic. It did not seem to him that the sort of circumstances envisaged would be likely to pertain, namely, that buses would in fact run full for 8 hours a day, 6 days a week, and so on. He found it extremely difficult to understand how that could happen, and if it did not happen, and if for a large proportion of the time they were not full, then the whole argument was affected most seriously.

He would like to see some sort of estimate made of the cost of the conversion; he had no idea what it would be, and it seemed to him that the matter could not be properly approached until one had some idea of the cost.

Apart from costs, there were certain basic considerations upon which he would like to hear the Author's further comments. There was, in particular, the question of widths. He thought the Author was correct in saying that 10-ft-wide lanes *had been* accepted by the Ministry of Transport but wrong in thinking that they *were still* accepted. The Minister of Transport had already stated that the traffic lane on new motorways would be 12 ft wide, and that basically affected the Author's proposals.

The danger of traffic running in two directions on the same carriageway at high speeds was, said the Author, to be avoided by instituting high professional standards of driving. But Dr Glanville was not content with that because whatever was achieved in improving driving standards accidents would still be much more likely to happen on narrow carriageways

than on wider carriageways. He was surprised to hear the Author suggest otherwise; it was an accepted principle that two carriageways should be used. The temporary swing in favour of single carriageways was only barely perceptible and could not be seriously considered at the moment. The present real trend of thought was towards motorways which had two carriageways, one for traffic in each direction, with wider traffic lanes than those specified in the Paper, and—what was equally important—shoulders where vehicles in trouble could pull off. It was difficult, even under the ideal conditions of vehicle operation envisaged by the Author, to imagine a successful high-speed motorway without some provision for wide shoulders where the vehicles could pull off.

He did not think that the accident figures quoted by the Author were likely to be at all representative. The very low figures obtained on motorways abroad were attributable to very strict control of traffic—with police patrols, careful segregation of traffic, shoulders for the traffic to pull off, separate parking areas, and so on. In his view figures of that order would be very difficult indeed to obtain under the conditions which the Author visualized.

In his conclusions, the Author had said " The philosophy of the matter can be summed up in the question of whether it is a good thing to save people time and money." Dr Glanville suggested that the Paper did not prove that people would be saved time and money, but he suggested that the economics of the proposal should be examined in greater detail.

Mr David Blee (Traffic Adviser, British Transport Commission) said that he had long since recognized that the first qualification for a traffic man was to keep his mind absolutely open to receive the earliest impressions on any change in the methods of production of transport which were calculated to achieve the ideals of the philosophy expressed in the Paper.

He was not qualified to express an opinion on any of the technical facets of the plan proposed by the Author. From the traffic point of view, however, he felt that the Author had fallen into profound errors by not making as thorough a study of the traffic problem as he had of the technical issues. Without first fully assimilating the nature of the work which was required to be done, how was it possible to calculate the tools best suited to perform the task? It was impractical, he suggested, to think in terms of planning, for example, for the jigging and tooling of a factory without considering what sort of commodity it was going to produce, what the production cost would be, and to whom the commodity, when produced, was to be sold at a price which showed a fair return on the investment.

The traffic problem divided itself naturally into two parts, freight and passengers respectively, and he would treat briefly each of those parts and touch upon the generalities which were common to both.

The first point to be taken into account was the enormous peaks of the transport requirements in Britain—peaks which recurred by the hour, by

the day, by the week, and by the month. There was no evenness of distribution. For example, in the case of a large steelworks, the movements of coal, iron, limestone, and other raw materials in relation to the volume of finished products, might be in the ratio of 5, 6, 7, or 8 to 1; and it was certainly true that any transport system which could achieve a balanced load ratio of approximately 50% over its whole range of operations was doing something remarkably efficient.

He wished to dispel the false impression which, inadvertently, the Author's comments might have implied—that the railways were virtually an outmoded institution dealing with a residuum of traffic. The facts were that when the overall figures for road traffic were stripped of the work done by the collection and delivery vehicles of local retail tradesmen and short-haul operators, the work done on the roads in respect of commodities requiring public transport over measurable distances was 7,000 to 8,000 million ton/miles as compared with 22,000 million ton/miles by rail. Furthermore, the railways were by no means carrying the volume of business which they would be carrying under a modernized and reconstructed railway organization and with a rate-charging scheme which gave them the same flexibility as their competitors.

The Author had completely ignored the problem of the peaks—a problem which occurred with equal force in the field of passenger traffic. He had considered, by way of illustration, the requirements of Waterloo. However, a realistic calculation of the requirements of the London termini of the Southern Region at the peak hour of the evening would show that almost the whole of that proportion of the road vehicles allocated for passenger traffic would be required and none would be left for Manchester.

But that was not the only kind of peak. Football matches and other special events had to be considered. More important still was the peak of the holiday traffic. In fact, in the two months of July and August there occurred rather more than a quarter and nearly one-third of the whole of the long-distance passenger movement in Britain, and that had to be met by any provider of public transport, unless what the public required and what trade and industry needed were to be ignored.

Failure to make a really profound study of the traffic requirements of trade and industry and of the travelling public had led the Author into such profound error that Mr Blee did not think he was exaggerating when he said that the number of road vehicles of the capacity which the Author had indicated would be required in the traffic conditions peculiar to the country would be nearer half a million than the figure indicated in the Paper—and that should be considered in relation to the total staff at present employed on British Railways.

Dr Glanville had touched, in passing, upon some of those points and had stated in his concluding remarks that a profound economic study of the Author's proposals was necessary before conclusions could be drawn. Mr Blee had given some thought to the relative costs which would appear

to be involved in the two alternative means of dealing with the fundamental national transport problem. Of course, if it was practicable to relieve trade and industry of the cost of the transfer of traffic from one form of transport to another, a major contribution would be made to a reduction in transport costs; but if the Author's proposals provided the only way of doing it (which he would dispute), then, on the best calculations which he could make, the cost of movement under the present system of British Railways operation was likely to work out at approximately a quarter of the cost of movement under the scheme predicated in the Paper. The present cost of providing British Railways services was of the order of £500 million a year. That figure would be more than doubled if the Author's proposal was to be carried to its logical conclusion.

Nothing that one could foresee in the economic life of the nation over the next 10–20 years indicated any significant change in the fundamental factors of transport to which he had referred, and he therefore submitted that the Author's interesting, provocative, and helpful contribution to thought failed because the Author had not had the opportunity of making a sufficiently close study of the nature of the traffic problem and thus had been led into grave economic errors in his conclusions.

Mr Stanley Mehew (County Surveyor, Derbyshire) said that, as one of the " ragged amateurs " at present engaged in maintaining the roads of Britain, he was much intrigued by the Paper, the clarity of which made one feel that there must be a catch in it somewhere.

On the question of width and the necessity for dual carriageways, he entirely agreed with Dr Glanville's remarks. He felt, however, that primarily a major question of policy was involved. Knowing nothing about plans for the future of the railways, other than what he had read, he had assumed that it was envisaged there was to be a process of electrification, followed eventually by the use of atomic power and the development of cheap sources of electricity. That might make economic competition from vehicles of the type envisaged by the Author quite impossible.

He agreed that there was a possibility of converting a four-line railway into a dual carriageway road and thought that the engineering difficulties were probably less than appeared at first sight. In the first place, the very difficult problem of severance of properties—the cutting-off of the farm from its land, industries from their sources of materials, and so on—was overcome already, because those things had grown up around the railway system as it now existed.

It had been his lot to plan two roads of a much smaller character than those under discussion—roads about 10 miles long, in one case utilizing the line of an old canal and in the other following a disused railway. Compared with railways of the width now under discussion, those existing installations, the railway and the canal, had been very minor, but they had been of surprising value as a basis for planning modern dual-carriageway

roads; the detailed work in that connexion had convinced him that the change-over from rail to road would probably by no means be so difficult as many people might imagine.

The Author was probably right about the comfort, silence, and smooth-running conditions possible on a modern road system. But with long-distance traffic, even in the British Isles, he doubted whether the fact that people would be unable to walk about in the way they were accustomed to do in a train, would be welcomed by the travelling public. However, that might be overcome by the trailer system with 8-ft or even wider vehicles.

He had some doubts about the Author's remarks on the subject of manpower. It seemed to him that if the commercial and industrial traffic were converted to a large number of small units, the manpower requirements must go up very substantially. He well remembered that during the war the proprietor of a very large road-haulage undertaking who, by a turn of fortune's wheel, had been put in charge of a very considerable coal traffic on both road and rail had told him how amazed he was at the ease of transporting large quantities of materials such as coal by rail.

He wished to make a point about the weather. The railed vehicle—the captive vehicle, as the Author had described it—was very much less affected by winter conditions of snow, frost, and fog, than non-captive vehicles. That was quite an important factor in certain parts of the country, because those conditions could persist for a considerable time.

After a careful study of the extremely provocative Paper, he had come to the conclusion that the Author had made out a case which justified a much more detailed analysis of the subject.

Mr John Ratter (Technical Adviser, British Transport Commission) suggested that if present-day scientific knowledge had been available 130 years ago, the railways would probably not have been built in their present form. Our forefathers might even have built motorways instead and the present meeting might now be bewailing the fact that the country was denied railways, with all that they could offer in speed, safety, and comfort, and with their potential to convert to the uses of transport future supplies of cheap electricity provided by nuclear power.

But nothing could alter the fact that the railways had been built, and even if there was advantage in doing it, the task of converting them to roadways was beyond the country's capacity in present times.

The engineering problem had been hardly mentioned in the Paper. Mr Ratter thought it was a fundamental mistake to consider conversion as simply laying concrete roadways on to formations where rails had lain before. A railway was far more than a system of tracks; it also comprised stations, workshops, docks, and many other buildings.

The engineering problem of conversion would also include the provision of road access to places where it did not exist—docks, workshops,

factories, and mines—which had been built on the assumption that the railways were there to serve them.

Further, during the period while conversion was being undertaken, the country's traffic must still be carried—and it should not be forgotten that most of the long-distance traffic was carried in bulk by rail.

When the railway from London to Edinburgh was being converted, for example, the whole of the traffic would be thrown on to the presently overcrowded route A.1.

The Author had not described the constructional difficulties bridges and tunnels would present. There were about 30,000 bridges on the railways, which, if they were to be used for roads, would in most cases be useful only so far as the main girders were concerned. Each would require a new floor.

Every station would have to be demolished. What would it mean, for example, to rebuild Waterloo to provide turning circles and a complete layout for buses ?

Those were real difficulties, and it was necessary to be realistic in considering them. No one present needed reminding of the lack of engineers which the country had to face for many years to come.

The Author had stated that driving a bus at 70 m.p.h. against oncoming traffic on a 24-ft road would keep the driver " alert ". He would certainly need to be. He would also be considerably frightened. If then, 24 ft was not wide enough, and the road had to be widened, then, since railways were built on high embankments and in deep cuttings to maintain easy gradients, heavy earthworks would result—far heavier than was usual in normal road construction.

Furthermore, railways ran over high-level viaducts and river bridges for the same reason. Widening them presented a formidable task.

The Author proposed the construction of roads with superfine level surfaces which would be very expensive to lay and to maintain against the dense fast traffic he envisaged.

It cost the railways £17 million a year to renew their tracks, of which about £6 million went in the purchase of new rail.

According to the Paper, 10,000 vehicles were going to run 2,500 hours a year at 60 m.p.h. to carry the railways' traffic. If that were so, each would have to cover 150,000 miles a year. On that basis the cost of tires alone would exceed British Railways' expenditure on rails.

Mr Ratter thought that comfort to the passenger did not depend on a level road surface alone. There was also the effect of steering. Even on the best road surface, soup could not be drunk in a car travelling at 60 m.p.h., a feat accomplished daily in trains!

He did not need to stress the effects of fog, snow, and rain on road traffic, for they were obvious.

He criticized the Paper because in his opinion it committed the error of being altogether too wholesale.

The railway authorities did not for one moment imagine that they should carry the whole of the country's traffic. They knew the important part the roads had to play in providing the nation with efficient transport and appreciated the need for better highways.

British Railways had launched an enormous modernization plan and were determined to carry it out. The Author should not think of railways as they were now. Two wars and their aftermath had arrested their development. The time could now be foreseen when trains would run smoothly on jointless rails at 100 m.p.h. and more, and passengers would sit at ease in comfort and safety, having their meals when they wanted them.

Goods traffic would be speedily distributed by making full use of the best features of both road and rail.

By all means let good highways be built, but let not the mistake be made of thinking that the best place to build them was on the railways.

Major H. E. Aldington (Technical Adviser, British Road Federation Ltd) thought that the Author had proved the case for a modernized highway system.

In the Paper there were certain references to taxation, but it was not perhaps generally realized that the motoring industry in Britain at present paid about £400 million per annum in taxation and, of that amount of money, less than 10% was spent on the roads. In the Paper reference was made to £80 million expenditure on the roads. That amount did not wholly come out of the £400 million, for about £40 million came out of taxation and the other £40 million came from the ratepayers. The £400 million represented about 2*s* in the £ of the national income, and was indeed quite a staggering amount.

He did not wish to refer to the question of the number of vehicles that would be required to run the Author's scheme, but it was interesting to note that at present the railway organization had about 19,000 locomotives, about 53,000 passenger vehicles, and about 1 million freight wagons. The utilization of those units had been fully discussed and criticized in a Paper[30] recently presented to the Institution of Transport.

Mr Aldington knew no one who really believed that a single 22-ft or 24-ft carriageway was adequate to carry heavy volumes of traffic. He thought the idea was quite preposterous. It was suggested in the Paper that the Ministry had agreed that certain roads should in the first instance be built with a single carriageway. That had not been for the reason that the single carriageway was justifiable; it had simply been on the ground of expediency—in other words, in some cases, to get a connexion through as quickly as possible with the limited amount of money which was available, it had been agreed that one carriageway should be built in the first instance. He personally would view with alarm any prospect of travelling at 60 m.p.h. on a single-carriageway road with traffic approaching at the same speed from the opposite direction—particularly at night with

glaring headlights. That was asking for trouble, as could easily be demonstrated by driving from London to Birmingham at night—it was quite a terrifying experience.

It was very necessary to be practical when considering new ideas. To refer to railways being in one plane—as compared with many roads, of course they were—was too facile. There was considerable curvature on many railway lines and it would be quite a useful exercise to take the length of railway from, say, Earls Court to Wimbledon and turn that into a road. Running over the viaducts approaching Putney Bridge Station there was only about 25 ft between the parapets, and the curves were sharp ; from an engineering point of view an enormous amount of money would be involved in doing the work.

With regard to tunnels, it would be quite impossible to get a 20-ft carriageway through an ordinary double-line tunnel. The headroom was all wrong, as indeed it would also be wrong on most of the older through-type railway bridges.

Mr Aldington found the Paper very interesting but felt that any money which was to be made available for roads should be spent on the scheme which had been prepared by Mr Barnes, when he was Minister of Transport, for a certain milage of motor roads which could be properly laid out. It was quite wrong to think that the newer roads which had been built recently had not been laid out properly, with regular curves and superelevation. British road engineers, contractors, and general suppliers of materials were well qualified and equipped to prepare such schemes and to execute them in a very satisfactory manner.

Mr J. B. Burnell (Operating Manager (Central Road Services), London Transport Executive) said that he would make one point only, because he believed that if there was agreement with him on that one point, there was no need to say anything more about the Paper. The point was not a technical one, but a human one.

He placed himself in the position of the driver of a vehicle on a 22-ft or 24-ft road, which it was known from experience had created on the high-speed roads in the United States a tremendous number of head-on collisions. He believed that in the United States 15 ft was recommended and almost insisted on between opposing carriageways on rural roads. He had recently had the frightening opportunity of riding on the eight-lane speedway outside Chicago where they reversed a certain number of lanes, allowing six lanes available for the traffic in the direction of the peak. He had been driving on the two lanes that had been left against the six lanes. Never in his life had he been more frightened and that notwithstanding, because of the head-on collisions, the fact that they had raised a 3-ft or 4-ft ramp between him and the oncoming traffic.

He believed that it was totally impracticable to ask drivers of road vehicles to drive along a road only 22 ft or 24 ft wide—and if his arithmetic

was right, about 80% of the railways were either single or double track, only a third being single track. He believed that the drivers would, quite rightly, refuse. He believed it would be absolutely and completely unsafe for them to drive on those roads.

In Britain there was tolerable weather only for a short time every year. There was every reason to expect 5 or 6 months bad weather and for 2 or 3 months there was every reason to expect fog and snow. Could one imagine a driver turning over to his relief and saying, " The engine is pulling well, the vehicle is loaded, there is ice and snow and fog ahead, but the radar is all right "?

Brigadier C. C. Parkman (a partner in the firm of Ward, Ashcroft and Parkman, Consulting Engineers) was pleased that the Paper had been presented by a Regular officer in the Corps of Royal Engineers, for there was much to be gained from the liaison of military and civil engineers in peace-time. Too often did it require a war to stimulate their joint contribution for the common good.

Brigadier Parkman himself had been trained as a railway engineer and was perhaps therefore a little biased ; the Author would no doubt expect him to be critical. Even after reading the Paper he was not convinced that it would be wise to assume that the railway system's only contribution to the present-day transport problem was that of its right of way.

So many vehicles were already using the roads that difficulties in regard to the supply of petrol, oil, and rubber, all of which had to be imported, would have to be faced in the near future. It was generally agreed that the balance of the national economy would have to be preserved by cutting imports, and he suggested that the country would soon be forced to produce its own power for the propulsion of nationalized and public transport ; that could be done by increasing the present supply of electrical power. With the development of atomic power, it would not be unreasonable to say that all the power needed for that purpose could be home-produced. He considered that one of the strongest reasons for retaining the railways was that they would accommodate a system of transport that could best make use of electrical power in its operation and control.

Brigadier Parkman could not agree with the assumptions which the Author based on the statistics given in Table 1. Even if the ratio of 12 : 1 in man-minutes or man-yards were accepted, the incidence of accidents was bound to increase when vehicles were travelling at 60 m.p.h. at 100-yd or 1½-min intervals, especially when visibility was impaired by rain and fog, or even during darkness. The drivers of the present trains—captive vehicles—were able to devote the whole of their attention to speed and signals, and in his opinion the present signal-box system was essential to the movement of large tonnages and large numbers of passengers. With electrical power and automatic control the number of signal boxes

could no doubt be cut down. Larger units moving at greater space intervals on their own tracks would appear to achieve the same movement of traffic with a greater safety potential. With the latest speeds achieved on the French railways, there would appear also to be ample future capacity on the railways. Two contributory causes of accidents were the human failings of the driver of the vehicle and the mechanical shortcomings of the vehicle itself. Both of those contributory causes were greatly magnified by the use of the proposed smaller trackless vehicle.

On the question of maintenance, he thought that, even with the improved alignment of the present roadways, repairs and reconstruction would be inevitable, and he suggested that those repairs and reconstruction could not be carried out without a greater loss of time than occurred on permanent way maintenance. The dislocation to the proposed reserved roadway bus timetable would, he submitted, be very much greater than that incurred by the modern railway train.

To sum up, whilst he agreed that the characteristics of roadways formed out of the present railway system would have much to commend them on riding qualities and gradients, he felt that, since an era of much faster rail traffic seemed near, operational safety could be best served by a transport system which would move with larger units on rail tracks at much increased speeds, rather than with trackless smaller units at increased densities. The captive-vehicle railway system should be retained for the movement of heavy tonnages and the movement of large numbers of passengers to and from the concentrated centres of population.

He concluded, however, on a note of limited concession to, and part-compromise with, the Author. The railways undoubtedly had been developed in the days of plenty by wealthy highly competitive 100%-private-enterprise companies who had been eager to offer services to the public and to capture every private trader's traffic. As a result the country had been left in 1922, when the railways had been grouped, with a multiplicity of lines. Many of those lines had been duplicated and more in the competitive era, and since nationalization some of them had proved unremunerative and redundant. He felt that in such cases serious consideration could be given, on grounds of national economy, to conversion and incorporation into the highway system.

Mr R. C. Bond (Chief Mechanical Engineer, British Railways Central Staff) said that on p. 740 the Author had referred very briefly to the question of manpower. It might be quite fortuitous that the number of vehicles which the Author had quoted, 10,300, was approximately the number of signalmen whom he suggested would be saved. As a motorist himself, Mr Bond felt that quite as elaborate a system of signalling as anything that was required on the railways would be needed to handle the sort of traffic that the Author envisaged. At Waterloo, for instance, with buses leaving from fourteen platforms in the morning or in the

evening at very frequent intervals, the signalling system would surely have to be very elaborate.

The physical difficulties of converting the railways to a road system had already been mentioned; there was, however, one point to which there had been no reference, namely, that at nearly all the principal junctions which were generally speaking at present laid out on one level he imagined that it would be necessary to contemplate fly-overs and a very elaborate form of clover-leaf construction in order to make it possible to keep the traffic moving in the way that the Author had suggested.

In any form of transport system fuel costs were most important. There was no information regarding the fuel costs of the 40-seater buses and the freight vehicles and trailers which would be involved, but—to consider for a moment freight traffic—he supposed that a fairly representative figure for a diesel lorry would be about 8 miles to the gallon for the 20-ton payload envisaged in the Paper. That would work out at about 65 ton-miles of work done per shilling expended, compared with 250 ton-miles per shilling of fuel costs on the railways as they were at the moment. Even if one assumed that fuel oil was available tax-free, the railways would still gain by a substantial margin.

Another point that should be remembered in connexion with the proposed roadawys was that all the fuel would presumably be imported, the use of electrical energy being precluded. It seemed to him that a system of transport which depended primarily on imported fuel and on imported material for the tires would be a precarious asset.

In the Appendix a 40-seat passenger bus was allowed 3·6*d* per mile for fuel, lubricants, and tires. That seemed to imply a very much better fuel performance than would in fact be possible if there was to be any money available for lubricants and tires.

In connexion with the figures quoted regarding the relative safety of the two systems of transport, he could not see any statistical meaning in the part played by roads and pavements measured in man-minutes, and it seemed to him that the position could be assessed only in relation to the number of people killed and injured per annum on the roads. He suggested that the figures used by the Author for rail casualties were unrealistic because the Author had chosen the year of the Harrow accident, whereas a truer figure could have been adduced.

To conclude, Mr Bond observed that the railways were not level, except relatively. But the vehicles, particularly the freight vehicles, that were to run on the motorways would have to be designed suitably to leave the main trunk routes and deliver their merchandise to all the many factories and establishments which at the moment were not on the proposed roadways. He therefore felt that some of the advantages of design which the Author had assumed would not be achieved, because if the freight vehicles were not taken off the " Trueways " and unloaded at the premises

to which the goods were consigned, there would still be a great deal of double handling into small consignments.

It was, of course, vital that the transport system should go on whatever the weather—so far as possible. At present, roughly half of the system—the railways—could and did function in any weather.

Mr S. B. Warder (Chief Electrical Engineer, British Transport Commission) gave the point of view of an electrical engineer. The Author had suggested a new approach to the transport problem, presumably on the assumption that the present methods had failed, and he implied that a colossal expenditure would be involved in the change.

It seemed to be generally accepted that steam had had its day and would give way to diesel or electric traction. He believed that in Britain the best future lay in electrification. It would therefore be interesting to test the Author's views against the modern alternative which might come quite soon.

The arguments against electrification during the past 25 years had rested mainly on the heavy first cost of the fixed equipment. So long as labour costs and material—for example, coal—had been cheap, there had not been such an enormous incentive to become involved in such expenditure. However, the conditions had changed, but even so he did not think it was generally appreciated that the cost of building an electrified railway was only 10% higher than the cost of building a railway without fixed equipment for electrification purposes. The question was, therefore, what could be had for spending 10% more when building a railway ?

First, prime movers could be taken off the rails entirely. The Author had referred to the 20,000 vehicles that would be required under his proposal, although other speakers had suggested that ten times as many would be needed. But removal of a prime mover eliminated all the trouble that accompanied a prime mover. (He was himself an electrical engineer and no doubt Mr Bond would not agree with him entirely, but he thought that most of the trouble was mechanical and not electrical.)

The ultimate result would be a system of reversible trains running at any desired speed.

The question was raised nowadays whether locomotive drivers were getting a proper incentive. He did not know what incentive they would want for driving the Author's lorries ! But with the possibilities that electrical engineering offered, it was quite likely in the future that the trains could set up their own route and really run automatically. Aircraft could now take off and land by radar ; he did not want radar, for he felt that control could be much more efficient with rails to guide the vehicles ; but by electrical means it would be possible to save a great deal of labour not only in train crews but also in the systems of signalling which the Author had suggested would still be required by his proposals.

A locomotive or a train was a power-conversion unit. All that it required was electric motors to convert the energy provided from the main supply system. All the trouble was taken off the system and put either on the side of the railway or handed over to the British Electricity Authority. The extraordinary thing was that the Authority did not have to provide an additional prime mover. The rate of expansion of the Authority far exceeded the rate of expansion in the railway electrification programme. New generating plant was being installed at the rate of 1,500,000 kW a year, and electrification could be done only at a rate requiring power at approximately 30,000 kW a year. Moreover, the power would not be wanted at the peak of the electricity supply period, so it would not be necessary to pay the maximum charge on all the traffic that was operated outside the peak periods in the morning and in the evening. It would therefore be a welcome proposition to the Electricity Authority and it would improve the load factor for the whole country. He suggested that no Government interested in the nationalized industries could afford to ignore such a possibility.

The country, he suggested, must look more to electrification as time passed and if the most was to be made of the country's resources. Since rail transport was a right and proper field which had been well exploited elsewhere, he had no reason to suppose that electrification would not be a better proposition than the one proposed by the Author.

Major J. E. L. Carter (Senior Instructor (Officers), Electrical and Mechanical School, School of Military Engineering) said that in his belief the Author was right, although not necessarily right in every detail and although the proposals made in the Paper were not necessarily the best in every way for everyone. Inevitably there would be disadvantages and difficulties associated with the disappearance of one form of transport, as indeed there had been in the past when previous forms of transport had been replaced by more modern developments.

The issue, however, was the fundamental one whether the Author's proposal was worthy of serious study, and Major Carter agreed that it should be carefully and independently examined and that the costs of the proposal should be carefully evaluated.

He thought that one of the points which made the proposal so significant was that Great Britain had grown up around the railway system, as the flesh on a body grew around the arteries and veins; and to the majority of cities, docks, and industries the railways, in their situation and functioning, were completely organic. Like arteries, they ran where they were wanted, and they were distinct from the flesh through which they ran. On the other hand, the roads, such as they were, were hopelessly intermingled with the body they were trying to serve, and the problem of making a road system was to provide access to and from the centres of population.

Although the economic experts said that the proposals were uneconomic and that the Author's traffic estimates were wrong, the fact was that there was a greatly increasing tendency to use the roads because, for many kinds of goods, road transport was cheaper in spite of petrol tax, purchase tax, and road-fund tax.

It therefore seemed to him that if some organic change was to be introduced into the transport system, then some use had better be made of the space now occupied by the railways. The wisdom of converting the whole railway system into a road system was arguable; perhaps part conversion was the answer; but he did not believe that a good road system could be developed without taking some of the space occupied by the railways.

He did not think it would be as difficult as might appear at first sight. Conversion should start at the coast, taking out of action about 30 miles of railway line; a transfer station should be created, at the change point; passengers could then transfer to conventional buses, and freight could be transferred quite readily with the use of modern mechanical handling equipment. When that 30 miles had been done, a further section of track could be taken. The process would have to be a gradual one, but he did not think it would be as difficult as some speakers had suggested.

He believed that the near future would show a diminution of the need for heavy traffic, arising from the development of the super-grid for handling electric power, the reduced availability of coal, the extended use of coastwise shipping, and the siting of power stations for service by water as opposed to rail. Inter-city air transport would also tend to draw off certain types of high-quality passenger and freight traffic. Those factors should be considered when assessing the value of the railways in 20 or 30 years' time.

There was, therefore, a good case for a very careful examination of the Author's proposals, and he thought there would be no *fundamental* difficulty in trying them out. The alternative seemed to be to carry on as at present with the two constantly improving systems, but with the railways continuing to lag behind because of their lack of flexibility and the road tending to lag behind the needs of the day because of its inability to get into the areas where the road communication was really needed.

Lt-Col. S. M. Lovell (County Engineer and Surveyor, West Riding of Yorkshire) said that he spoke as a highway engineer, and perhaps also as rather a heretic. He agreed partly with the Author in that Britain's great need was for the co-ordination of road and rail transport. Was it heresy to suggest that the way to do it was to build roads over the railways and to electrify the railways?

From the point of view of gradients, the railway locations were ideal. He knew the argument that the area of land required to build brand new roads would not represent a major problem, but with the suggestion that

he had made no new land at all would be required. Another point to be borne in mind was that if the roads were to be built over the top of the railways, there would already exist throughways through the provincial towns, and the colossal task of having to pull down property would not arise.

The value of the tourist industry at present approached £60 million a year. If the roads were up in the air, that figure might increase quite considerably, because the tourists would be able to see and to enjoy the country wherever they might go!

From the strategic point of view and the point of view of vulnerability during war, he thought that the Author would agree with him that if ever, unfortunately, there should be a war there would be such hydrogen-bomb devastation that it would not matter where the roads or the railways were.

In connexion with the construction of roads over railways, no costs had ever been worked out, although various costs had been suggested. He suggested that if the proposal could be tried out between, say, London and Birmingham on the best route possible over the railways, and if engineers really applied themselves to the design of factory-produced standard pre-stressed concrete units, the costs would not be so formidable as might be thought. In any case, so far as the present projected motorways were concerned, it had been very interesting recently to hear Sir Owen Williams say that a proportion of between 25 and 60% would have to be up in the air in any case because of crossing obstructions, rivers, canals, and railways. Why not the other 75 or 40%?

Mr H. J. B. Harding (Director of John Mowlem & Co., Ltd, Contractors) said that contractors were neutral, for they hoped to be able to help to spend some of the £1,200 million either on the railways or the roads.

As the Author had pointed out, the rail had been invented 400 years ago to ease the labour of horse and man by reducing friction. The invention of the locomotive had speeded up the movement so much that roads had become very secondary, and had started the age of railways. The roads had now recovered their position, not through the discovery of oil and the internal combustion engine, but by the discovery of indiarubber, which made it possible for engineers to build roads relieved of the pounding of wheeled vehicles.

The combined effect of those inventions, together with telephone, radio, and typewriter, had been to introduce the "Age of Impatience". Simultaneously, by the development of very powerful plant, instead of the principle of least resistance, there had been substituted the principle of brute force.

The Author's critics said that his proposals—apart from difficulties of width—fell down when they reached a tunnel. But from recent experiences

in Bo-peep and other tunnels it was more likely that the tunnels themselves would fall down, for most of them were 100 years old and in need of much maintenance. The Author's retort could be that with a motor vehicle it would be possible to build a by-pass and climb out of the cuttings and skirt the tunnels, if that were more economic than enlargement.

It was of great importance in the Age of Impatience for materials to be delivered to their destinations without re-handling. If Brunel had had his way, and if his broad gauge had been adopted, the Paper might never have been written, for the railways would have been big enough to carry road vehicles upon special trucks, which could then complete their journey by road.

All the docks in Britain had been designed for railway traffic, but now most of the freight arrived by road, causing great congestion.

People in Britain liked freedom of movement and were quite undisciplined in the matter. Dr Glanville was right in his warning that when everyone owned a car, everyone would be brought to a standstill. Wide vision had to be brought to the problem. In the past " reckless economy " had been our downfall. By fear of spending money we had been forced to waste in other ways.

In 30 years' time the new locomotives to be provided out of the £1,200 million would be obsolete. Now was the time to think as far ahead as that, and whether one agreed with the Author or not, his challenge was a valuable shock to complacency.

In the past the railways had killed the canals for their own gain, a folly from which the country had suffered in time of war. Whether or not it would be a just retribution to turn the railways into reserved roadways, or if it would be another folly to destroy a national asset, was food for thought.

The Author had brought a storm of opposition about his head. Some contributors had been wide-minded; others had, like the railways, run on narrow lines. It would be interesting in 30 years' time to re-read the Proceedings in the light of future developments.

Mr Alfred Goode (Deputy Director of Works, Air Ministry) said that the Author had not emphasized sufficiently the enormous benefit which would accrue to industry by a door-to-door transit of goods. The double, treble, and even quadruple handling which at present was necessitated by the railway system would be eliminated by freight vehicles loading up at a factory or a warehouse and the goods being unloaded at their ultimate destination. Vehicles on inter-town runs would perform the major part of their journey on the new roads, but would be free to leave them and use the present roads to arrive at their unloading point.

He was not clear whether the Author intended to segregate traffic on the new roads. He would suggest that only vehicles holding a commercial licence and public service vehicles should be allowed on them, leaving the

present road system, apart from the terminal journeys of freight vehicles, almost entirely to the private motorist. Whether, however, fast-moving public service vehicles should be using roads at the same time as comparatively slow-moving freight vehicles was a moot point, although the Author envisaged the build-up of a fleet of fast-moving freighters. If the roads were divided into lanes of various speeds, such as the Author had instanced in the Mersey Tunnel, Mr Goode believed that no real difficulty would arise owing to disparity in speeds.

Another point which the Author had mentioned was that of fuel. It was thought in some quarters that the railways were essential to Britain in time of emergency and that that viewpoint was given more power by the fact that, generally speaking, they used an indigenous fuel—coal. To convert the system into dependence on imported fuel might, to the holders of that view, seem suicidal; but he looked forward to the development by British manufacturers—and he was sure they could do it—of a fleet of economical " steam wagons " which in the past one had seen in large numbers on the roads and which were now rare owing to taxation. Their contribution to atmospheric pollution by smoke would be very small, and that argument against them would be completely nullified by the fact that they would be using fuel obtainable in Britain.

Turning to the engineering aspect, he thought that 50,000 track miles of railroad were capable of conversion into the equivalent of 11-ft-wide traffic lanes. That meant that the construction of the enormous area of 323 million sq. yd of pavement was necessary to convert the rail system into roads. Was that figure, however, really formidable ? The average large military airfield had about 1 million sq. yd of pavement, and one in Britain had—or soon would have—a paved area of 1,400,000 sq. yd. So the problem was, in reality, only that of building the same pavement area as 300 large airfields, for which most of the earthworks had already been carried out. Furthermore, the road pavements would be thinner, having to carry a much lighter load, and the problem was reduced to that of providing the equivalent of something considerably less than 300 airfields. The work necessary would include provision for additional drainage, enlarging or uncovering the comparatively few tunnels, removing platforms where necessary, converting sidings into parks, etc. (including all preliminary surveying, soil testing, and design). He estimated that the cost, allowing for a single-wheel load of 10,000 lb. would not exceed at the outside £1,000 million. He was confident that it could be carried out in 10 years at the rate of £100 million per year. That would not strain the resources of those public works contractors accustomed to the paving of airfields; in fact, he was sure that a referendum among them would produce the result that their combined resources could easily build twenty, if not thirty, airfields per annum. The planning of the sequence of conversions would, of course, require a very great deal of thought to

prevent disruption of services in a change-over, but the problem was by no means insuperable.

The Author had mentioned the riding qualities of the converted roads. Mr Goode's opinion, based on experience with aircraft, was that a concrete surface would not be good enough. Modern aircraft with high tire pressures were peculiarly susceptible to unevenness in an airfield surface and when they were required to run at speeds in excess of 15 m.p.h. it had been found that concrete was too rough and that a blacktop surface was preferable. It might be interesting to note that the present specification for airfield surfaces was that the deviation from a plane surface when tested with a 10-ft straight-edge should not exceed $\frac{1}{8}$ in. Profilometer tests had recently been carried out on two fields which had been strengthened and resurfaced about 18 months ago. The specification in those cases had been that the deviation from a plane surface should not exceed $\frac{1}{4}$ in. in any direction when tested with a 16-ft straight-edge. In both cases the irregularity index measured after the fields had been in use for 12 months had been less than 40 in./mile. Thus, it was clear that the riding qualities could be obtained by British contractors working (in those particular cases at very high speed) with a blacktop surface.

Despite the example of the Lindley testing track, he was doubtful whether those riding qualities could be obtained with concrete, even if the joints were sawn, which, he remarked, was extremely difficult with gravel aggregates. With rock aggregates, depending, of course, on the hardness of the rock, sawing joints was very costly, owing to the great wear on the saws. On the other hand when contraction joints were formed by vibrating a bar into the concrete, the concrete thus displaced produced a surface irregularity. At expansion joints also, despite care taken in their formation, an irregularity always occurred, and in his experience, after many miles driving in countries all over the world, plain concrete roads had not as good riding qualities as those with blacktop finish. He would recommend, therefore, the adoption of lean-mix concrete slabs, surfaced with blacktop using both bituminous and tar binders, thus employing three sections of the nation's paving industry to spread the load.

In conclusion, since the proposal to convert the railway system was of such importance and, in his opinion, so practical and potentially so beneficial to the country's economy, he suggested that the Institution, being the senior one in Great Britain, should set up a committee to consider all aspects of the problem.

Mr A. A. Osborne (Resident Engineer for Messrs J. S. Wilson and John Mason) said that there had been a short period before the 1939–45 war when dual carriageways had been built, or such appropriate future width provided, on many improvement schemes on what were then called Class 1 roads, because, irrespective of traffic capacities and traffic densities, it had been believed that dual carriageways were essential for safety. The

adoption of trunk roads by the Ministry under the Trunk Roads Act had enabled the Treasury's increasing stranglehold on main-road-improvement expenditure to cause the death-rattle of realistic highway improvement. Incidentally, the Author's references under " Safety " on p. 740 could not, in Mr Osborne's opinion, be considered as supporting a swing of professional favour away from dual carriageways ; the road widths given in Road Paper No. 42[12] were the figures which should be adopted when considering safety. They stipulated an overall highway width of 88–93 ft with dual 22-ft carriageways and 15-ft verges ; if that width was radically reduced to a 6-ft central strip and only 5-ft verges, the minimum then became 60 ft. The formation width of double-track railways was 30 ft, reduced to 19–22 ft in tunnels and deep cuttings with retaining walls, whilst the quadruple track was only 55 ft wide. It would be seen, therefore, that the 30-ft double-track width was the bottleneck (ignoring the cost of tunnelling, etc., for even narrower widths), which would allow only a narrow 22-ft carriageway without the important visibility allowance of verges and increased carriageway widths on bends.

It was agreed that the railway alignments were a great improvement, but there were bends on some main lines of 10 to 20 chains radius, particularly through stations, whilst the motorway standard was 2,865 ft minimum radius, with 1,508 ft in hilly country.

The Author had therefore adopted the smallest highway widths, which would, from the safety aspect, put his new B.R. system back to conditions that were becoming intolerable on the present highways. High-speed motor travelling demanded ample road widths for overtaking, good horizontal visibility—the vertical visibility of the railways was of course ideal—and a safety roadside margin.

Referring to the Author's remarks on superelevation (p. 735) the converted railways would have to be cleared down to formation level to construct a road and the formation was usually level, for the 6-in. maximum superelevation per track on railway curves was made up in the ballast. The reference to automatic traffic-light control under " Intersections " on p. 736 was surely a retrograde step which would soon upset the 51-m.p.h. average mentioned on p. 738 for the London–Bristol journey.

The statistics quoted under " Safety " in Table 1, p. 741, were not wholly applicable, for the comparison should be strictly between road and rail accidents. As was well known, the railways had had a very low accident mortality record before the war, and the figures in Table 1 for killed included 163 passengers, the remainder being railway servants and 52 others. Similarly, the injured total of 26,114 included only 8,297 passengers. The year 1952, however, was exceptional for it included the Harrow and Wealdstone disasters which had caused 112 of the 163 deaths mentioned.

The Author had laid much stress upon new opportunities for better roads with smooth surfaces but Mr Osborne could not understand why they

should be any different from the surfaces provided on new roads elsewhere. The very flat railway gradients would, in road engineering, present some difficulties because a gradient of less than 1 in 200 was unsuitable for normal surface-water drainage in a road channel and would necessitate a series of short reverse channel grades causing unevenness in the channels in order that water could reach the gullies. Consequently, the riding conditions in the channels would be worse than on a normal road where self-cleansing gradients made such expedients unnecessary. It should be realized also that the increased run-off arising from the large area of impermeable carriageway meant a completely new and larger drainage system. Such problems were small, however, compared to that of the method to be adopted to construct the new roads; could the Author explain how such roads could be built while the railway system was maintained until the roads were ready for traffic? Both the passenger and freight railway traffic could not use a single line, or double tracks on quadruple track lines, while half a roadway was being built. Even if that was possible, road engineers would shudder at the thought of building 20,000 miles of modern highway with only half the formation or sub-base being formed at one time and having a foundation construction joint in the centre. Such restricted conditions would not give sufficient clearance for up-to-date mobile road-making plant nor any material or plant storage space where verges were non-existent. Mr Osborne considered that it was not practicable to build a road on a railway track until trains and track had been removed. Except in rare situations where there might be an alternative railway route, railway services as they now exist could not be maintained while conversion to roads was taking place. Did the Author consider that the country's communications economy, apart from the consequent risk of no rail communications in the event of war, could stand the chaos that would be inevitable? For those reasons Mr Osborne thought that conversion of the British Railways system into a reserved roadway system had no potentiality because it would be economically impossible to make such a conversion without dispensing with railway services while each portion was being converted.

Turning from the possibility of conversion to its desirability, Mr Osborne said he personally preferred to make a long journey by rail and felt that railways were essential and had a permanent place in the country's communication system. As with other motorists he had long felt that too much heavy material travelled by road, causing delay, frustration, and accidents, when the interests of the country could be better served by a greater use of railways as the main means of freight movement. He recommended the banishment of long so-called indivisible loads from the roads; that there might be no railways to which such loads could be transferred was a thought sufficient to cause a motorist's nightmare.

It was interesting to note that *The Times* of 25th April had reported very satisfactory results in the operation of new lightweight diesel trains,

giving considerable increases in the passengers carried and receipts increasing up to 40%. That foretaste of what might be expected under the British Railways' modernization plan would simplify the road engineer's problems, for modern roads with the ever-increasing vehicle registrations needed some relief from traffic that should use the railways.

It was the variation in speeds that necessitated wider roads than those envisaged by the Author and by segregating the bulk of heavy freight traffic to railways, new roads would become faster and safer without the change-over chaos and doubtful economics of adding a reserved roadway system.

In conclusion there might well be sections of disused railways or minor uneconomic lines without freight traffic that could be dispensed with and adopted to form road by-passes or link roads. The use of abandoned railway permanent way, widened if necessary to suit safe roadway widths, had been and perhaps would be made in the future and Mr Osborne hoped that the Paper would be a reminder of such limited potentialities of converted railways.

Dr A. W. T. Daniel (Lecturer in Civil Engineering, Queen Mary College, University of London) referred to the speed of 60 m.p.h. and said that it was not quite clear from the Paper whether the Author was thinking in terms of cruising speeds or of start-to-stop averages, which were quite different propositions. If the former, then presumably the start-to-stop averages would be of the order of 50–55 m.p.h., which would imply a timetable of approximately the same standard as that of 1914; in fact, it would show no improvement on that of 1900; and it was sincerely to be hoped that there was no intention of spending hitherto uncalculated millions of pounds in order to revert to the position as it had been 40 years ago.

If, however, the latter was intended then the standard implied would hardly reach that of the current timetable, and would fall far short of that of 1939, when in Britain alone there had been more than 200 trains booked at start-to-stop averages of between 58 and 72 m.p.h. Those figures were for orthodox steam operation and by no means represented the limit of possibilities, as was evident from Fig. 1, in which all forms of motive power were represented, as well as several countries—Great Britain, the United States, France, Germany, and Italy. Some of the information was difficult to obtain, and he would be glad to hear of any amendments or omissions.

Record maximum speeds were shown by the full line, and it was surprising to find that so long ago as 1903 a German electric train had reached 130 m.p.h.; that had been a military operation and had been kept secret until many years had elapsed. In 1931 a German petrol car driven by a propeller had reached 143 m.p.h. but the idea had not been pursued, since the use of a propeller for a land-based vehicle had been considered

undesirable. The graph showed a reversion to orthodox diesel and steam at points 4, 5, and 6, and it was interesting to note that the record of 151 m.p.h. by a French electric train in 1954, shown at point 7, represented normal progress when previous history was taken into account. But the most recent speed of 206 (point 8) achieved in France would appear to have been reached 10 or 20 years before it could reasonably have been expected, and was therefore a great achievement on which the French authorities should be congratulated.

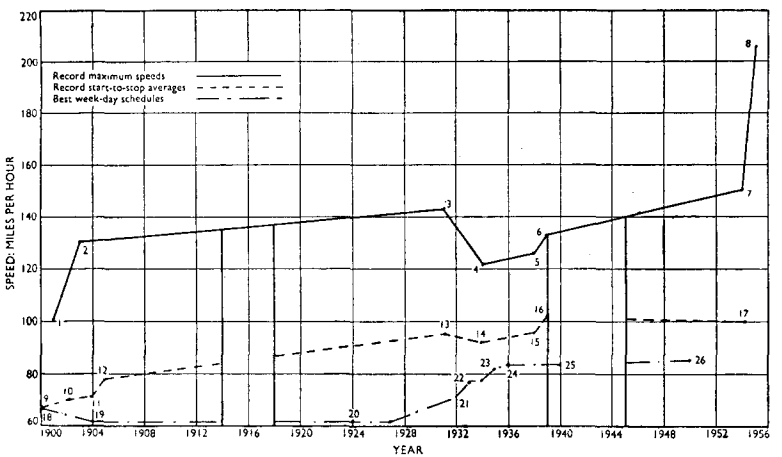

FIG. 1.—RAILWAY SPEEDS

The dotted lines showed the record start-to-stop averages, and the most significant was shown at point 16, when in 1939 an Italian electric train had run 196 miles in 115 min, giving a start-to-stop average of 102 m.p.h. That had so far not been beaten, and indicated the obvious direction in which future progress should be made.

It was obvious that to achieve a high speed in a specially arranged test was one thing, but to achieve it throughout the year in normal service was another; hence the chain-dotted line showed the best scheduled weekday averages. It was evident that records did eventually have an effect on schedules, but what was not shown by the curve was the general effect on the whole service. The handful of trains of which point 20 was the best had grown to large proportions; the 1954 French timetable had involved 329 runs at start-to-stop averages of from 60 to 77 m.p.h., and in the United States the similar figures for 1950 had been 2,500 runs at from 60 to 86 m.p.h. It would be appreciated that start-to-stop averages in the higher ranges required running speeds of 90 to 100 m.p.h. The totals for Europe and the United States so far available amounted to about

3,270 runs between 60 and 86 m.p.h. involving a daily milage of 182,000. The figures were smaller than they might be because those for Britain and Germany were well below the figures for 1939. It was evident that no one had attempted a statistical analysis of the schedules between 50 and 60 m.p.h.

Reverting to the French record of 206 m.p.h., the effects would be felt in the future. To Britain, the significance was that in the existing conditions and the distances between cities as they were, the challenge by the railway to the air could not be ruled out. The curve of progress was steepening; if it was true that a busy industrial nation such as Britain could not afford to stand still, how much the more could it not afford to go backwards. The world stood on the threshold of another great railway era, and any scheme, no matter how superficially attractive, which denied the nation its fair share could not be considered.

Mr Nigel Seymer (Editor of *International Road Safety and Traffic Review*) thought that a very good point was made on p. 739, where the Author had pointed out that motorways as at present planned would not run where they were needed most, namely, into the towns and cities. Personally, he felt that plans had to be made to extend the motorway system into the main towns and cities, and he considered that, although a wholesale abandonment of the railways was not at all indicated, possibly the only feasible and economic way of bringing motorways into the centres of the larger cities, such as London, would entail in some cases putting the railways underground and putting the motorways on the railway viaducts. For instance, the lines serving Charing Cross and Cannon Street could be put underground. According to his arithmetic, only two underground lines would be required to replace those surface lines. There would then be a right of way for a four-lane motorway which would go right to Charing Cross, and it could be continued from there right across the centre of London, partly in tunnel.

He suggested that if any committee were to be set up to go into the Author's proposals, special attention should be given to the possibilities of building motorways in place of railways in the big cities and linking up the suburban lines—having electrified those that were not already electrified—underground right across the central area, which would also improve the public transport system.

*** **Lt-Col. H. Cartwright-Taylor** (Instructor, School of Military Engineering) observed that there appeared to be two separate questions in the discussion. Was such a change practicable, or even possible, and if so would it be to the advantage of the nation?

Previous contributors had produced figures to show that the change, although a major task, would not be too much to undertake in a period

*** This and the following contributions were submitted in writing after the closure of the oral discussion.—SEC.

as short as 10 years, and that its cost might be of much the same order as that of the present proposed re-organization. Much of the work, after all, such as rebuilding tunnels, stations, and other installations, would be needed in any event.

Regarding its desirability, he thought that there were two points which many speakers in their desire to maintain the *status quo* had overlooked. First, the Author's proposal was for a " reserved " roadway; it would be presumably operated at one speed or at differing speeds on differing occasions. There would be no overtaking, unregulated stopping or turning. Of course, there would be operating difficulties, but they would be far less than those of a railway. He could not really see that nervousness was more likely to attack the drivers of the trucks and buses than the drivers of two French trains approaching at a relative speed of 400 m.p.h. Secondly, the Author's real plea was that railway operating methods limited the capacity of the route to far less than what it might achieve under his system. Nowhere in the Paper was it stated that the British Railways present traffic would be carried by 10,000 road vehicles. What the Author had, in fact, said was that 10,000 vehicles on a road operating under not very difficult conditions, could carry an equivalent to British Railways. He admitted that there would be many more than 10,000 or 20,000 vehicles. Special traffic problems would, of course, demand special solutions, but even when they had been solved there would still be plenty of room for more.

Some speakers had made much of the weather conditions—frost and fog—maintaining that they would put out of action any system such as the Author proposed. Lt-Col. Cartwright-Taylor thought it should be remembered that it was not many years since railway operators overcame the delays and difficulties of fog—at considerable capital and maintenance cost in signalling equipment. Frost could, and did, still reduce journey speeds with electric trains to well below 20 m.p.h., and except in the most adverse conditions would not do worse than that with well-designed trucks and buses.

Mr F. P. Dath (Civil Engineer, Central Electricity Authority) thought that the discussion had proceeded along the lines generally expected and it would seem that the scheme could be either condemned or upheld on a few of the salient points raised. In the first place, to those speakers who had mentioned the possibilities and the potentialities of another war it could be argued that there would quite plainly and definitely be another war, the magnitude of which would be predictable and so great that it would not matter anyway whether the nation was dependent upon home-produced electricity or upon foreign oils and rubber. Experience of previous wars showed that that factor alone would be sufficient to condemn the scheme for the very simple reason that the merchant navy, which was always strained to the uttermost at such times, would not want the

additional hazard of supplying fuel for transport which could otherwise be supplied with home-produced electricity.

He felt sure that the Author was under no illusion regarding the extent of the opposition to his ideas but was also sure that there was much to support the proposals. After 35 years of regular travelling on the railways, Mr Dath had formed the opinion that it was not a case of the railways serving the public but one of condescendingly allowing the public to use their railways. Apart from being possessive they were cautious to the *n*th degree.

Too often, a change in methods suggested to an old-established organization evoked the reply " we have done it in a certain way for the past fifty years ". Whilst agreeing that a tried and tested method which had proved its worth should not be lightly pushed to one side, Mr Dath thought that that remark typified the general attitude towards drastic change. For example, such accidents as those caused when the off-side door of a crowded carriage was accidentally opened and ripped off by a train passing in the opposite direction would be eliminated if the planners were more amenable to stepping forward from 1830 and would build with sliding doors.

The density of passenger traffic had increased many-fold on some suburban lines over the past 30 years or so, and it was high time that inefficient and uneconomic methods and designs were replaced.

Serious trouble frequently required a drastic remedy and it might well be that the solution of the traffic problem lay in scrapping the railways and moving forward with modern ideas. There seemed no real reason why the present system of railways should not give way to a more efficient means of transport if one could be found. There were a number of instances which could be cited as parallels. The aeroplane had taken the place of the less efficient airship, and when the advantages had been appreciated little real objection had been raised. Mr Dath had wondered if sentiment did not play too big a part in the retention of the railways—whatever the reason, the price the nation and the public were paying was too high. He travelled each day to London on what was generally accepted as being one of the worst of all suburban lines and if, during the peak hours of travel, a fault or fog caused delay, the chaos was unbelievable. He was sure the passengers on that line would give whole-hearted support to their railway being motorized if it could be taken away from its present possessors.

Finally, how did the Author propose that the transition should be carried out on those lines with very dense traffic ?

Professor Hermann Bondi (Professor of Mathematics, King's College, London) observed that a more limited approach would overcome the objections raised against the Author's brilliant ideas. It was generally agreed that a number of motorways would have to be provided in spite of

their enormous estimated cost, in spite of their waste of land, and in spite of their inability to run into city centres. Could the permanent ways of British Railways be of any assistance in those matters ? Closed sections of railways were unlikely to run where roads were most needed. But could not some main lines be more useful as roads than as railways ? Surely it was not a law of nature that London had to be connected with the Midlands and the North by five main lines, some of them four-tracked for long stretches ? A concentration of rail traffic on fewer of them would not only be possible, but economically preferable.

A good road should consist of two carriageways, each containing two driving lanes (each 10 to 11 ft wide*) and a parking strip, not necessarily continuous, 8 ft wide. A twin-tracked railway line was therefore quite wide enough for *one* carriageway, though the parking strip would have to be dispensed with in tunnels and on bridges (as it was on American highways). Two more or less parallel railway lines could therefore make a motorway. The wide separation of the two carriageways, though inconvenient in some ways, would greatly aid night driving.

As a start, the Marylebone–Rugby–Sheffield line might be made into a northbound road, and the line Sheffield–Kettering–St Pancras into a southbound road. There were enough tracks to retain the London–Aylesbury suburban rail service on the one and the whole rail service on the other, for it was four-tracked south of Kettering, and ran north from there along several parallel twin-tracked routes. The cost of conversion, though no doubt large, would be far smaller than for the construction of a new motorway ; the road would run into the cities and would not waste any land.

Ultimately, Mr Bondi suggested, those railway lines that were, or were due to be, electrified (owing to their heavy traffic) should remain railways, but the others might all be considered for conversion into roads. Incidentally, rail diesel haulage relied on imported fuel as much as did road transport.

Mr W. P. Andrews (Roads Consultant to the Cement and Concrete Association) remarked that the Author had referred to the irregularity index of 35 in./mile obtained recently on a high-speed motor track. The present method of measuring the irregularity index revealed only small surface irregularities and did not indicate the presence of surface waviness. That waviness might be the result of bad rolling or might be developed in a flexible surfacing by traffic. It caused long-pitch variations in level which could give unpleasant riding qualities and be very uncomfortable for the driver.

---

* Returning to Britain after many thousands of miles of motoring in the United States, Mr Bondi had been struck by the wasteful and unhelpful width of the lanes in England. A 10-ft lane was quite adequate, more than 11 ft width was positively dangerous in encouraging small cars to pass in one lane.

A second point was the permanence of a good surface giving good riding quality. It had been customary in Britain in the case of concrete roads to specify a maximum tolerance of $\frac{1}{8}$ in. in 10 ft, and that somewhat stringent standard had been consistently obtained, especially on main roads. What was equally important was that it had been maintained throughout the life of the road, often up to 25 years. There were many examples of such roads leading from London to the coast. Equally good riding qualities could be obtained with other surfaces, but they might soon disappear if creeping of the surfacing occurred, and waviness or corrugations developed.

Those considerations were of the greatest importance in the roads visualized by the Author, in which the traffic flow should suffer the minimum of interruptions such as were caused by repairs, ironing-out, and resurfacing.

Mr F. W. Davey (Consulting Engineer in private practice) remarked that even if the Author's proposals were not adopted in their entirety they might usefully be considered as a basis for schemes to relieve congestion in large cities. The case of London was an outstanding example. A possible application was illustrated in Fig. 2.

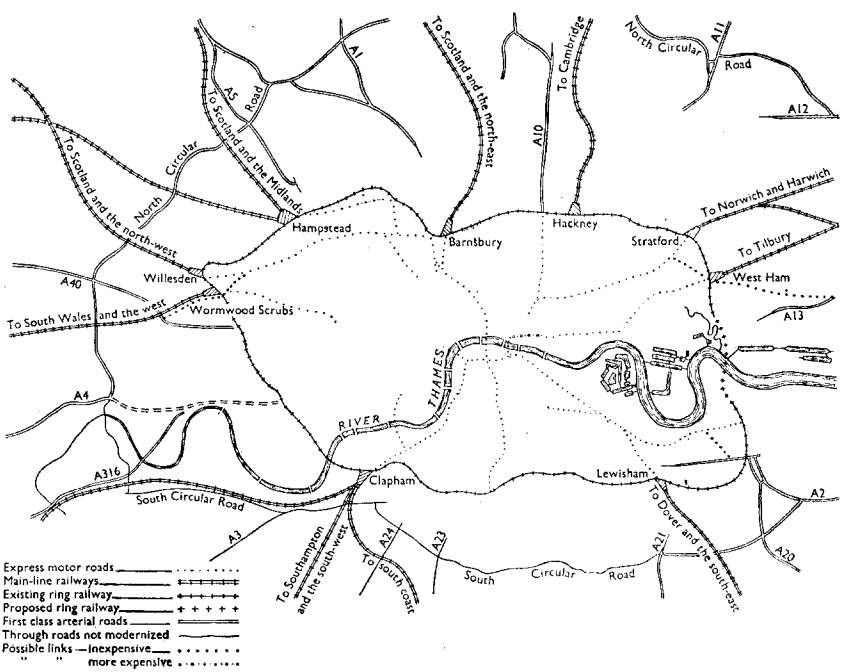

FIG. 2

There was in existence an almost complete ring of double-track railway. By means of works which, compared with the magnitude of the problem were of comparatively minor order, that ring could be made suitable for fast and frequent electric services. To be really efficient, the ring would have to be completed in the Greenwich–West Ham area by means of a tunnel under the Thames.

If now all main-line terminals were re-sited on that ring and all rail tracks within the ring were converted into motor roads the following considerations would apply.

1. All through rail traffic would transfer to the ring at the incoming terminal, and from the ring to the outgoing main line at the appropriate outgoing terminal. For example, passengers from Liverpool to Dover would transfer to the ring at the new Willesden terminal and from the ring to the Southern Region at the new Lewisham terminal. Luggage, etc., would similarly be dealt with expeditiously by modern installations.
2. Passengers and goods arriving at the new terminals for London would have the benefit of fast motorways to the central area. It was estimated that more than 90% of passengers arriving at existing terminals immediately transferred to some other form of conveyance.
3. There would be no road congestions at the existing terminal sites since road traffic to and from the new terminals would filter on and off the express roads *en route*.
4. In many cases the new express roads would fit conveniently into the existing scheme of arterial roads. In other cases links could be provided at relatively moderate cost. One major high level road link which might be considered would be between the existing terminals at Cannon Street and Fenchurch Street.
5. With the exception of Waterloo, all existing terminals were out of date and needed rebuilding. Moreover, existing main-line trains travelling from the ring to existing terminals seldom averaged more than 30 m.p.h., a speed which would be considerably exceeded by motor traffic on the new express roads.
6. In many cases the suggested new terminal sites would be adjacent to existing servicing sheds and tracks, thus assisting the operating departments to a considerable degree.
7. The project lent itself admirably to delegation of design work to many independent engineers and architects with the minimum of interference from a central authority, thus making for speed in execution. For that reason Mr Davey suggested that a period of the order of 10 years should suffice to bring

the plan to fruition and that in no other way could London's traffic problem be solved so soon.

Mr W. K. Taylor (First Principal Assistant Engineer, City Engineer and Surveyor's Department, Exeter) suggested that to justify their adoption the Author's proposals should :

(1) provide a highway system at least equivalent to recognized contemporary design standards for fast motorways ;
(2) use the nation's fuel and manpower resources to the best advantage ; and
(3) render services superior to those given by the railways using modern equipment and operational methods.

(1) *Highway system*

It did not appear that the converted road system would be entirely up to present standards for motorways since obtainable widths would be inadequate. Hutton[31] gave an overall width of from 88 ft to 93 ft having a median strip from 10 ft to 15 ft, dual 22-ft carriageways with 1-ft marginal strips and 15-ft verges. The American Association of State Highway Officials[32] recommended 12-ft traffic lanes where traffic density exceeded 200 v.p.h. per lane with 8-ft to 10-ft shoulders (except in mountainous terrain), and a median strip having minimum and desirable widths of 15 ft and 40 ft respectively in rural areas.

Adequate verges were essential for amenity, drainage, signs, and visibility[31] and also for storing snow cleared from the carriageway, as a " pull off " for brokendown or damaged vehicles and as a margin to accommodate men and materials when the road was being inspected, serviced, or repaired.

Regarding the suggestion that one 22-ft carriageway would suffice, Hutton[31] said that whilst it was possible that one might sometimes be constructed at first, ultimately dual carriageways must be provided for safety. Coburn[33] gave tabulated particulars of percentages of different types of accidents on roads without a speed limit (taken from " Ministry of Transport and Civil Aviation Road Accidents 1952 "). That showed 17% as involving " two vehicles moving on same road in opposite directions." He stated that on dual carriageways collisions between vehicles travelling in opposite directions were eliminated and that the provision of a central reservation would be expected to reduce accidents by 17%, that expectation being in fact confirmed by accident rates given by Drake.[34]

In discussing motorway design, consideration must be given to :

(*a*) inadequate headroom and width in railway tunnels and bridges ;
(*b*) ventilation required in tunnels ;
(*c*) provision of flying or burrowing junctions ; and
(*d*) that traffic control by signals would lead to increased journey times.

Thus it seemed that the railway tracks could not provide the required dimensions for motorways carrying traffic at minimum speeds of 60 m.p.h. and that there were other drawbacks which would be extremely expensive to overcome, even if at all possible.

(2) *Fuel and manpower*

(*a*) *Fuel.*—McBride [35] quoted Mr W. T. Faricy, President of the Association of American Railroads, as saying recently that to move 100,000 tons of freight from the Atlantic to the Pacific or vice versa, the requirements of diesel fuel would be 90 tank cars by rail, 250 by truck, and 2,700 by air, and, in terms of manpower, 3,500 man-days of train-crew time, 90,000 of truck-driver time, and 50,000 of plane-crew time. Whilst those figures might not be strictly comparable for Britain, they indicated great differences in requirements which needed serious consideration since oil fuel had to be imported.

Broadbent [36] stated that Mr J. Eccles, in his Inaugural Address as President of the Institution of Electrical Engineers in October 1954, had said that the accessible coal in Britain might be exhausted within about 200 years and that it was possible that the supply of oil might easily become critical within the lifetime of the present rising generation.

He gave the following reasons which made electric traction for railways more attractive than coal or oil from the viewpoint of energy conservation.

(i) The degree to which it could be integrated into the nation's power supply system.

(ii) The generator could be coupled to any source of energy—coal, oil or derivatives, hydro-electric, tidal, wind, solar, atomic, fuel cell, or any future development.

(iii) Possibilities of using waste heat.

(iv) Returning power to the system by regenerative braking.

It seemed desirable, therefore, that ultimately oil should be allocated to forms of transport other than railways, leaving the latter to use power sources available to them alone, thus conserving oil supplies.

Incidentally, railway vehicles did not run upon imported rubber.

(*b*) *Manpower.*—Against the estimate of 840 buses per hour as being required in Waterloo's rush hour, the timetable for August 1954 showed about 68 trains between 5 and 6 p.m., giving a very considerable saving in train crews. Furthermore, 500 trains carried 300,000 passengers on the Southern Region alone in London's morning rush-hour. That would require about 5,000 buses, about one half of the Author's figure of 10,300 vehicles. It must be remembered that multiple-unit trains could be increased and electric or diesel motive-power units coupled into twin or triple units and still only require one driver.

(3) *Service*

(*a*) *Weather.*—With modern colour light and automatic signalling, track circuiting, automatic train control, and centralized traffic control as provided in the British Transport Commission Plan,[37] and locomotive cab signals as used in America, the railways should be almost, if not entirely, unaffected by fog when road traffic was suffering the severest dislocation. Likewise, using de-icing measures, point heaters, etc., the railways should still be running when traffic was skidding to a standstill on ice-bound roads.

Those considerations would be of vital importance in war-time.

(*b*) *Services.*—Mr Taylor doubted whether the typical passenger service would work out as evenly throughout the day as suggested and it was quite certain that the large crowds at summer week-ends and other holiday times could not be so handled.

The use of car-hire service as the equivalent of first-class passenger travel, did not appear to compare favourably with long distance rail travel with its restaurant, toilet, and other facilities. For night rail travel, sleeping cars were available which could be of the American roomette or bedroom type.

The British Transport Commission [37] aimed to achieve speeds of at least 100 m.p.h. where conditions permitted. With electric rail traction high speeds were easily obtainable, as for instance on express services in France and the United States. In the former country, an electric locomotive had reached 205·6 m.p.h. with a light test train, and the S.N.C.F. had running on their Western Region multiple-unit electric sets capable of accelerating to 62 m.p.h. in 35 sec and 93 m.p.h. in 93 sec [38] and of reaching a maximum speed on test of 103 m.p.h. It could be seen that with modern equipment railways could run services at average speeds well in excess of 60 m.p.h.

(*c*) *Safety.*—Mr Taylor did not consider 1952 to be a representative year for accident comparisons, since it included the Harrow and Wealdstone smash which produced the second largest number of deaths in a British rail accident.

(*d*) Finally, since the Author's Paper was written, the British Transport Commission's Plan [37] had been published and he would, no doubt, agree with Mr Taylor that when that had been fully implemented, the railway system and services would then differ considerably from those of 1952.

The Author, in reply, dealt with the points raised under subject headings rather than *seriatim.*

Traffic control

He wished first to assure Dr Glanville that he visualized a system of control fully as strict as that which yielded the very low accident figures of motorways abroad. All lanes would be marked with highly mounded catseyes, and the traffic code would include rules such as :—

(*a*) A strict keep-in-lane rule except at clearly marked places of transfer to an adjacent lane.
(*b*) Only uni-directional overtaking allowed on a three-lane roadway, the middle lane being allotted to one direction or the other, never both.
(*c*) No overtaking at all on two-lane stretches of roadway.
(*d*) No dawdling.
(*e*) No parking except in an authorized lay-by or shunt lane in a station, leaving the through lane clear.
(*f*) Forfeiture of special driving licence, for a period or permanently, on breaking the rules.

Single carriageways

In view of the considerable criticism of the Author's suggestion that double-track railway should be converted into single carriageway, instead of the more expensive dual construction, he felt it necessary to give his line of reasoning in that matter.

He had first regarded the indifferent roads on which he (and his critics) travelled daily with fair speed and safety. He had then considered the improved speed and safety that would be available on the permanent ways converted in the simplest manner without major earthwork. Finally, he had taken into account the further considerable gains resulting from the exclusion of undesirable traffic and the observance of a traffic code as given above.

To attempt to improve further upon the motoring conditions he daily experienced, by adding a second carriageway, seemed to the Author extravagant.

In the discussion, however, he had been confronted with a surprising postulate. Speakers had presumed the converted railways teeming with traffic, as if all the alternative existing roads had been closed down.

That was very flattering to the principle of railway conversion ; and if it happened it would probably render dual carriageways necessary, the Author agreed, for traffic volume was the accepted criterion for a second carriageway ; but mathematically it seemed impossible for a great many years to come.

Traffic censuses had shown that few stretches of the Class A trunk routes, beyond the confines of towns and cities, were habitually used by more than 6,000 vehicles a day. Only a proportion of those vehicles would be eligible for transfer to the converted railways as toll traffic. To them had to be added the former rail traffic ; but, as had been shown in the Paper, that would appear very sparse in its new form. Finally, it seemed to have been agreed that the bulk of the traffic would be carried satisfactorily on the 1,954 miles of roadway formed from triple or wider railway.

Accordingly on the stretches of roadway formed from double-track railway, which lay mainly beyond the confines of towns and cities, the

traffic flow would be very much too thin, the Author thought, to justify the expense of providing more than a single carriageway of basically three-lane width, intermittently of two-lane width, as described in the Paper. The capacity of that type of roadway would be more than twenty times the capacity of the double-track it had replaced. If it were overtaxed at any particular place the railway there clearly ought to have been triple originally, and it would no doubt have been scheduled for tripling under the railway modernization scheme.

Toll traffic

It appeared to have been accepted without discussion that the converted railways would be used as toll roads. The Author entirely agreed with that. The Paper had dealt mainly with passenger and freight public services only because the basic functions of British Railways would be fulfilled by those particular services.

Mr Goode had suggested restricting use of the system to commercial and public service vehicles only. But that would waste its capacity and limit the general benefit. The Author considered that as many drivers and vehicles as were fit to use the system should certainly be allowed to do so, paying toll. One aim should be to reduce congestion on the public roads as much as possible ; another should be to keep the toll rate low, and that also demanded the maximum volume of toll traffic.

Journey speed

The Author had observed a tendency to read too much into his suggestion of 60 m.p.h. as the minimum acceptable journey speed, particularly on the part of Mr Taylor. That would, of course, not be a rigid minimum speed limit. The figure of 60 m.p.h. was only the Author's estimate of the average speed that would be achieved voluntarily by the traffic over the entire system, round the clock, and over the four seasons. No precise speed was essential to the argument for railway conversion : 40 m.p.h. might render it worth while. Initial experimental conversions would enable a closer estimate to be made, on which a re-evaluation of the scheme could be based. If it were found that the drivers slowed down excessively at the 24-ft bridges and tunnels, then the question of widening the bridges and tunnels should be taken up.

In bad weather every form of transport was subject to delay. The Author suggested that on that point, as on many others, there had been a tendency to think too much in terms of ordinary road traffic. The roadway traffic would not have to negotiate corners and gradients of the type that caused most of the trouble on public roads in icy weather. Prompt sanding and snow clearance could be arranged.

Safety

Three contributors to the discussion had impugned the Author's

selection of 1952 as the year instanced for railway casualties in Table 1. He had merely quoted the latest figures available to him when writing, and he had inadvertently given the provisional instead of the final figures for the August 1954 road casualties (23,784); the final figures were: killed 408; injured 23,357; total 23,765.

A straight comparison for the year 1953 had become available: roads 226,770; railways 25,475—a ratio of 9 to 1. The aggregate of human exposure to accident, howsoever measured, must be vastly greater on the roads than on railway property, certainly more than 9 times as great, in the Author's opinion. Furthermore three-quarters of the road casualties were slight, whereas a railway employee injured at work was not deemed a casualty unless absent for more than 3 days. Suicides and trespassers were not included in the railway figures.

Mr Osborne had distinguished between railway passengers and employees, and had been correct in stressing the relative safety of the passengers, for expert analysis had shown that " in undertaking a journey by public transport a passenger is as safe by road as by rail." [39]

Urban areas

In saying that the Author had proved the case for a modernized highway system Major Aldington implied a system akin to that planned in the Ministry of Transport under Mr Barnes, comprising new motorways that avoided or stopped short of towns and cities. But the Author disclaimed having made any such case; he would never have concerned himself greatly over those motorways—" pipes with their ends blocked " as Mr E. C. Gordon England had called them. The essence of railway conversion was that it provided high-speed routes where they were needed most, namely into and through urban and metropolitan areas.

Mr Seymer had appreciated that point, but his suggestion for putting the railways underground within such areas seemed impracticable financially: London Transport had stated that not even their proposed new tube railway, aligned to attract maximum traffic, could support the capital charges incurred in tunnelling. For similar reasons it must be doubtful whether the ideas of Lt-Col. Lovell for overhead construction were realistic. Perhaps those two speakers believed, as did many people, that Government subsidy was a legitimate principle in transport. That principle was certainly looming over the affairs of British Railways, but it might never achieve legitimacy in the eyes of the taxpayer. Instead the latter might come to regard British Railways as an affliction, which seemed to be how Mr Dath regarded them already.

It was important, the Author thought, that the public should appreciate the effects of railway conversion on themselves personally: perhaps they alone stood to gain from it at first; there seemed to be no " interest " that would profit from it initially, though all would gain in the long run. He therefore welcomed the limited schemes put forward by Professor Bondi

and Mr Davey: the people concerned could work out the effect on themselves; the London and Home Counties Traffic Advisory Committee might be interested to do that on behalf of Londoners in respect of Mr Davey's scheme. Moreover, as the Author fully realized, conversion would need to start in limited areas. He himself would not prejudice matters by suggesting which areas. The demand should come from the area, he felt. One such demand had materialized on the 1st November, 1954, when Sir David Robertson, Member of Parliament for Caithness and Sutherland, appealed in Parliament for the conversion of the line from Inverness to Wick. That line would provide perfect rural experience, but more would be learnt from urban areas.

Vehicle milage

Mr Ratter had been depreciatory of an annual vehicle milage of 150,000 because of the resulting £600 tire bill. The Author replied upholding that milage because of its effect on another item in the running costs of a vehicle.

Any vehicle had a fixed life which would be expressed in miles: a bus for instance commonly had a life of 500,000 miles in city service. If such a bus had forty-eight seats, with fares 1*d* per mile and a load factor of 50%, it could bring in at the very most, throughout its entire existence, a sum of £50,000.

In a city the bus would run approximately 33,300 miles annually and last for 15 years. Over this period its crew (5½ persons gross) would have to be paid say £2,500 a year, a total of £37,500, which at once lowered the ceiling of earnings from £50,000 to £12,500.

Were that bus given roads on which it could run 150,000 miles a year it would demand only 3⅓ years' work of its crew in accomplishing its £50,000 mission, and £41,666 instead of £12,500 would remain available to meet the other costs incurred in travelling the 500,000 miles.

That seemed just a typical instance of the known advantage in running machinery at a fast pace in a high-wage economy. It revealed the unimportance of £600 tire bills, and also of annual depreciation charges of about £1,000 per vehicle, once journey speed had been increased from 11 m.p.h. (London traffic) to 60 m.p.h.

In any event, at the present rate of technical progress, the Author submitted, there was much to be said for a system that enabled vehicles to be replaced every 3 or 4 years by new vehicles of greater efficiency. And 150,000 miles a year was not a lot. Motor coaches already ran 10,000 miles a month on the Scotland–London road service. Freight vehicles could be expected to achieve more running hours than passenger vehicles: a lorry in round-the-clock operation on say a 60-mile coal run between pit and power station, averaging no more than eight round trips a day, would cover 350,000 miles in one year. If it were a 20-tonner and the freight charge were 1½*d* per ton-mile, even though it always did the return journey

empty, it would still earn £60 a day gross—£21,900 a year. Altogether the Author felt he had been moderate in instancing in the Paper a vehicle that covered no more than 150,000 miles a year.

Number of vehicles

Mr Blee had indicated that the number of vehicles required might approach 500,000. The Author had been disappointed to glean nothing more substantial than indications from Mr Blee, but himself admitted having left that particular subject somewhat in the air; Lt-Col. Cartwright-Taylor had been able to interpret him satisfactorily.

The Author had, however, estimated on p. 738 that the number of vehicles might eventually reach 164,800 (41,200 × 4). " Nearer half-a-million " could therefore be put at 332,401. If that number of vehicles averaged 150,000 miles annually they would equal British Railways' 1952 output of passenger- and ton-miles when their load factor reached 3%, i.e., 40-seater buses carrying 1·2 passenger and 20-ton lorries laden with 12 cwt.

In contrast the Author had presumed a high standard of managerial efficiency, and his estimate of 164,800 vehicles had allowed for the traffic having quadrupled; his extrapolation had embraced hire cars and other light vehicles in public service. He suggested that Mr Blee's indication of " nearer half-a-million vehicles " could not be accepted outright, though it was by no means formidable in relation to the 6 million vehicles already in Britain, or to the British motor industry's annual output of more than 1 million vehicles.

Peak hours

The particular problem of deploying the passenger vehicles correctly during rush hours had been covered by Mr Blee in his remark that the demand in the Southern Region would leave none for Manchester. Mr Taylor had been more specific and had allotted the Southern Region 5,000 buses for the morning rush of 300,000 passengers. But Mr Taylor had not taken into account the fact that the average commuting distance was of the order of 14 miles. Over that distance a bus would take 40 minutes for the round trip and would therefore complete three journeys into London during the normal 1½-hour rush: only 1,666 buses might be required.

The Author agreed with Mr Taylor in disregarding standing room.

Manpower

On the subject of manpower Mr Taylor had quoted a railwayman who sought to leave an impression that 3,500 railwaymen were worth 90,000 lorrymen, and Mr Blee had invited consideration of the subject in relation to the staff employed in British Railways.

That had prompted the Author to point out that, roundly, British Railways employed 600,000 people in order to run daily 40,000 trains grossing 1 million train-miles. By simple proportion: 15 employees

produced daily no more than 1 train which accomplished one 25-mile run. Assessing the duration of that average train-run at 1½ hour, and the average employee's working day throughout the year at 6 hours, the Author deduced that British Railways' average train had to earn, in 1½ hour, sufficient to cover the wages of 15 people for 6 hours. The train was in effect carrying a " crew " of 60, though only 3 might be visible.

On the other hand a bus commonly necessitated 5½ employees and spent appreciably more than 6 hours in operation daily: its " crew " was therefore less than 5½ net—perhaps 4, compared with the train's 60. That disparity was offset to only a limited extent by the extra size of the train. Significantly the average takings in 1952 of a British Railways' passenger train and of a London bus *per diem* were approximately equal at about £13.

Mr Taylor had also pointed out that 68 trains ex-Waterloo would be replaced by 840 buses. By the Author's reckoning the manpower backing of the 68 trains would be 4,080. And if the buses were operating under city conditions their backing would amount to perhaps 3,360. But the buses would be operating under very different conditions: for instance they would not require conductors, and their " ground staff " and many of their overheads would be charged against toll receipts, not against bus takings. The inference was that a minority of the 600,000 employees would be directly engaged in passenger and freight public services: the salaries, wages, and pensions of the majority would derive, appropriately enough, from toll traffic.

Speed, in relation to other factors

The Author regretted he could not share Dr Daniel's interest in passenger train timings. To the Author's way of thinking the paramount factor in public transport was convenience, and the chief element in that was frequency. He had been disappointed that in the discussion the need for frequent services had been mentioned only once—by Mr Davey in respect of his ring main.

An expert evaluation of the factors that weighted with the public had placed them in the order: comfort, frequency, cost, time.[40]

The Author visualized a long-distance bus on the converted railways giving passengers all the comfort of an air liner without the noise, earache, bumps, and air sickness.

With regard to cost the Author had been particularly interested to note that his estimated running costs had been criticized by Mr Bond only in respect of the item 3·6*d* per mile for fuel, lubricant, and tires. The Author had been influenced by figures from a motorway in the United States, but did not wish to dispute the criticism. It would have been noted that his ½*d* fare allowed an overall margin of 108%, to cover criticism of costs and load factor; he had refrained from claiming a fare of ¼*d* per mile.

Although speed might be only the fourth factor from the passenger's viewpoint, it was a vital factor in reducing the costs of operation, and it

made a very interesting study. The Author expressed a hope that Dr Daniel would include road speed in his researches.

Transit time

Dr Glanville had raised the point that the use of special vehicles that could not quit the converted railways would create trans-shipment difficulties. In the Paper the use of trailers had been suggested in partial anticipation of that problem; but the Author admitted he had been over-imbued with a desire—very understandable in 1955— to evade the taxation and legislation that assailed any vehicle the moment it was driven on to a public road. He agreed that in practice it would often be best to use conventional vehicles and so compete on equal terms with toll traffic.

Mr Goode in his opening sentences had dwelt on the advantages of door-to-door transport and had shown how they could be reaped through railway conversion. They could be summed up as a saving in " transit time," and perhaps transit time was the truest yardstick to apply in transport matters.

The yardstick used by Mr Blee in comparing rail traffic with road traffic had been ton-miles: 22,000 million by rail, 7,000 to 8,000 million by road. Mr W. Andrews, Chairman of the Royal Automobile Club, writing in the *Sunday Times* on the 19th June, 1955 had used plain tons: roads 72%, rail 24%, coastal shipping 4%. In the Paper a financial yardstick had been used: roads £1,700 million, rail £500 million. No doubt all those comparisons were questionable, and the Author suggested that what was required in order to survey the national transport problem was a new analysis taking into account transit time.

In support of transit time as a basis for analysing transport problems the Author quoted the British Transport Commission: " a high proportion of the costs of railway operation is related to time rather than distance." [41] That principle was not novel: it underlay the development of jet air liners. A stage seemed to have been reached in transport affairs when time mattered more than distance: when the lowest-priced freight (which could not afford high-cost transport) ought to be conveyed fastest. If that were correct a highly relevant fact in any investigation of railway conversion would be that on British Railways the average haul for coal was only 56 miles, and for minerals 76 miles, and therefore lorries engaged on that important class of traffic would be able after conversion to *deliver* their loads successively sooner than railway wagons could at present be marshalled into train, let alone start their journey.

Brigadier Parkman favoured the train as a " larger unit," and elsewhere there had been postulated " the great natural advantages of railways as bulk transporters." [41] But, in the Author's view, bulk transportation was incompatible with the economics of an age in which the old saying " time is money " had gained force. The ideal form of transportation for the convenience of the client or customer had always been a flow, or movement in

small units ; that type of movement had perhaps become essential to the financial viability of the transporting agency, especially in a small country such as Britain.

Cost of conversion

The Author was confident of not being alone in feeling that Mr Goode's contribution on the cost of conversion had added greatly to the value of the discussion.

Mr Goode had arrived at a figure of £1,000 million. He had remarked that that figure would not be exceeded at the outside, but the Author felt it might still give a wrong impression. It represented approximately £3 per sq. yd overall.

The blacktopped portion of the Lindley track had cost only £2 per sq. yd ; it had been constructed on virgin land, and the stone had had to be hauled about 40 miles. The Author wondered whether Mr Goode had allowed sufficiently for the incorporation of railway ballast in the road structure, and for the use of the out-size pavers that might be specially developed for such highly repetitive work.

There were approximately 8,000 stations (including 2,200 for freight only) to be considered in addition to the paving ; but at those stations people would no longer need to congregate in mass : they would enter their bus at once or after only a short wait. The stations could therefore be simpler, and very little more than platform removal would be required at the minor stations comprising the majority of the 8,000.

The Author would have included lighting at £4,000 per mile along the 12,300 miles of former double and wider track, but even so would not have put the figure above £600 million.

Fuel

Mr Warder had stated that additional railway electrification could not absorb more than 2% of the concurrent *increase* in the national generating capacity. The Author hoped that that statement would help to bring the fuel problem into perspective ; in relation to the total output of electricity the demands of transport must always remain unimportant.

There was a common tendency, the Author thought, to exaggerate the fuel problem, perhaps because of British Railways' annual consumption of 13 million tons of coal. That consumption was attributable mainly to the limited efficiency of steam locomotives, and to the deadweight of trains, which was seldom less than 1 ton per passenger.

The minimum essential power for the movement of a passenger or a load was trivial, and that was a field in which great advances could be expected, motive units becoming more efficient and all vehicles lighter, with resulting economy in fuel. Appreciable advances in that field could hardly occur in railway locomotion because of the fixed power-weight ratio of locomotives ; but tremendous advances could be expected as soon as Britain's

mechanical engineers started designing special vehicles for special roads. The solid-fuel gas-turbine might eventually reduce Britain's dependence on imported fuel ; finally the atomic vehicle might materialize.

The future

There had been a robust warning from Mr Harding on the need to look ahead, and it was on that note the Author wished to end.

A vast increase in the ownership of vehicles by individual people and businesses was certain to occur. Meanwhile, as had been mentioned by Major Carter, the overall volume of freight might diminish rather than increase. Under those circumstances what was to be the future of British Railways ? Already the volume of traffic accruing to them seemed to have fallen below the critical level for viability. Their forlorn palliative, comprising a reduction in the services they offered to the public, was to be adopted as a main feature of their proposed modernization ; it would enable their remaining services to be improved and to be run at lower charges than would otherwise prevail.

Thus contraction seemed to be the keynote of British Railways' plans for the future ; and the growth of commercial and private motoring, fostered by a modest improvement in the public road system, threatened to enforce a greater degree of contraction than had been planned.

The Author submitted that the straightforward civil engineering operation of turning the railways into roads seemed to offer British Railways expansion in the place of contraction. It would increase the traffic-carrying capacity of the permanent ways far beyond their present capacity as railways, and it would enable them to be used by the chosen vehicles of this generation and doubtless of future generations. In the opinion of the Author there might be a wonderful future for British Railways as the proprietors of truly arterial roads that could play a vital part, directly or indirectly, in the daily lives of every man, woman, and child in Britain.

Finally, the Author endorsed gratefully a recommendation made by several contributors to the discussion ; namely that the subject, which the Institution had graciously invited him to present before them, should be further examined.

Correspondence on the foregoing Paper is now closed.—SEC.

REFERENCES

29. P. Barnes, "Some Aspects of Railway Track." J. Instn Perm. Way Engrs, vol. 72, p. 35 (Apr. 1954).
30. H. H. Phillips, " The economics of intensified use of railway operating and motive power resources." J. Inst. Transport, vol. 26, p. 77 (Mar. 1955).
31. T. E. Hutton, " The Design of Motorw s." Proc. Instn Civ. Engrs, Pt II, vol. 2 p. 701 (Oct. 1953).

32. H. F. Hammond and L. J. Sorenson, "Traffic Engineering Handbook." Inst. Traffic Engrs, New Haven, Connecticut, 1950.
33. T. M. Coburn, "Accidents in Rural Roads in Great Britain." Bull. 10th Int. Rd Congr., 1955.
34. J. Drake, "Road Plan for Lancashire." Report for Lancashire County Council, 1949.
35. H. A. McBride, "Trains Rolling." Macmillan, New York, 1953.
36. H. R. Broadbent, "Energy Conservation on the Railways." Brit. Transp. Rev., vol. 3, No. 4, p. 350 (Apr. 1955).
37. "Plan for the Modernisation and Re-equipment of British Railways." Brit. Transp. Comm., Dec. 1954.
38. "Modern French Locomotive Performance." Rly Mag., Lond., vol. 98, p. 802 (Dec. 1952). *See* p. 809.
39. Road Accident Statistical Review No. 83 (Sept. 1954) Roy. Soc. for the Prevention of Accidents.
40. Henry Spurrier, "Road Transport and the Commercial Motor Manufacturer." 9th Henry Spurrier Memorial Lecture, J. Inst. Transport, vol. 25, p. 290 (Jan. 1954).
41. "British Railway Modernisation and Re-equipment."—British Transport Commission 1955.